LECTURE NOTES

For Environmental and Occupational Health Students

Occupational Health and Safety

Ethiopia Public Health Training Initiative

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CHAPTER ONE

OCCUPATIONAL HEATH AND SAFETY

1.1. Learning objectives

At the end of this chapter, the student will be able to:

1. Define occupational health
2. Discuss challenges for the development of occupational health and safety.
3. Explain the scope of occupational health and safety.
4. Describe the interrelationship between ooccupational health and development
5. Identify the elements of a work environment.
6. Discuss the three common interactions in the work place.
7. Explain the interrelationships between work and health.

1.2. Introduction

Occupational health and safety is one of the most important aspects of human concern. It aims an adaptation of working environment to workers for the promotion and maintenance of the highest degree of physical, mental and social well being of workers in all occupations.

The question of occupational health and safety, as a global issue, is now taking a new turn. The main contributory factors towards this idiocyncracy seem to be due to the rapid industrial and agricultural development that are taking place in the developing countries, and the emergence of new products and product processes from these places. Many of these countries are moving from manual labour to service mechanization in the main productive sectors, such as manufacturing, mining and agriculture, hence the potential occupational health ramifications should be anticipated. Also the insatiable desire of these countries for technical advancement has brought about the importation of sophisticated machinery and pieces of equipment not only into the industrial production sector, but also to services and commerce. This invariably has been associated with a change in the structure of the labour force as a whole including a rise in the employment of women. As to be expected the health problems would also change. For example, more emphasis on ergonomics and occupational psychosocial factors would be needed in the services industry. This obviously would be a new challenge for occupational health and safety practice in most of the African countries because the tool to deal with such a problems and the expertise is not yet advanced when compared to the developed countries.

The benefit of occupational health service in developing countries is seen locally as well as on a national level. The positive impact of occupational health service locally may be observed in reducing morbidity and work-related injuries. In addition, this also means fewer losses to employer and worker as there will be a reduction of wage losses and decreased compensation costs. The reduction of absenteeism is of great importance concerning skilled labour, especially so in countries where there is a shortage of skilled labour.

Making working conditions healthy and safe is in the interest of workers, employers and governments, as well as the public at large. Although it seems simple and obvious, this idea has not yet gained meaningful universal recognition. Hundreds of millions of people throughout the world are employed today in conditions that breed ill health and/or are unsafe.

Each year, work-related injuries and diseases kill an estimated 2 million people worldwide, which is greater than the global annual number of deaths from malaria. Annually, an estimated 160 million new cases of work-related diseases occur worldwide, including respiratory and cardiovascular diseases, cancer, hearing loss, musculoskeletal and reproductive disorders, mental and neurological illnesses.

An increasing number of workers in industrial countries complain about psychological stress and overwork. These psychological factors have been found to be strongly associated with insomnia, depression and fatigue, and burn-out syndromes, as well as with elevated risks of cardiovascular diseases. Only 5-10% of workers in developing countries and 20-50% of workers in industrial countries (with a few exceptions) are estimated to have access to adequate occupational health services. Even in advanced economies, a large proportion of work sites are not regularly inspected for occupational health and safety.

1.3. Definition of Terms

According to WHO (1995), occupational safety and health can be defined as a multidisciplinary activity aiming at:

- Protection and promotion of the health of workers by eliminating occupational factors and conditions hazardous to health and safety at work
- Enhancement of physical, mental and social well-being of workers and support for the development and maintenance of their working capacity, as well as professional and social development at work
- Development and promotion of sustainable work environments and work organizations

The ILO/WHO definition of occupational health is "The promotion and maintenance of the highest degree of physical, mental social well- being of workers in all occupation" and the WHO considers occupational health service to be responsible for the total of worker and, if possible, his or her family.

Occupational Health is a diverse science applied by occupational health professionals engineers, environmental health practitioners, chemists, toxicologists, doctors, nurses, safety professionals and others who have an interest in the protection of the health of workers in the workplace.

The discipline covers the following key components:

1. the availability of occupational health and safety regulations at workplace
2. the availability of active and functional occupational health and safety committee at workplace
3. monitoring and control of factory hazards to health
4. supervision and monitoring of hygiene and sanitary facilities for health and welfare of the workers
5. inspection of health safety of protective devices
6. pre-employment, periodical and special health examination.
7. performance of adaptation of work to man
8. provision of First Aid
9. health education and safety training to the worker
10. Advice to employers on the above mentioned items
11. Reporting of occupational deaths, diseases, injuries, disabilities ,hazards and their related preventive measures at working

According to a statement by occupational health institutes collaborating with the WHO (1995) the most important challenges for occupational health for the future will be:

- Occupational health problems linked to new information technologies and automation;
- new chemical substances and physical energies;
- health hazards associated with new biotechnologies;
- transfer of hazardous technologies;
- aging working populations;

- special problems of vulnerable and underserved groups (e.g. chronically ill and handicapped), including migrants and the unemployed; and,
- problems related to growing mobility of worker populations and occurrence of new occupational diseases of various origins**.**

Interdisciplinary Relationships

Environmental Managers: are those trying to eliminate hazards from the workplace cause many environmental problems.

Toxicology: is the science that studies poison ands toxic substances and their mechanisms and effects on living organisms. In other words toxicology is the study of adverse effects of chemical on biologic systems, or when a substance has a capacity to produce undesirable physiological effect when the chemical reached a sufficient concentration at a specific site in the body.

Toxicologists: are persons who study poisoning and responsible defining quantitatively the level of exposure at which harm occurs and they also prescribe precautionary measures and exposure limitations so that normal recommended use of chemical substance does not result in excessive exposure and subsequent harm

Ergonomics: is a multidisciplinary activity dealing with the interaction between man and his total working environment plus such traditional environmental elements as atmosphere, heat, light, and sound as well as all tools and equipment of the work place.

Chemical engineers are those who design process plant, they choose values, decide on how access will be gained and how cleaning will take place.

Mechanical engineers are those who responsible for choosing materials handling systems or for specifying noise levels on machinery.

Environmental health professionals: are those who **a**pply their knowledge and experience, understand the environmental health hazards, analyze the technical and social approaches and reduce and eliminate human exposures and health impacts.

Industrial hygienists are scientists, engineers, and public health professionals committed to protecting the health people in the workplace and the community

1.4 Occupational health and development

The health status of the workforce in every country has an immediate and direct impact on national and world economies. Total economic losses due to occupational illnesses and injuries are enormous (WHO 1999). The International Labor Organization (ILO) has estimated that in 1997, the overall economic losses resulting from work-related diseases and injuries were approximately 4-5 % of the world's Gross National Product.

Workforce is a backbone of a country development. A healthy, well-trained and motivated workforce, increases productivity and generates wealth that is necessary for the good health of the community at large.

Magnitude of the problem/disease

The difficulty of obtaining accurate estimates of the frequency of work-related diseases is due to several factors.

1. Many problems do not come to the attention of health professionals and employers and, therefore, are not included in data collection systems.
2. Many occupational medical problems that do come to the attention of physicians and employers are not recognized as work related.
3. Some medical problems recognized by health professionals or employers as work- related are not reported because the association with work is equivocal and because reporting requirements are not strict.
4. Because many occupational medical problems are preventive, their very persistence implies that some individual or group is legally and economically responsible for creating or perpetuating them.

However, globally, millions of men and women work in poor and hazardous conditions. According to International Labour Organization

- 1.2 million working peoples die of work related accident and diseases every year
- More than 160 million workers fall ill each year due to workplace hazards

- ❖ UN estimates 10,000,000 occupational disease cases occur each year globally, severity and frequency is greatest in developing countries.
- ❖ Women , children and migrant workers are least protected and most affected
- ❖ Micro and small enterprises account for over 90 % of enterprises where conditions are often very poor and the workers particularly in the informal sectors are often excluded from all legal protection.

Reasons for these are:-

Workplace

- Unsafe building
- Old machines
- Poor ventilation
- Noise
- Inaccessible to inspection

Workers

- ❖ Limited education
- ❖ Limited skill and training

Employers

- ❖ Limited financial resources
- ❖ Low attention and knowledge

In many developing nations, death rates due to occupational accident among workers are five to six times higher than those in industrialized countries; yet, the situation in developing countries is still largely undocumented due to poor recording system.

Table 1-1: Estimated Global Burden of Disease from Selected Environmental Threats

Type of environmental and principal related diseases	Burden from these diseases (Million of DALYs per year)	Reduction achievable through feasible interventions (percent)	Burden averted by feasible interventions (Millions of DALYs per year)	Burden averted per 1,000 population (DALYs per year)
Occupational	318	-	36	7.1
Urban air	170	-	8	1.7
Road transport(motor vehicle injuries)	32	20	6	1.2
All the above	473	-	50	10.0

Source: World Bank, 1993

1.5. Historical background of occupational health

The work place is a potentially hazardous environment where millions of employees pass at least one-third of their life time. This fact has been recognized for a long time, although developed very slowly until 1900.

There has been an awareness of industrial hygiene since antiquity. The environment and its relation to worker health was recognized as early as the fourth century BC when Hippocrates noted lead toxicity in the mining industry. In the first century AD, Pliny the Elder, a Roman scholar, perceived health risks to those working with zinc and sulfur. He devised a face mask made from an animal bladder to protect workers from exposure to dust and lead fumes. In the second century AD, the Greek physician, Galen, accurately described the pathology of lead poisoning and also recognized the hazardous exposures of copper miners to acid mists.

In the middle Ages, guilds worked at assisting sick workers and their families. In 1556, the German scholar, Agricola, advanced the science of industrial hygiene even further when, in his book De Re Metallica, he described the diseases of miners and prescribed preventive measures. The book included suggestions for mine ventilation and worker protection, discussed mining accidents, and described diseases associated with mining occupations such as silicosis.

Industrial hygiene gained further respectability in 1700 when Bernardo Ramazzini, known as the "father of industrial medicine," published in Italy the first comprehensive book on industrial medicine, De Morbis Artificum Diatriba (The Diseases of Workmen). The book contained accurate descriptions of the occupational diseases of most of the workers of his time. Ramazzini greatly affected the future of industrial hygiene because he asserted that occupational diseases should be studied in the work environment rather than in hospital wards.

Industrial hygiene received another major boost in 1743 when Ulrich Ellenborg published a pamphlet on occupational diseases and injuries among gold miners. Ellenborg also wrote about the toxicity of carbon monoxide, mercury, lead, and nitric acid.

In England in the 18th century, Percival Pott, as a result of his findings on the insidious effects of soot on chimney sweepers, was a major force in getting the British Parliament to pass the Chimney-Sweepers Act of 1788. The passage of the English Factory Acts beginning in 1833 marked the first effective legislative acts in the field of industrial safety. The Acts, however, were intended to provide compensation for accidents rather than to control their causes. Later, various other European nations developed workers' compensation acts, which stimulated the adoption of increased factory safety precautions and the establishment of medical services within industrial plants.

In the early 20th century in the U.S., Dr. Alice Hamilton led efforts to improve industrial hygiene. She observed industrial conditions first hand and startled mine owners, factory managers, and state officials with evidence that there was a correlation between worker illness and exposure to toxins. She also presented definitive proposals for eliminating unhealthful working conditions.

At about the same time, U.S. federal and state agencies began investigating health conditions in industry. In 1908, public awareness of occupationally related diseases stimulated the passage of compensation acts for certain civil employees. States passed the first workers' compensation laws in 1911. And in 1913, the New York Department of Labor and the Ohio Department of Health established the first state industrial hygiene programs. All states enacted such legislation by 1948. In most states, there is some compensation coverage for workers contracting occupational diseases.

The U.S. Congress has passed three landmark pieces of legislation related to safeguarding workers' health: (1) the Metal and Nonmetallic Mines Safety Act of 1966, (2) the Federal Coal Mine Safety and Health Act of 1969, and (3) the Occupational Safety and Health Act of 1970 (OSH Act). Today, nearly every employer is required to implement the elements of an industrial hygiene and safety, occupational health, or hazard communication program and to be responsive to the Occupational Safety and Health Administration (OSHA) and its regulations.

However, concrete approach to the control of occupational diseases became valid in most countries after the twentieth century. Emphasis was then given to the control of working hazards, and multidisciplinary approach to such effective measures in which at least triparty: the employer, the employee, and the competent authority are together participating in the problem solution. Much improvement in the workers health protection has been made in developed countries in the field of industrial hygiene and safety, and occupational medicine. There is still a long distance ahead for developing countries.

1.5.1 OSHA and occupational health

Under the OSH Act, OSHA develops and sets mandatory occupational safety and health requirements applicable to the more than 6 million workplaces in the U.S. OSHA relies on, among many others, industrial hygienists to evaluate jobs for potential health hazards. Developing and setting mandatory occupational safety and health standards involves determining the extent of employee exposure to hazards and deciding what is needed to control these hazards to protect workers. Industrial hygienists are trained to anticipate, recognize, evaluate, and recommend controls for environmental and physical hazards that can affect the health and well-being of workers.

More than 40 percent of the OSHA compliance officers who inspect America's workplaces are industrial hygienists. Industrial hygienists also play a major role in developing and issuing OSHA standards to protect workers from health hazards associated with toxic chemicals, biological hazards, and harmful physical agents. They also provide technical assistance and support to the agency's national and regional offices. OSHA also employs industrial hygienists who assist in setting up field enforcement procedures, and who issue technical interpretations of OSHA regulations and standards.

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 OSHA industrial hygienist are to spot those conditions and help eliminate or control them through appropriate measures.

1.5.2 National Labor Law Profile: Federal Democratic Republic of Ethiopia

According to labor proclamation No. 377/2003, the Ministry of Labor and Social Affairs of Ethiopia is the organ charged with the responsibility to inspect labor administration, labor conditions, occupational health and safety

1. Labor regulation

Talking about labor Law in Ethiopia means to basically review the history of the last 40-50 years. Present-day labor law, as a specialized law designed to protect employees' welfare, only came into existence as a result of the modern industrial development and with the rise of the status of the employee as wage earner. Until recently, the main source of labor law, the Labor Proclamation, Proclamation No. 42/1993, was developed in the post-socialist time, marking the overcoming of the centralized state-economy towards a market oriented, pluralistic society.

Ethiopia was criticized for several years by the ILO Committee of Experts, which noted serious discrepancies between the national legislation and the Freedom of Association and Protection of the Right to Organize Convention, 1948 (No. 87). It was partly in response to the observations made by the House of People's Representatives adopted Labor Proclamation No. 377/2003, effective since 26 February 2004. This text repealed Labor Proclamation No. 42/1993 (as amended by Proclamation 88/1994). It has become the principal source of labor law in Ethiopia. So far the Committee of Experts has not published its comments on the new law.

The new statute represents an important tool for unions and employers to participate in all labor matters. The innovation concerns the right of workers, without distinction whatsoever, to form organizations of their own choosing and the right of these organizations to organize their activities without interference by the public authorities and not to be dissolved by administrative authority (Article 114 (1), (2) and (7)).

Labor Proclamation 377/2003 amends the previous Labor Proclamation on the following points:

- It defines “managerial employees” in Article 3 (2) c);
- It introduces an obligation of employers to maintain records;
- It tightens the legal procedure by setting several new deadlines;
- It introduces a clear ban for compulsory HIV/AIDS testing (Article 14 (2) d);
- It strengthens the workers' position in case of termination (Article 27 (2) and (3);

- It clarifies regulations on severance pay and compensation, disablement payment and dependants benefits (Arts. 39, 40, 109, 110);

- It creates the full guarantee of freedom of association by abolishing trade union monopoly (Article 114), provided that the number of members of the union is not less than ten;

- It recommends regulations on trade union property to be included into the constitution of workers' organizations (Article 117 (12) (new));

- It clarifies the cancellation of a union to be effective only after a court decision (new Article 120 (1));

- It introduces a simpler system of collective bargaining and labor dispute settlement, with specified time limits to speed up the resolution of conflict (Articles 130 (2), 142 (3), 143 and 151);

- It intends to improve the efficiency of the Labor Relation Boards (Articles 145, 1474 (4), 149 (6), 150, 153 and 154);

- It restricts the definition of “essential services” (Article 136 (2)), excluding railway and inter-urban bus services, filling stations and banks, thereby entitling workers or employers of these undertakings to the right to strike or lockout.

Working time

Hours of work

Normal working hours are 8 hours a day or 48 hours a week (Article 61). They should be distributed evenly, but may be even calculated over a longer period of time (Articles 63 and 64).

Overtime

Any work exceeding the normal working time of 48 hours a week is overtime. Overtime is only permissible for up to 2 hours a day, or 20 hours a month, or 100 hours a year, in the following cases (Article 67):

Night work

Pursuant to Article 68 (1) b), night work is work realized between 10 PM and 6 AM.

Paid leave

Annual, uninterrupted leave with pay shall be a minimum of 14 working days, plus one working day for every additional year of service (Article 77). Additional leave is granted for employees engaged in particularly hazardous or unhealthy work. It is forbidden to pay wages in lieu of the annual leave (Article 76).

Public holidays

Ethiopia has twelve public holidays – historical memorial days and holidays of Christian and Moslem origin - described by law.

Maternity leave and maternity protection

As mentioned in paragraph 2.5, the Constitution of Ethiopia grants the right to maternity leave with full pay.

Furthermore, the Ethiopian Labor Proclamation provides one part (Part Six) to the Working Conditions of Women and Young Workers. Maternity leave and maternity protection are regulated in Articles 87 and 88.

Other leave entitlements

Articles 85 to 86 provide for an entitlement to sick leave after the completion of the probation period. An employee is entitled to a maximum of 6 months of sick leave within 1 year of service. An employer will only be obligated to grant paid sick leave for the first months, whereas the wage is reduced to 50 % for the second and third month, and reduced to zero for the third to the sixth month of sick leave within a year. For any absence for longer than one day the employee has the obligation to produce a valid medical certificate.

Moreover, Article 81 to 84 of the Proclamation provide for special leave for family events, union activities and other special purposes, such as for hearings before bodies competent to hear labor disputes, to exercise civil rights, and for training purposes according to collective agreements or working rules.

Minimum age and protection of young workers

Under Article 89 of the Labor Proclamation the statutory minimum age for young workers is 14 years. Beyond the age of 14 years, no person may employ a child for work that is inappropriate or that endangers his or her life or health (Article 89 (2) and (3)). Special measures of protection of young workers (e.g. work in transport, night work, work in arduous, hazardous or unhealthy activities, such as mining) may be taken by the Minister. Work performed under the regime of a vocational training course is exempted from this protection (Article 89 (5)).

As shown above, the Ethiopian Constitution gives children general protection from exploitative labor practices – Article 36 – Rights of Children.

Ethiopia ratified the ILO Worst Forms of Child Labor Convention, 1999 (No. 182), in September 2003.

Equality

The Constitution guarantees the right to equality in employment, promotion, pay and the transfer of pension entitlement (Article 35 (8) of the Constitution).

Pay issues

Ethiopian law does not prescribe minimum wages through statute. Usually wages are fixed by the employer or by collective agreements or by the employee's contract of employment.

2. Legal framework – Federal Democratic Republic of Ethiopia

The Constitution of the Federal Democratic Republic of Ethiopia (1995) has made a progress in terms of addressing the concern of persons with disabilities. In Article 41 of the Constitution, it is stated that the State shall, within available means, allocate resources to provide rehabilitation and assistance to the physically and mentally disabled, the aged, and to children who are left without parents or guardian.

Purpose of the Proclamation

The Right of Disabled Persons to Employment Proclamation No.101/1994 is the only legislation of its kind which is specifically concerned with the rights of disabled persons to employment. In paragraph 3 of the preamble it is stated that the objective of the Proclamation is to stop such discriminations and protect the rights of disabled persons to compete for and get employment on the basis of their qualifications.

Scope of the Proclamation

Article 2(1) of the Proclamation defines a "disabled person" as a person who is unable to see hear, or speak or suffering from injuries to his limbs or from metal retardation due to natural or man made causes provided however that the term does not include persons who are alcoholics, drug addicts and those with psychological problems due to socially deviant behaviors.

Article 3 of the Proclamation provides for a list of protections pertaining to the rights of disabled persons. Under this article it is stated that:

1. Disabled person having the necessary qualifications shall, unless the nature or the work dictates otherwise, have the right to compete and to be selected for.

    a. a vacant post in any office or undertaking through recruitment, promotion, placement or transfer procedures;

Model of Disability.

Where disability is understood as a 'moral' matter, associated with shame or guilt, the policy response is generally one of care by the family or by religious institutions, and solutions often involve charity. The legal approach associated with this understanding of disability has been described as 'Charity Law (c.f. Degener and Quinn, 2000). This type of law (often called 'Poor Law') aims to alleviate complete destitution and provides for basic services, in segregated settings which are often stigmatised.

The working group conclusions on this topic are listed below:

- Disability should be regarded as a human rights issue
- Medical provision should be required at the workplace
- Provision should be made for social security benefits

- Enforcement mechanisms are essential
- Anti-discrimination provisions should be made
- Measures to promote employment opportunities should be introduced
- Equality should be the basic principle
- People with disabilities should be encouraged to be independent
- People with disabilities should be represented in workers' and employers' organisations
- Education for all people with disabilities should be compulsory
- A national body to coordinate and consolidate policies and existing services/activities relating to disability should be established
- Training of staff to provide services to employers and workers is required
- ILO Convention No. 159 should be ratified and adapted to the specificity of each country
- Data on disability should be collected /analysed/ disseminated

- All disability-related laws should be reviewed and amended in line with modern law. Implementation should be persuasive at the beginning
- ‘Disability’ should be clearly defined
- Quota schemes should be provided for
- Equal opportunities should be promoted
- Registration of employers/registration of persons with disabilities seeking employment is required
- Incentives to employers should be introduced
- Accessibility/reasonable accommodation to buildings /information/labour market/technical devices should be provided for
- Personal support service to ease communication barriers should be provided for
- Measures to promote job retention should be introduced
- A national multi-sectoral mechanism -a Council or Committee- should be established
- Reservation of posts should be provided for

Session 2: What are the strengths and weaknesses of existing laws concerning the employment of people with disabilities, and their implementation measures?

The conclusions of the three working groups on this topic are listed below:

Strengths

- Laws have been introduced
- Provision for the rights of people with disabilities is made in some national constitutions
- Laws put forward a human rights approach to disability
- Laws are flexible
- Laws make provision for formal, integrative employment
- Specific provisions are made for training
- Some provision is made for social security
- Provision is made for data collection, registration of people with disabilities, in some cases
- Disabled persons' organisations are involved in the development of laws, in some cases

Weaknesses

In the laws themselves

- Laws too general, vague, specific
- No enforcement/implementation mechanisms specified

- No provision for affirmative action
- No provision for reasonable accommodation
- No provision for equal opportunities
- Definition of disability too narrow
- No provision for representation of people with disabilities
- No consideration of financial implications
- No provisions for coordination mechanisms, in some cases
- Lack of constitutional provision, in some cases
- Narrow scope – only apply to public sector in some cases
- No specific provision for civil service, in some cases

In the wider context

- No policy framework
- Lack of programmes to support laws
- Lack of supportive services and facilities
- Lack of labour market information
- Inability to cope with the implications of globalization, liberalization

Session 3: What needs to be done to improve the existing national laws and their implementation?

Working Groups were formed for each country to identify what needs to be done in each case to improve the impact of national laws.

The common problems encountered in the development of occupational health service include:

1. Lack of awareness among workers, employers, health planners, policy makers, health professionals and public at large.
2. Lack of trained human resource.
3. Inadequate, inaccessible, and inequitably distributed health service institutions.
4. Lack of multidisciplinary staff, absence of field-testing equipment for conducting environmental and biological monitoring of the work place and the health of the workers.
5. Insufficient budget for carrying out regular inspections, conducting research activities.
6. The characteristics of the workers, the majorities are poor, illiterate or poorly educated.
7. Poor working environment.
8. No specific regulation/ legislation on occupational health and safety issues.

9. Unfavourable climatic condition and heavy load of endemic disease: such as bilharzia, onchocerciasis, malaria, leishhuhumaniasis, and trypanosomiasis.
10. Absence of training institution on occupational health and safety.
11. Little or no collaboration or cooperation among stakeholders
12. Poor information exchange /net work in the area of OHS
13. Lack of multidisciplinary forum or panel
14. Absence of integration of occupational health and safety with general health service

Principles of occupational Health and Safety

The basic principles for the development of occupational health and safety services are as follows:

a) The service must optimally be preventive oriented and multidisciplinary.
b) The service provided should integrate and complement the existing public health service.
c) The service should address environmental considerations
d) The service should involve, participation of social partners and other stakeholders
e) The service should be delivered on panned approach
f) The service should base up to date information, education, training, consultancy, advisory services and research findings
g) The service should be considered as an investment

contributing positively towards ensuring productivity and profitability.

1.6. Scope of occupational health and safety

Factory management spends large amount of expenses for health insured workers. The workers compensation expenses include medical payments (hospital and clinic treatment); partial, temporary, and permanent disability costs; death benefits; and legal costs. The cost claims may steadily rise up if the employers do not take measure to intervene the problem. The productivity of the factory will obviously decline in such situations. The role of occupational health and safety, therefore, lies in designing ways and means for cost reduction through workers proper health service provision. Occupational diseases, accidents, and death prevention are the issues to be addressed.

The scope of occupational health and safety is three-fold. It begins with the anticipation and recognition of workers' health problems in an industrial atmosphere. The causes of these problems may be chemical, physical, biological, psychological, and ergonomical environments. The second scope includes evaluation of the recognized problem, which encompasses mainly data collection, analysis, interpretation, and recommendations. Finally, the third scope involves the development of corrective actions to eliminate or limit the problem. Generally, the work frame of occupational health and safety is wide and needs multidisciplinary approach. It requires the knowledge of physics, biology, chemistry, ergonomics, medicine, engineering, and related sciences. It also requires public health management skills for proper communication and decision making.

1.7. Elements of the work environment

The basic elements in an occupational setting such as a manufacturing plant, industry, or offices are four. These are:

1. The worker
2. The tool
3. The process
4. The work environment

1 The worker

In developing countries like Ethiopia, the work force has several distinct characteristics:-

1. Most people who are employed to work in the informal sectors, mainly in agriculture, or in small-scale industries, such as garages, tannery and pottery.
2. There are high rates of unemployment, some- times reaching 25% or higher. In huhumany developing countries the rates of unemployment and under employment is increasing each year.
3. In general, workers are at greater risk of occupational hazards for a variety of reasons because of low education and literacy rates; unfamiliarity with work processes and exposures, inadequate training, predisposition not to complain about working conditions or exposures because of jobs, whether or not they are hazardous, are relatively scarce; high prevalence

of endemic (mainly infections) diseases and malnutrition; inadequate infrastructure and human resources to diagnose, treat, and prevent work - related diseases and injuries.

4. The annual per capita income for Ethiopia is about $ 120 (USD) or less per year which makes it one of the lowest in the world. Daily wage for all Ethiopian daily laborers is less than $1 US dollar.
5. Vulnerable populations in any country are at even greater risks.

These groups are:

a. Women, who make up a large proportion of the work force in many developing countries and often face significant physical and psychosocial hazards in their work. Besides this they also face similar problem at home as mothers and cooks
b. Children, who account for a significant part of the work force in many developing countries, often undertake some of the most hazardous work. In many of these countries, primary education is not required and there are no legal protections against child labor.
c. Migrants - both within countries and between countries who, for a variety of reasons, face significant health and safety hazards at work.

Industrial workers constitute only a segment of the general population and the factors that influence the health of the population also apply equally to industrial workers, i.e., housing, water, sewage and refuse disposal, nutrition, and education. In addition to these factors, the health of industrial worker, in a large measure, will also be influenced by conditions prevailing in their workplace. One of the declared aims of occupational hygiene is to provide a safe occupational environment in order to safeguard the health of the workers and to set up industrial production.

The employee plays a major role in the occupational hygiene program. They are excellent sources of information on work processes, procedures and the perceived hazards of their daily operations or activities. The industrial hygienist will benefit from this source of information and often obtain innovative suggestions for controlling hazards.

Obviously there is wide variation among workers in genetic inheritance, constitutions, and susceptibility to disease. Regardless of the industrial hygienist will start his or her activities in sorting all those aspects of hazards including the worker himself.

2 The Tool

Tools can range from very primitive tools like a hammer, chisel, and needle, to automated equipment.

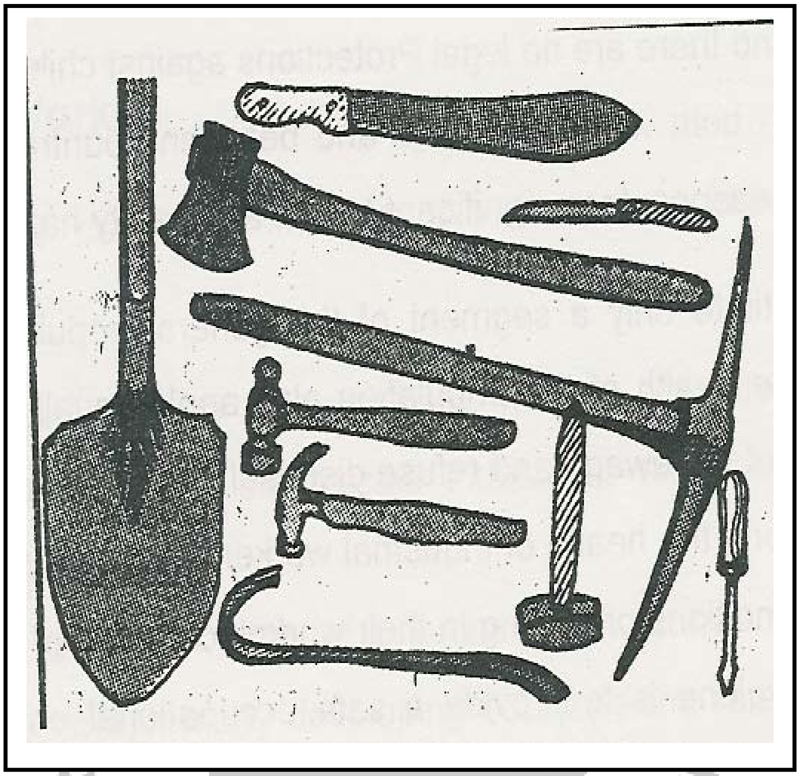


Figure.1-1.Simple hand tools are the causes of many accidents.

Source: Deglaville et.al. Occupational Health, a manual for health workers in developing countries

3 The process

In the process, materials used can be toxic. The process itself can affect the potential harmfulness of the materials. For example, the particle size or physical state (solid, liquid and gas) of potentially harmful substances can determine to a large extent what ill effects in workers may develop from those substances.

4 The work environment.

Occupational environment means the sum of external conditions and influences which prevail at the place of work and which have a bearing on the health of the working population. The industrial worker today is placed in a highly complicated environment and the work environment is getting more complicated as human is becoming more innovative or inventive.

Basically, there are three types of interaction in a working environment: -

1. **man and physical, chemical and biological agents.**
   a. The physical agents. These include excessive level of
      - noise
      - heat and humidity
      - dust
      - Vibration
      - Electricity or lighting
      - Radiation etc.

b. Chemical agents. These arises from excessive air borne concentrations of

- Chemical dust
- Mists
- Fumes
- Liquids
- Vapors
- Gases
- dust

C. The biological agents. These include

- Presence of insects and rodents
- Microorganisms
- Poisonous plants and animals

D.Ergonomic hazards. These include excessive improperly designed tools, work areas, or work procedures. Improper lifting or reaching, poor visual conditions, or repeated motions in an awkward position can result in accidents or illnesses in the occupational environment.

2. Man and machine

An industry or factory uses power driven machines for the purpose of mass production. Unguarded machines, protruding and moving parts, poor electrical and machinery installation of the plant, and lack of safety measures are the causes of accidents. Working for long hours in an awkward postures or positions is the causes of fatigue, backache, diseases of joints and muscles and impairment of the workers health and efficiency.

3. Man and his psychosocial environment.

There are numerous psychosocial factors, which operate at workplace. These are the human relationships among workers themselves and those in authorities over them.

Examples of psychosocial factors include:-

- The type and rhythm of work.
- Work stability.
- Service conditions.
- Job satisfaction.
- Leadership style.
- Security.
- Workers` participation and communication.
- Motivation and incentives.

The occupational environment of the worker cannot be considered apart from his domestic environment. Both are complementary to each other. The worker takes his worries to his/her home and bring to his work disturbances that has arisen in his/her home. Stress at work may disturb his sleep, just as stress at home may affect his work.

1.8. Review Questions

1. Define the following terms:
    a. Anticipation
    b. Recognition
    c. Evaluation
    d. Control
2. What are the challenges for the development of occupational health and safety?
3. Why is occupational health considered as one part of preventive medicine?
4. What are the three types of interaction in the working environment?
5. How can work affect health and health affect work? Give practical examples
6. Mention the main roles of Environmental Health Officers in occupational health and safety programs

CHAPTER TWO

RECOGNITION OF OCCUPATIONAL HEALTH AND SAFETY HAZARDS

2.1. Learning Objectives

At the end of this chapter, the student will be able to:

1. Identify the occupational health and safety hazards in workplace
2. Explain the effects of chemicals such as organic solvents.
3. Discuss the difference between ionizing and non-Ionizing radiations.
4. Mention the two main effects of noise.
5. Describe the occupational exposure to biohazards.
6. Give examples of some ergonomic hazards

2.2. Introduction

Identification of occupational health and safety hazards has often come from observations of adverse health effect among workers. We can say that potential problem areas must be identified and its extent should be defined.

The purpose of identification is to:

1. Obtain information on occupational health stresses
2. Collect information on working conditions
3. Collect information on processes and products

4. Obtain the threshold limit values for substances
5. Collect information on the effects of exposure on human
6. Collect data on exposure levels by conducting elementary measurements
7. Determine where problem or potential problem area exist

Advantages of Identification

Not all exposure to occupational stresses are hazardous and in some instances occupational Exposure limits are never reached, these areas can be eliminated from extensive evaluation, this reduces the total evaluation and monitoring process with follows. Identification lays the foundation of the evaluation, which follows as we have obtained a lot of information we are going to use in the evaluation phase. Of course it is not necessary to carry out identification in an area every time one wishes to quantify workers' exposure in an area that would be like redesigning the wheel. Identification saves time, effort and eventually money.

Identification of health and safety problems includes the following:

- Observe workplace
- Investigate complaints from workers
- Examine accident and near-miss records
- Examine sickness figures
- Use simple surveys to ask co-workers about their health and safety concerns;
- Use check-lists to inspect your workplace;
- Learn the results of inspections that are done by the employer, the union or anyone else;

- Read reports or other information about the workplace

2.3. Classifications of occupational health and safety hazards

The various hazards which give rise to occupational injuries, diseases, disabilities or death through work may be classified as: -

2.3.1 Physical Hazards
2.3.2 Mechanical Hazards
2.3.3 Chemical Hazards
2.3.4 Biological Hazards
2.3.5 Ergonomic Hazards
2.3.6 Psychosocial Hazards

2.3.1 Physical Hazards

Physical hazards, which can adversely affect health, include noise, vibration, ionizing and non-ionizing radiation, heat and other unhealthy microclimatic conditions. Between 10 and 30% of the workforce in industrialized countries and up to 80% in developing and newly industrialized countries are exposed to a variety of these potential hazards.

Physical hazard has possible cumulative or immediate effects on the health of employees. Therefore, employers and inspectors should be alert to protect the workers from adverse physical hazards.

A. Extremes of Temperature

The work environment is either comfortable or extremely cold or hot and uncomfortable. The common physical hazard in most industries is heat. Extreme hot temperature prevails on those who are working in foundries or in those industries where they use open fire for energy. Examples of these include soap factories in large industries and in the informal sectors that use extreme heat to mold iron or process other materials.

Effects of hot temperature in work place include:

1. Heat Stress

Heat stress is a common problem in workplace because people in general function only in a very narrow temperature range as seen from core temperature measured deep inside the body. Fluctuation in core temperature about 2 ^{0} C below or 3 ^{0} C above the normal core temperature of 37.6 ^{0} C impairs performance markedly and a health hazard exists. When this happens the body attempt to counteract by:

- Increasing the heart rate
- The capillaries in the skin dilate to bring more blood to the surface so that the rate of cooling is increased.
- Sweating to cool the body

2. Heat stroke

Heat stroke is caused when the body temperature rises rapidly in a worker who is exposed to a work environment in which the body is unable to cool itself sufficiently. Predisposing factors for heat stroke is excessive physical exertion in extreme heat condition. The method of control is therefore, to reduce the temperature of the surrounding or to increase the ability of the body to cool itself.

3. Heat Cramp

Heat cramp may result from exposure to high temperature for a relatively long time particularly if accompanied by heavy exertion or sweating with excessive loss of salt and moisture from the body.

4. Heat Exhaustion

This also results from physical exertion in hot environment. Signs of the problem include:

- Mildly elevated temperature
- Weak pulse
- Dizziness
- Profuse sweating
- Cool, moist skin, heat rash

5. Cold Stress

Cold stress could mainly be defined as the effect of the external working environment (Very low temperatures i.e. less than 6 ^{0} C) and the resultant inability of the body to maintain a constant internal body temperature. High airflow is a critical factor here, as it will increase cold stress effects considerably. This is commonly referred to as the wind chill factor.

Special condition that occur in cold weather

1. **Trench Foot**

   An injury which result from long exposure of the feet to continued wet condition at temperature of freezing 10 ^{0} C with little movement causes changes in the circulation of blood in the feet.

Result: loss of toes or part of the feet.

Treatment: keep foot dry and worm, do exercise for good circulation.

2. Immersion foot

Immersion of foot in water that is below 10 ^{0} C, for a prolonged time, usually in excess of 24 hours

3. Frostbite

Injury of tissue from exposure to intense cold, body parts most easily frostbitten is cheeks, nose, ears, chin forehead, wrists, hands and feet.

Prevention

- Wearing the proper amount warm, loose, dry clothing.
- Massaging the face, hand, and feet periodically to promote good circulation.
- Troops travelling in cold weather by, particularly in the rear of trucks should be allowed to dismount and exercise periodically to restore circulation.
- If clothing become wet, it should be dried or change at once.

B. Vibration Motion Conditions

Vibration causes vascular disorders of the arms and bony changes in the small bones of the wrist. Vascular changes can be detected by X-ray examination of the wrist. The most common findings is rarefaction of the lunate bone.

C. Pressure –Atmospheric (high and low)

Exposure to increased atmospheric pressure (under water) leads to aseptic bone necrosis around the knee, hip and shoulder that can be detected by X-ray examination

D. Ionizing and Non-Ionizing Radiation

Radiation having a wide range of energies forms the electromagnetic spectrum, which is illustrated below. The spectrum has two major divisions: non-ionizing and ionizing radiation.

Radiation that has enough energy to move atoms in a molecule around or cause them to vibrate, but not enough to remove electrons, is referred to as "non-ionizing radiation." Examples of this kind of radiation are sound waves, visible light, and microwaves.

Radiation that falls within the ionizing radiation" range has enough energy to remove tightly bound electrons from atoms, thus creating ions. This is the type of radiation that people usually think of as 'radiation.' We take advantage of its properties to generate electric power, to kill cancer cells, and in many manufacturing processes.

1. Nonionizing Radiation

We take advantage of the properties of non-ionizing radiation for common tasks:

- microwave radiation-- telecommunications and heating food

- infrared radiation --infrared lamps to keep food warm in restaurants
- radio waves-- broadcasting

Non-ionizing radiation ranges from extremely low frequency radiation, shown on the far left through the audible, microwave, and visible portions of the spectrum into the ultraviolet range.

Extremely low-frequency radiation has very long wave lengths (on the order of a million meters or more) and frequencies in the range of 100 Hertz or cycles per second or less. Radio frequencies have wave lengths of between 1 and 100 meters and frequencies in the range of 1 million to 100 million Hertz. Microwaves that we use to heat food have wavelengths that are about 1 hundredth of a meter long and have frequencies of about 2.5 billion Hertz.

2. Ionizing radiation

Ionizing radiation has many practical uses, but it is also dangerous to human health. Both aspects are treated below.

Ionizing radiation is either particle radiation or electromagnetic radiation in which an individual particle/photon carries enough energy to ionize an atom or molecule by completely removing an electron from its orbit. If the individual particles do not carry this amount of energy, it is essentially impossible for even a large flood of particles to cause ionization. These ionizations, if enough occur, can be very destructive to living tissue, and can cause DNA damage and mutations. Examples of particle radiation that are ionizing may be energetic electrons, neutrons, atomic ions or photons. Electromagnetic radiation can cause ionization if the energy per photon, or frequency, is high enough, and thus the wavelength is short enough. The amount of energy required varies between molecules being ionized. X-rays, and gamma rays will ionize almost any molecule or atom. Far ultraviolet, near ultraviolet and visible light are ionizing to some molecules; microwaves and radio waves are non-ionizing radiation.

However, visible light is so common that molecules that are ionized by it will often react nearly spontaneously unless protected by materials that block the visible spectrum. Examples include photographic film and some molecules involved in photosynthesis.

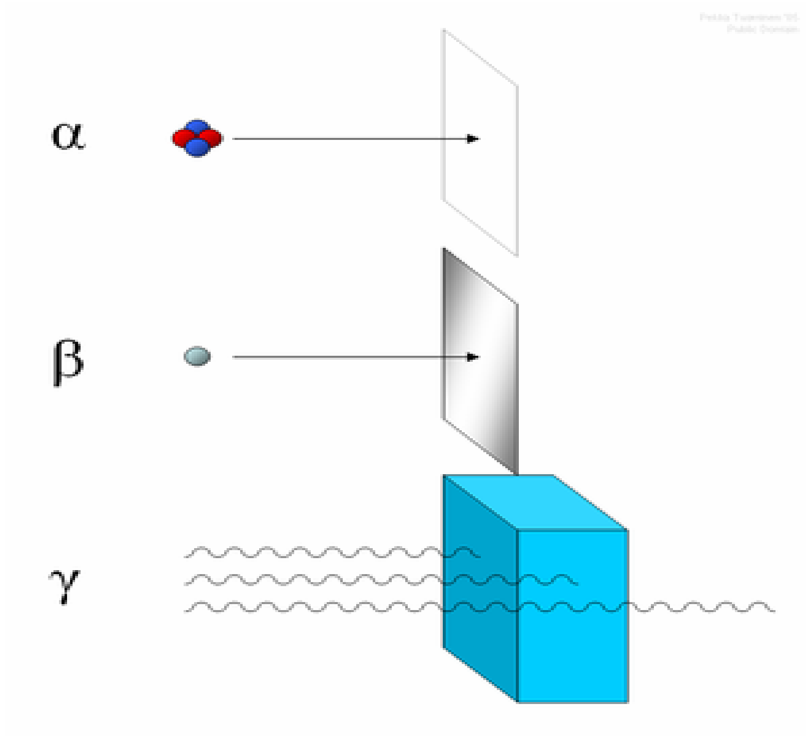


Figure 2-1 Types of radiation
Source: Adapted from a 2005 National Research Council report .

Alpha radiation consists of helium-4 nuclei and is readily stopped by a sheet of paper. Beta radiation, consisting of electrons, is halted by an aluminium plate. Gamma radiation is eventually absorbed as it penetrates a dense material.

Ionizing radiation is produced by radioactive decay, nuclear fission and nuclear fusion, by extremely hot objects (the hot sun, e.g., produces ultraviolet), and by particle accelerators that may produce, e.g., fast electrons or protons or bremsstrahlung or synchrotron radiation.

In order for radiation to be ionizing, the particles must both have a high enough energy and interact with electrons. Photons interact strongly with charged particles, so photons of sufficiently high energy are ionizing. The energy at which this begins to happen is in the ultraviolet region; sunburn is one of the effects of this ionization. Charged particles such as electrons, positrons, and alpha particles also interact strongly with electrons. Neutrons, on the other hand, do not interact strongly with electrons, and so they cannot directly ionize atoms. They can interact with atomic nuclei, depending on the nucleus and their velocity, these reactions happen with fast neutrons and slow neutrons, depending on the situation. Neutron radiation often produces radioactive nuclei, which produce ionizing radiation when they decay.

The negatively charged electrons and positively charged ions created by ionizing radiation may cause damage in living tissue. If the dose is sufficient, the effect may be seen almost immediately, in the form of radiation poisoning. Lower doses may cause cancer or other long-term problems. The effect of the very low doses encountered in normal circumstances (from both natural and artificial sources, like cosmic rays, medical X-rays and nuclear power plants) is a subject of current debate. A 2005 report released by the National Research Council (the BEIR VII report indicated that the overall cancer risk associated with background sources of radiation was relatively low.

Radioactive materials usually release alpha particles which are the nuclei of helium, beta particles, which are quickly moving electrons or positrons, or gamma rays. Alpha and beta rays can often be shielded by a piece of paper or a sheet of aluminium, respectively. They cause most damage when they are emitted inside the human body. Gamma rays are less ionizing than either alpha or beta rays, but protection against them requires thicker shielding. They produce damage similar to that caused by X-rays such as burns, and cancer through mutations. Human biology resists germline mutation by either correcting the changes in the DNA or inducing apoptosis in the mutated cell.

Non-ionizing radiation is thought to be essentially harmless below the levels that cause heating. Ionizing radiation is dangerous in direct exposure, although the degree of danger is a subject of debate. Humans and animals can also be exposed to ionizing radiation internally: if radioactive isotopes are present in the environment, they may be taken into the body. For example, radioactive iodine is treated as normal iodine by the body and used by the thyroid; its accumulation there often leads to thyroid cancer. Some radioactive elements also bioaccumulate.

Example: Electromagnetic radiation

The energy of a photon (i.e., a quantum of electromagnetic radiation) is given by the Planck equation:

$$E = hv$$

where

E is the energy of the photon
h is Planck's constant
v is the frequency of the photon

The wavelength of a photon is related to its frequency by the equation of a wave's velocity:

$$c = \lambda v$$

where

c is the speed of light
λ is the wavelength of light

Plugging back in and solving for the wavelength, we get,

$$\lambda = hc / E$$

The elements with the lowest and highest ionization potential are cesium (3.89 eV) and helium (24.6 eV), respectively. Compounds can have low ionization potentials as well. For example, PMMA has an ionization potential of 8.1 eV. Photons with energies less than 3.89 eV ($\lambda > 318.8$ nm) are non-ionizing radiation, photons with energies greater than 24.6 eV ($\lambda < 50.4$ nm) are ionizing radiation, and photons with energies between 3.89 eV and 24.6 eV may be either ionizing or non-ionizing radiation depending on the nature of material (e.g., cesium or helium). Visible light corresponds to photons with energies from 1.77 eV (λ = 700.6 nm) to 3.10 eV (λ = 400 nm) and are thus non-ionizing electromagnetic radiation. Ultraviolet (UV) radiation spans the energy range from 3.10 eV (UV-A) to 12.4 eV (UV-C, λ = 100 nm). Because UV radiation, especially UV-C, exceeds the ionization energy of many of the elements, it is often considered ionizing radiation rather than non-ionizing radiation.

2.1. Uses of ionizing radiation

Ionizing radiation has many uses. An X-ray is ionizing radiation, and ionizing radiation can be used in medicine to kill cancerous cells. However, although ionizing radiation has many uses the overuse of it can be hazardous to human health. Shop assistants in shoe shops used to use an X-ray machine to check a child's shoe size, which would be a big treat for the child. But when it was discovered that ionizing radiation was dangerous these machines were promptly removed.

2.2 Effects of ionizing radiation upon human health

Natural background radiation

Natural background radiation comes from four primary sources: cosmic radiation, solar radiation, external terrestrial sources, and radon.

Cosmic radiation

The earth, and all living things on it, are constantly bombarded by radiation from outside our solar system of positively charged ions from protons to iron nuclei. The energy of this radiation can far exceed energies that humans can create even in the largest particle accelerators. This radiation interacts in the atmosphere to create secondary radiation that rains down, including x-rays, muons, protons, alpha particles, pions, electrons, and neutrons.

The dose from cosmic radiation is largely from muons, neutrons, and electrons. The dose rate from cosmic radiation varies in different parts of the world based largely on the geomagnetic field, altitude, and solar cycle. The dose rate from cosmic radiation on airplanes is so high that, according to the United Nations UNSCEAR 2000 Report ,airline workers receive more dose on average than any other worker, including nuclear power plant workers.

Solar radiation

While most solar radiation is electro-magnetic radiation, the sun also produces particle radiation, solar particles, which vary with the solar cycle. They are mostly protons; these are relatively low in energy (10-100 keV). The average composition is similar to that of the Sun itself. This represents significantly lower energy particles than come form cosmic rays. Solar particles vary widely in their intensity and spectrum, increasing in strength after some solar events such as solar flares. Further, an increase in the intensity of solar cosmic rays is often followed by a decrease in the galactic cosmic rays, called a

Forbush decrease after their discoverer, the physicist Scott Forbush. These decreases are due to the solar wind which carries the sun's magnetic field out further to shield the earth more thoroughly from cosmic radiation.

External terrestrial sources

Most material on earth contains some radioactive atoms, if in small quantities. But most of terrestrial non-radon-dose one receives from these sources is from gamma-ray emitters in the walls and floors when inside the house or rocks and soil when outside. The major radionuclides of concern for **terrestrial radiation** are potassium, uranium and thorium. Each of these sources has been decreasing in activity since the birth of the Earth so that our present dose from potassium-40 is about ½ what it would have been at the dawn of life on Earth.

Radon

Radon-222 is produced by the decay of Radium-226 which is present wherever uranium is. Since Radon is a gas, it seeps out of uranium-containing soils found across most of the world and may concentrate in well-sealed homes. It is often the single largest contributor to an individual's background radiation dose and is certainly the most variable from location to location. Radon gas is the second largest cause of lung cancer in America, after smoking.

Human-made radiation sources

Natural and artificial radiation sources are identical in their nature and their effect. Above the background level of radiation exposure, the U.S. Nuclear Regulatory Commission (NRC) requires that its licensees limit human-made radiation exposure to individual members of the public to 100 mrem (1 mSv) per year, and limit occupational radiation exposure to adults working with radioactive material to 5,000 mrem (50 mSv) per year.

The average exposure for Americans is about 360 mrem (3.6 mSv) per year, 81 percent of which comes from natural sources of radiation. The remaining 19 percent results from exposure to human-made radiation sources such as medical X-rays, most of which is deposited in people who have CAT scans. One important source of natural radiation is radon gas, which seeps continuously from bedrock but can, because of its high density, accumulate in poorly ventilated houses.

The background rate varies considerably with location, being as low as 1.5 mSv/a in some areas and over 100 mSv/a in others. People in some areas of Ramsar, a city in northern Iran, receive an annual radiation absorbed dose from background radiation that is up to 260 mSv/a. Despite having lived for many generations in these high background areas, inhabitants of Ramsar show no significant cytogenetic differences compared to people in normal background areas; this has led to the suggestion that the body can sustain much higher steady levels of radiation than sudden bursts.

Some human-made radiation sources affect the body through direct radiation, while others take the form of radioactive contamination and irradiate the body from the inside.

By far, the most significant source of human-made radiation exposure to the general public is from medical procedures, such as diagnostic X-rays, nuclear medicine, and radiation therapy. Some of the major radionuclides used are I-131, Tc-99, Co-60, Ir-192, Cs-137. These are rarely released into the environment.

In addition, members of the public are exposed to radiation from consumer products, such as tobacco (polonium-210), building materials, combustible fuels (gas, coal, etc.), ophthalmic glass, televisions, luminous watches and dials (tritium), airport X-ray systems, smoke detectors (americium), road construction materials, electron tubes, fluorescent lamp starters, lantern mantles (thorium), etc.

Of lesser magnitude, members of the public are exposed to radiation from the nuclear fuel cycle, which includes the entire sequence from mining and milling of uranium to the disposal of the spent fuel. The effects of such exposure have not been reliably measured. Estimates of exposure are low enough that proponents of nuclear power liken them to the mutagenic power of wearing trousers for two extra minutes per year (because heat causes mutation). Opponents use a cancer per dose model to prove that such activities cause several hundred cases of cancer per year.

In a nuclear war, gamma rays from fallout of nuclear weapons would probably cause the largest number of casualties. Immediately downwind of targets, doses would exceed 300 Gy per hour. As a reference, 4.5 Gy (around 15,000 times the average annual background rate) is fatal to half of a normal population.

Occupationally exposed individuals are exposed according to the sources with which they work. The radiation exposure of these individuals is carefully monitored with the use of pocket-pen-sized instruments called dosimeters.

Some of the radionuclides of concern include cobalt-60, caesium-137, americium-241 and iodine-131. Examples of industries where occupational exposure is a concern include:

- airline crew (the most exposed population)
- Fuel cycle
- Industrial Radiography
- Radiology Departments (Medical)
- Radiation Oncology Departments
- Nuclear power plant
- Nuclear medicine Departments
- National (government) and university Research Laboratories

2.3. The effects of ionizing radiation on animals

The biological effects of radiation are thought of in terms of their effect on living cells. For low levels of radiation exposure, the biological effects are so small they may not be detected in epidemiological studies. The body repairs many types of radiation and chemical damage. Biological effects of radiation on living cells may result in a variety of outcomes, including:

1. Cells experience DNA damage and are able to detect and repair the damage.

2. Cells experience DNA damage and are unable to repair the damage. These cells may go through the process of programmed cell death, or apoptosis, thus eliminating the potential genetic damage from the larger tissue.

3. Cells experience a nonlethal DNA mutation that is passed on to subsequent cell divisions. This mutation may contribute to the formation of a cancer.

Other observations at the tissue level are more complicated. These include:

1. In some cases, a small radiation dose reduces the impact of a subsequent, larger radiation dose. This has been termed an 'adaptive response' and is related to hypothetical mechanisms of hormesis.

2. Cells that are not 'hit' by a radiation track but are located nearby may express damage or alterations in normal

function, presumably after communication between the 'hit' cell and neighboring cells occurs. This has been termed the 'bystander effect'.

3. The progeny of a cell that survives radiation exposure may have increased probabilities for mutation. This has been termed 'genomic instability'.

Chronic radiation exposure

Exposure to ionizing radiation over an extended period of time is called chronic exposure. The natural background radiation is chronic exposure, but a normal level is difficult to determine due to variations. Location and occupation often affect chronic exposure.

Acute radiation exposure

Acute radiation exposure is an exposure to ionizing radiation which occurs during a short period of time. There are routine brief exposures, and the boundary at which it becomes significant is difficult to identify. Extreme examples include

- Instantaneous flashes from nuclear explosions.
- Exposures of minutes to hours during handling of highly radioactive sources.
- Laboratory and manufacturing accidents.
- Intentional and accidental high medical doses.

The effects of acute events are more easily studied than those of chronic exposure.

2.4. Minimizing health effects of ionizing radiation

Although exposure to ionizing radiation carries a risk, it is impossible to completely avoid exposure. Radiation has always been present in the environment and in our bodies. We can, however, avoid undue exposure.

Although people cannot sense ionizing radiation, there is a range of simple, sensitive instruments capable of detecting minute amounts of radiation from natural and man-made sources.

Dosimeters measure an absolute dose received over a period of time. Ion-chamber dosimeters resemble pens, and can be clipped to one's clothing. Film-badge dosimeters enclose a piece of photographic film, which will become exposed as radiation passes through it. Ion-chamber dosimeters must be periodically recharged, and the result logged. Badge dosimeters must be developed as photographic emulsion so the exposures can be counted and logged; once developed, they are discarded.

Geiger counters and scintillometers measure the dose rate of ionizing radiation directly.

In addition, there are four ways in which we can protect ourselves:

Time: For people who are exposed to radiation in addition to natural background radiation, limiting or minimizing the exposure time will reduce the dose from the radiation source.

Distance: In the same way that the heat from a fire is less intense the further away you are, so the intensity of the radiation decreases the further you are form the source of the radiation. The dose decreases dramatically as you increase your distance from the source.

Shielding: Barriers of lead, concrete, or water give good protection from penetrating radiation such as gamma rays and neutrons. This is why certain radioactive materials are stored or handled underwater or by remote control in rooms constructed of thick concrete or lined with lead. There are special plastic shields which stop beta particles and air will stop alpha particles. Inserting the proper shield between you and the radiation source will greatly reduce or eliminate the extra radiation dose.

Shielding can be designed using halving thicknesses, the thickness of material that reduces the radiation by half. Halving thicknesses for gamma rays are discussed in the article gamma rays.

Containment: Radioactive materials are confined in the smallest possible space and kept out of the environment. Radioactive isotopes for medical use, for example, are dispensed in closed handling facilities, while nuclear reactors operate within closed systems with multiple barriers which keep the radioactive materials contained. Rooms have a reduced air pressure so that any leaks occur into the room and not out of it.

In a nuclear war, an effective fallout shelter reduces human exposure at least 1,000 times. Most people can accept doses as high as 1 Gy[*citation needed*], distributed over several months, although with increased risk of cancer later in life. Other civil defense measures can help reduce exposure of populations by reducing ingestion of isotopes and occupational exposure during war time. One of these available measures could be the use of potassium iodide (KI) tablets which effectively block the uptake of dangerous radioactive iodine into the human thyroid gland.

E. Noise

Noise is defined as unwanted sound. Sound is any pressure variation or a stimulus that produces a sensory response in the brain. The compression and expansion of air created when an object vibrates.

Magnitude

Approximately 30 million workers are exposed to hazardous noise on the job and an additional 9 million are at risk for hearing loss from other agents such as solvents and metals. Noise-induced hearing loss is one of the most common occupational disease and the second most self-reported occupational illness or injury.

Industry specific studies reveal:

- 44% of carpenters and 48% of plumbers reported that they had a perceived hearing loss.
- 49% of male, metal/non-metal miners will have a hearing impairment by age 50 (vs. 9% of the general population) rising to 70% by age 60.

While any worker can be at risk for noise-induced hearing loss in the workplace, workers in many industries have higher exposures to dangerous levels of noise. Industries with high numbers of exposed workers include: agriculture; mining; construction; manufacturing and utilities; transportation; and military.

Industrial Noise

Although the problem of noise was recognized centuries ago, for example Ramazini in 1700 described how workers who hammer copper have their ears injured due to exposure to the sound. The extent of the problem, which was caused by such noise, was not felt until the industrial revolution in England. The increasing mechanization in industries, farms, transport and others are likely to be more intense and sustained than any noise levels experienced outside the work place.

Industrial noise problems are extremely complex. There is no “standard " program that is applicable to all situations. However, industries are responsible to consider and evaluate their noise problems and to take steps toward the establishment of effective hearing conservation procedures.

The effectiveness of hearing conservation program depends on the cooperation of employees, supervisors, employers, and others concerned. The management responsibility is to take measurements, initiating noise control measures, undertaking the audiometer testing of employees, providing hearing protective equipment with sound policies, and informing employees of the benefits to be derived from a hearing conservation program.

General Class of Noise Exposure

There are three general classes into which occupational noise exposure may be grouped.

1. Continuous noise: Normally defined as broadband noise of approximately constant level and spectrum to which an employee is exposed for a period of eight hours per day or 40 hours a week.
2. Intermittent Noise: This may be defined as exposure to a given broadband sound pressure level several times during a normal working day
3. Impact (impulse) type Noise: is a sharp burst of sound. A sophisticated instrumentation is necessary to determine the peak levels for this type of noise.

Effects of noise exposure

Noise is a health hazard in many occupational settings. Effects of noise on humans can be classified into various ways. For example, the effect can be treated in the context of health or medical problems owing to their underlying biological basis. Noise induced hearing loss involves damage to the structure of the hearing organ.

The effects of noise on humans can be classified into two types:

- Non auditory effect
- Auditory effect

Non-auditory effects

This consists of fatigue, interference with communication, decreased efficiency and annoyance.

Auditory effects

Auditory effects consist of permanent or temporary hearing loss. The ear is especially adapted and most responsive to the pressure changes caused by airborne sound or noise. The outer and middle ear structures are rarely damaged by exposure to intense sound energy except explosive sounds or blasts that can rupture the ear drum and possibly dislodge the ossicular chain. More commonly, excessive exposure produces hearing loss that involves injury to the hair cells in the organ of corti within the cochlea of the inner ear.

Noise-induced hearing loss

Work-related hearing loss continues to be a critical workplace safety and health issue. The National Institute for Occupational Safety and Health (NIOSH) and the occupational safety and health community named hearing loss as one of the 21 priority areas for research in the next century. Noise-induced hearing loss is 100 percent preventable but once acquired, hearing loss is permanent and irreversible. Therefore, prevention measures must be taken by employers and workers to ensure the protection of workers' hearing.

Prevention of noise exposure

OSHA requires a five phase hearing conservation program for industry:

1. Noise Monitoring
2. Audiometric (Hearing) Testing
3. Employee Training
4. Hearing Protectors
5. Recordkeeping

E. Illumination

Good and sufficient lighting is aimed at promoting productivity, safety, health, well being and pleasant working conditions at an economical cost.

Luminance: is the brightness on an object.

Illuminance: is the amount of light, which falls on the surface. It is measured in lux.

Purpose of good lighting

- help provide a safe working environment;
- Provide efficient and comfortable seeing
- reduce losses in visual performances.

Effects of Poor Illumination

Some less tangible factors associated with poor illumination are important contributing causes of industrial accidents. These can include:

- direct glare
- reflected glare from the work
- dark shadows which may lead to excessive visual fatigue
- visual fatigue, it self may be a causative factor in industrial accidents
- delayed eye adaptation when coming from bright surroundings into darker ones .

2.3.2 Mechanical Hazards

Mechanical factors include unshielded machinery, unsafe structures at the workplace and dangerous unprotected tools are among the most prevalent hazards in both industrialized and developing countries. They affect the health of a high proportion of the workforce. Most accidents could be prevented by applying relatively simple measures in the work environment, working practices, and safety systems and ensuring appropriate behavioural and management practices. This would significantly reduce accident rates within a relatively short period of time. Accident prevention programmes are shown to have high cost-effectiveness and yield rapid results. However, ignorance of such precautions, particularly in sectors where production has grown rapidly, has led to increasing rates of occupational accidents.

Workers who use hand tools such as picks, hammers, shovels, or who habitually kneel at their work may suffer from “beat" condition of the hand, knee or elbow. Beat hand is subcutaneous cellulites, which occurs among miners and stoker caused by infection of tissues devitalized by constant bruising.

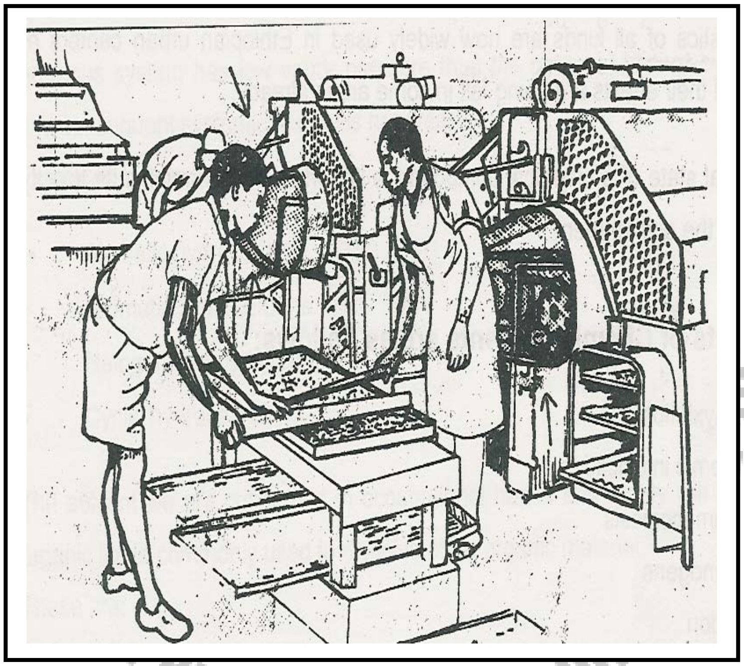


Figure .2-1. Moving part of machinery is securely fenced

Source: Deglaville et.al. Occupational Health, a manual for health workers in developing countries.

2.3.3 Chemical Hazards

Average annual world production of chemicals amounts to an estimated 400 million tones. There are between 5 to 7 million known chemicals, however, only 70,000 to 80,000 are on the market, with 1,000 or so being produced in substantial quantities. In North America around 1,000 to 1,200 are produced annually (50 % are polymers).In Western Europe, some 150 to 200 new substances are registered each year. Of the 70,000 to 80,000 chemicals only 5 to 10 %(i.e., 500 to 7,000 should be considered hazardous; 150 to 200 of these are carcinogenic.

Chemical hazards are dependent on their amount:-

- Amount
- Concentration
- Time of exposure
- Mode of entry to the body
- Age
- Sex
- Health status
- Resistance of the exposed workers

The effects of chemical agents are as follows:

1. Asphyxiation
2. Systemic intoxication
3. Pneumoconiosis
4. Carcinogens
5. Irritation
6. Mutagencity

7. Teratogenicity

Among all chemical agents in work place the most notorious and most in contact with the skin or respiratory system that deserve attention is solvent

Solvent

In most occupational settings or industries a potential threat to the health, productivity and efficiency of workers is their exposure to organic solvents. Exposure to solvents occurs throughout life. Example, organic solvent vapor inhaled by a mother could reach the fetus.

Classification of Solvents

The term solvent means materials used to dissolve another material and it includes aqueous or non-aqueous system. Aqueous solutions include those based in water.

Example:

- Aqueous solution of acids
- Aqueous solution of alkalis
- Aqueous solution of detergents

Aqueous solutions have low vapor pressure thus the potential hazard by inhalation and subsequent systemic toxicity is not great.

Examples of non-aqueous solutions

- Aliphatic hydrocarbons.
- Aromatic hydrocarbons.

- Halogenated hydrocarbons.
- Cyclic hydrocarbons.

The solvent we are concerned in occupational health and safety will include any organic liquid commonly used to dissolve other organic material.

These are:

- Naphtha
- Mineral spirits
- Alcohol,etc

Effects of Solvents

The severity of a hazard in the use of solvents and other chemicals depends on the following factors.

1. How the chemical is used.
2. Type of job operation, which determines how the workers are exposed.
3. Work pattern.
4. Duration of exposure.
5. Operating temperature.
6. Exposed body surface.
7. Ventilation rates.
8. Pattern of airflow.
9. Concentrations of vapors in workroom air.
10. House keeping

1 Health Effect

The effect of solvents varies considerably with the number and type of halogen atoms (fluorine and chlorine) present in the molecules.

Carbon tetrachloride, which is a highly toxic solvent act acutely on the kidney, the liver, gastro intestinal tract (GIT). Chronic exposure to carbon tetrachloride also, damages and cause liver cancer. This solvent should never be used for open cleaning processes where there is skin contact or where the concentration in the breathing zone may exceed recommended level.

2. Fire and explosion

Using non-flammable solvents can minimize the potential for this or solvents with flash point greater than 60 degree Celsius or 140 degree Fahrenheit. However the non-flammable halogenated hydrocarbons decompose when subjected to high temperature and give off toxic and corrosive decomposition products. If flammable solvents with Flash point less than this are used precaution must be taken to:

- Eliminate source of ignition such as flames, sparks, high temperature smoking etc.
- Properly insulate electrical equipment when pollutants are released outdoors.

Solvent hydrocarbons are important compounds in the formation of photochemical smog. In the presence of sunlight they react with oxygen and ozone to produce Aldehyde, acids, nitrates, and other irritant and noxious compounds. The great portion of hydrocarbons contributing to air pollution originates from automobiles and industries.

Figure 2-2. Pesticides are dangerous wherever used.

Source: Deglaville et.al. Occupational Health, a manual for health workers in developing countries

Dangerous chemical substances

Many dangerous substances are used in industry, commerce, agriculture, research activities, hospitals and teaching establishments.

The classification of dangerous substances is based largely on the characteristic properties of such substances and their effects on man. Legislation on this subject also requires the provision of a specific pictorial symbol on any container or package.

The following terms are used in the classification of dangerous substances in the classification, packing and labeling of dangerous substances regulations 1984.

A. Corrosion
B. Oxidizing
C. Harmful
D. Very toxic and toxic
E. Irritant
F. Highly flammable
G. Explosive

A. Corrosive

Hazard: Living tissues as well as equipment are destroyed on contact with these chemicals.

Caution: Do not breathe vapors and avoid contact with skin eyes, and clothing

B. Oxidizing

Hazard: ignite combustible material or worsen existing fire and thus make fire fighting more difficult.

Caution: Keep away from combustible material. Restrict smoking in that area.

C. Harmful

Hazard: Inhalation and insertion of or skin penetration by these substances is harmful to heath.

Caution: Avoid contact with the human body, including inhalation of vapors and in cases of malaise consult doctor.

D. Very toxic and toxic

Hazard: The substances are very hazardous to health whether breathed, swallowed or in contact with the skin and may even lead to death.

Caution: Avoid contact with human body, and immediately consult a doctor in case of malaise.

E. Irritant

Hazard: May have an irritant effect on skin, eyes and respiratory organs

Caution: Do not breathe vapors and avoid contact with skin and eye

F. Highly Flammable

Hazard: Substances with flash point less than 60 ^{0} C or 140 ^{0}F

Caution: keep away source of ignition.

G. Explosive

Hazard: Substances which may explode under certain condition

Caution: Avoid shock, friction, sparks and heat.

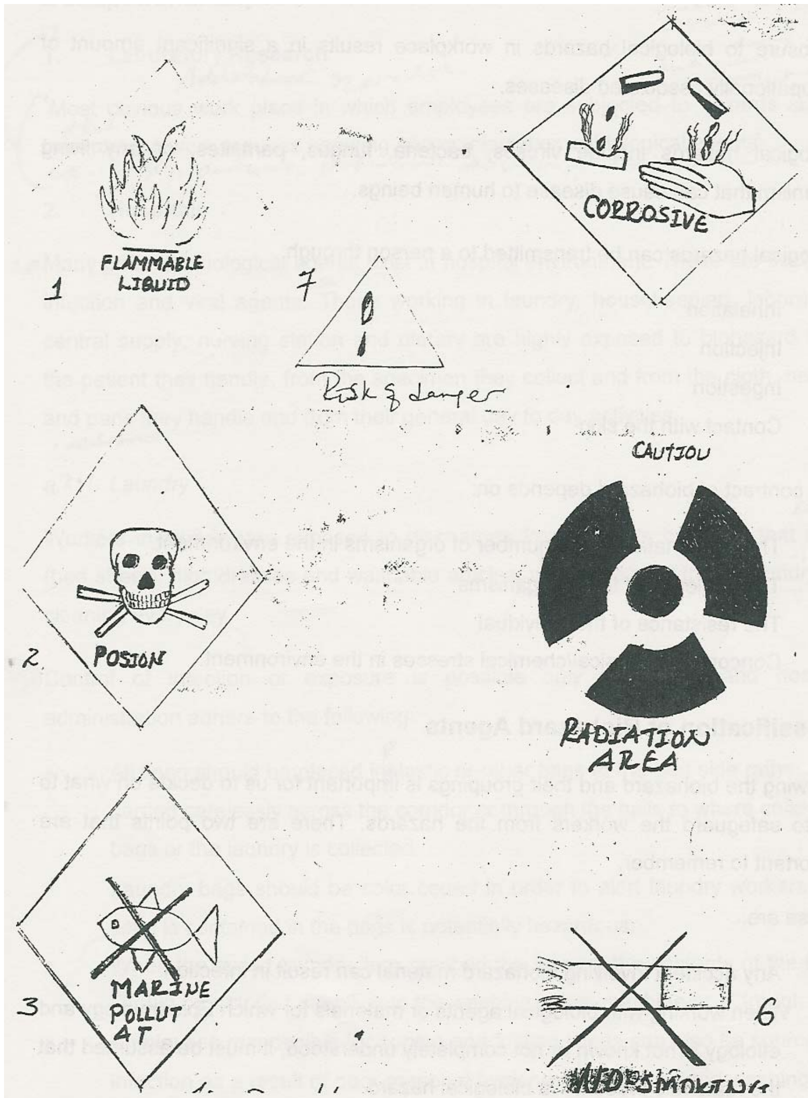


Figure 2-3. Hazard warning signs and symbols

Source: Barbara A. Plog, Fundamentals of Industrial hygiene, 4th. Edition, 1996

Chemical Hazards Evaluation

- Toxicity assessment
- Work activity/risk assessment evaluation
- . Assessment of controls effectiveness to block routes of entry
- Exposure monitoring
- Recommendations for improvement

Chemical Hazards: - Exposure Monitoring

- Special instruments - infrared absorption, photo-ionization, gas
  Chromatography
- Detector tubes
- Air sampling and lab analysis
- Professional judgment

Chemical Hazards: Engineering Controls

- Substitution (use lower toxicity materials)
- Enclose processes and otherwise engineer for low emission / low risk
- Provide local exhaust to remove airborne agents
- Local exhaust ventilation
  - Need to have even air flow for hoods
  - Need to design for adequate capture velocity - usually about 100 feet/minute
  - Need sufficient make up air
  - Use ACGIH Ventilation Manual for design
- Reduce exposure time
- Better procedures
- Training

- PPE - gloves, face shields, respirators
- Remote Operation

2.3.4 Biological Hazards

Many biological agents such as viruses, bacteria, parasites, fungi, moulds and organic dusts have been found to occur in occupational exposures. In the industrialized countries around 15 % of workers may be at risk of viral or bacterial infection, allergies and respiratory diseases. In many developing countries the number one exposure is biological agents.

HIV/AIDS, Hepatitis B and C viruses and other blood borne pathogens, tuberculosis infections (particularly among health care workers), asthmas (among persons exposed to organic dust) and chronic parasitic infections (particularly among agricultural and forestry workers), are the most common occupational diseases that result from such exposures.

Exposure to biological hazards in workplace results in a significant amount of occupationally associated diseases.

Biological hazards include viruses, bacteria, fungus, parasites, or any living organism that can cause disease to human beings.

Biological hazards can be transmitted to a person through:

a. Inhalation
b. Injection
c. Ingestion
d. Contact with the skin

The contract of biohazard depends on:

a. The combination of the number of organisms in the environment.
b. The virulence of these organisms
c. The susceptibility of the individual
d. Concomitant physical/chemical stresses in the environment.

Classification of Biohazard Agents

Knowing the biohazard and their groupings is important to decide on what to do to safeguard the workers from the hazards. There are two points that are important to remember. These are:

1. Any accident involving biohazard material can result in infection.
2. When working with biological agents or materials for which Epidemiology and etiology is not known or not completely understood, it must be assumed that the materials present a biological hazard.

Occupational Exposure to Biohazards

The most obvious work place in which employees are subjected to hazards as a result that the work requires handling and manipulation of biological agents include: surgery, autopsy, contaminated discharges, blood, pipettes, laboratory specimens, etc.

1. Research Laboratory

Health personnel such as laboratory technicians and scientists working on biological specimens are at risk with biological hazards in the laboratory. Specimen such as blood, pus, stool and other tissue samples may expose the workers to hazards such as HIV, Hepatitis, etc.

2. Health care facilities

Many potential biological agents exist in hospital environment. These are bacterial infection and viral agents. Those working in laundry, housekeeping, laboratory, central supply, nursing station and dietary are highly exposed to biohazard from the patient they handle, from the specimen they collect and from the cloth, needle and pans they handle and from their general day to day activities.

A/Laundry

Workers in laundry are exposed to discharges from patients by virtue of the fact that contact with linen (bed sheet), nightdresses and washable articles that are sent to the laundry for cleaning every day.

Control of infection or exposure is possible only if workers and hospital administration adhere to the following:

- All linen should be placed in plastic or other bags at the bed side rather than carried carelessly across the corridor or through the halls to where collection bags or the laundry is collected.
- Laundry bags should be color coded in order to alert laundry workers that, what is contained in the bags is potentially

hazardous.

- When the soiled laundry item reached the laundry the contents of the bags should be emptied directly into the washing basin, machine or trough.
- Employees responsible for sorting and folding linens can also be sources of infection as a result of poor personal hygiene. Thorough hand washing and the use of rubber gloves are essential and basic infection control methods.

B/Housekeeping

Housekeepers in hospitals are the single highest group exposed to infectious biological agents.

The areas and condition of contamination are:

- Contact with discarded contaminated disposable materials during all general cleaning activities.
- Widespread use of disposable materials, especially those used in intravenous administration and blood collection.
- Contaminated hypodermic needles and intravenous catheters
- Dry sweeping of the floor does not remove many microbes. It rather pushes dust and other materials from one area to the other. When mops and brooms are improperly treated dust is dispersed back into the air.

C/Central Supply

The most serious problem in this department is the cleansing of surgical instruments. Grossly contaminated materials should be sterilized in an autoclave before any handling or rinsing.

Scrubbing action is much more efficient than soaking, but it is during scrubbing that exposure to biohazard is the greatest. Direct injection of microorganisms is possible if the skin is punctured with dirty instruments or if the skin has a lesion that comes into contact with contaminated instruments.

D/Health care staff

The possibility of exposure to infection of health care professionals that have direct contact with patients is always present. Infection can be spread in health care facilities through:-

- Patient to patient
- Patient to other staff
- Patient to his/her own family
- Patient to visitors especially if consulting with family members of the patient

Health care workers are not the only person to spread infection. Others are

- Patient
- Waste handlers, transporters
- Laundry staffs

Poor health care waste management system hazardous to:-

- Health care workers
- Patients
- Visitors
- Community

- Environment

To avoid such contamination health care workers should:

- Dispose of contaminated equipment properly so that no health hazard is exposed to infect others.
- Hands should be thoroughly washed with soap and water after visiting each patient to minimize the chance of spreading harmful infection or organisms from patient to patient.
- Gowns, masks and caps must be worn whenever necessary and removed before entering clean areas such as rest areas and lunchrooms.

E/Dietary

Staffs involved in food preparation are exposed to infection from infectious agents such as salmonella, botulism, amoeba and staphylococcus, which can result from contact with raw fish, meat, and some vegetables contaminated by sewage or human waste or dirty water.

Primary prevention against infection or contamination of the food include:

- Proper handling of food products (raw or cooked)
- Use clean hands and garments in the food processing areas
- No skin lesion of the food handlers
- Refrigeration of the food products at a safe temperature level in order to prevent growth of bacteria.
- Adequate cooking of foods.

The problem of biological hazard in health care delivery system is increasing because of:

1. Inadequate sanitation, disinfection and sterilization methods.
2. Increase in drug as well as chemical resistant strains of microbes.
3. Increase of high-risk patients (HIV/AIDS and TB).

3. Agriculture

Occupational exposures to biohazard also occur in agriculture. There are three types of relationships in terms of disease transmission between humans and animals. These are:

- Disease of vertebrate animals transmissible to human and other animals (Zoonosis)
- Disease of humans transmissible to other animals (Anthropozooonois)
- Disease of vertebrate animals chiefly transmissible to humans (Zooanthroponosis)

Zoonosis

It consists of viral, bacterial, rickettsial, fungal, protozoal, and helminthic disease. Among the most important through out the world are: Anthrax, brucellosis, tetanus, encephalitis, leptospirosis, rabies, and salmonellosis. The infection could enter the body through inhalation, ingestion, or through the skin or mucus membrane.

Biohazard Control Program

1. Employee health.
   - Pre-placement examination for new employee.
   - Periodic physical examination as part of a surveillance program.
   - Vaccination.
2. Laboratory safety and health.
   - Employee training
   - Avoid if possible entering into a biohazard areas.
   - Avoid eating, drinking, smoking and gum chewing in biohazard areas
   - Wearing personal protective equipment is always advisable.
3. Biological safety cabinet
   - To protect workers from exposure to aerosols especially when there is contact with biohazards in laundry activities.
4. Animal care and handling
   - Periodic examination, disposal of manure, cleanliness, collection of medical history and treatment.

2.3.5 Ergonomic Hazards

2.3.5.1 Ergonomics

Ergonomics, also known as human engineering or human factors engineering, the science of designing machines, products, and systems to maximize the safety, comfort, and efficiency of the people who use them. Ergonomists draw on the principles of industrial engineering, psychology, anthropometry (the science of human measurement), and biomechanics (the study of muscular activity) to adapt the design of products and workplaces to people's sizes and shapes and their physical strengths and limitations. Ergonomists also consider the speed with which humans react and how they process information, and their capacities for dealing with psychological factors, such as stress or isolation. Armed with this complete picture of humans interact with their environment, ergonomists develop the best possible design for products and systems, ranging from the handle of a toothbrush to the flight deck of the space shuttle.

Ergonomists view people and the objects they use as one unit, and ergonomic design blends the best abilities of people and machines. Humans are not as strong as machines, nor can they calculate as quickly and accurately as computers. Unlike machines, humans need to sleep, and they are subject to illness, accidents, or making mistakes when working without adequate rest. But machines are also limited—cars cannot repair themselves, computers do not speak or hear as people do, and machines cannot adapt to unexpected situations as humans. An ergonomically designed system provides optimum performance because it takes advantage of the strengths and weaknesses of both its human and machine components.

In general, ergonomics deals with the interaction between humans and such additional environmental elements such as heat, light, sound, atmospheric contaminants and all tools and equipment pertaining to the work place.

Ergonomics or the proper designing of work systems based on human factors has the following advantages:

1. There will be more efficient operations
2. There will be fewer accidents
3. There will be reduced training time
4. There will be fewer costs of operations
5. There will be more effective use of workers or personnel.

The goal of "ERGONOMICS" or human factors ranges from making work safe to humans, and increasing human efficiency and well-being. To ensure a continuous high level performance, work system must be tailored to human capacities and limitations measured by anthropometry and biomechanics.

2.3.5.2 Ergonomic Hazards

Between 10% and 30% of the workforce in industrial countries and between 50% and 70% in developing countries may be exposed to heavy physical workload or to unergonomic working conditions such as lifting and moving of heavy items or repetitive manual tasks. Repetitive tasks and static muscular load are found in many industrial and service occupations. In many industrial countries musculoskeletal disorders are the main cause of both short-term and permanent work disability, which can cause economic losses that may amount to 5% of the GNP.

Most exposures can be eliminated or minimized through mechanization, improvement of ergonomics, and better organization of work and training. In particular, the growing numbers of elderly workers and the female workforce require constant vigilance from those responsible for the work organization.

Improving the conditions of the work environment and opportunities for providing workers' health, safety and wellbeing essentially means contributing to sustainable improvement of ergonomics. Local perceptions about ergonomics in many countries have not captured headlines in the newspapers. However safe and hygienic workplaces contribute to sustainable development and this issue can be raised through proper media exposure.

Principles of biomechanics

It deals with the functioning of the structural element of the body and the effect of external and internal forces on various parts of the body.

Taking an example of "lifting" an object from the ground bio-mechanics seek relevant information:

1. What is the task to be performed (task variable)
2. Would the person be able to do the task (human variable)
3. What is the type of work environment (environmental variable)

Task variable

- Location of object to be lifted
- Size of object to be lifted
- Height from which and to which the object is to be lifted
- Frequency of lift
- Weight of object
- Working position

Human Variable

- Sex of worker
- Age of worker
- Training of worker
- Physical fitness of worker
- Body dimension of worker

Environmental variable

- Extremes of temperature (hot/cold)
- Humidity
- Air contaminants

Work physiology

People perform widely different tasks in daily work situation. These tasks must be matched with human capabilities to avoid "over loading" which may cause the employee to breakdown, suffer reduced performance capability or even permanent damage.

Matching people with their work

It is important to match human capabilities with the related requirements of a given job. If the job demands are equal to the worker's capabilities or if they exceed them, the person will be under much strain and may not be able to perform the task.

Work classification

The work demands are classified from light work to extremely heavy in terms of energy expenditures per minute and the relative heart rate in beats per minute. For example the energy requirement for light work is 2.5 Kcal/minute and the heart rate is 90 beats rate per minute, while it was extremely heavy work energy requirement is 15 Kcal/minute and heart beat is 160/minute.

Workstation design

Workstation means the immediate area where the person is performing his/her duties. The goal of designing a workstation is to promote ease and efficiency of the person’s performance. Productivity will affected if the operator is uncomfortable and the workstation is awkwardly designed.

Workplace design

Workplace is the establishment or department where the person or worker is performing his/her duties. The most basic requirement for a workplace is that it must accommodate the person working in it. Specifically this means that:

1. The workspace for the hands should be between hip and chest height in front of the body.
2. Lower location are preferred for heavy manual work.
3. Higher locations are preferred for tasks that require close visual observations.

Another key ergonomic concept is that workplace should be designed relating the physical characteristics and capabilities of the worker to the design of equipment and to the layout of the work place.

When this is accomplished:

- There is an increase in efficiency
- There is a decrease in human error
- Consequent reduction in accident frequency.

Design is accomplished after learning what the worker's job description will be, kind of equipment to be used for that process and the biological characteristic of the person (worker).

Workspace dimension

Workspace dimension can be grouped in three basic categories: minimal, maximal, and adjustable dimensions.

- Minimal workspace provides clearance for ingress and egress in walkways and doors.
- Maximal workspace dimensions permit smaller workers to see the equipment.

This is ensured by selecting workspace dimension over which a small person can reach or by establishing control forces that are small enough so that even a weak person can operate the equipment.

- Adjustable dimensions permit the operator to modify the work environment and equipment so that it conforms to those individuals on particular set of anthropometric characteristics.

Effects of non ergonomic working conditions

- Tendosynovitis
- Bursitis
- Carpal tunnel syndrome
- Raynaud's syndrome ("white fingers")
- Back injuries
- Muscle strain

To avoid ergonomic hazards the following points should be considered:-

- Sensibility and perceptibility (visual,audible,tactile)
- Kinetic ability and muscular power or strength
- Intelligence
- Skill
- Ability to learn a new technique of skill
- Social and group adaptability
- Kinetic conditions (body size or physical constitution)

- Effect of environmental conditions on human ability
- Long term short term or short term adaptable limits of man(desirable or normal, compensatory or fatal)
- Reflexion and reaction patterns
- Mode of living (custom) and sex distinction
- Racial differences
- Human relationship
- Factors that affect on synthetic judgment

2.3.6 Psychosocial hazards

Up to 50% of all workers in industrial countries judge their work to be "mentally heavy". Psychological stress caused by time pressure, hectic work, and risk of unemployment has become more prevalent during the past decade. Other factors that may have adverse psychological effects include jobs with heavy responsibility for human or economic concerns, monotonous work or work that requires constant concentration.

Others are shift-work, jobs with the threat of violence, such as police or prison work, and isolated work. Psychological stress and overload have been associated with sleep disturbances, burn-out syndromes, stress, nervousness and depression. There is also epidemiological evidence of an elevated risk of cardiovascular disorders, particularly coronary heart disease and hypertension.

Within the work environment emotional stress may arise from a variety of psychosocial factors, which the worker finds unsatisfactory, frustrating, or demoralizing.

For example:

- A peasant who migrates from the rural areas to a city will face entirely different environment if he/she start to work in an industry. In his /her rural life he used to work at his /her own speed but in the factory he may have to work continuously at speeds imposed by the needs of production.
- Workers may be working in shifts that will expose them to unusual hours. They may upset their family's life as a result of their work conditions.
- Workers may be working with a person who is paid more but who is incapable of working.
- Financial incentives are too low etc.

These and other stresses will have adverse psychosocial problems on workers.

Reduction of occupational stresses depends not only on helping individuals to cope with their problems but also on:

- Improved vocational guidance,
- Arrangement of working hours,
- Job design, and work methods;
- Good management.

2.4 Review questions

1. Select ten occupations common to your community. List the potential and real occupational risks associated with each type of employment.
2. What are the common health hazards of organic solvents?
3. Explain the reasons why the magnitude of occupational health hazards is increasing in health care industries (hospitals, health centers, laboratory etc).
4. What are the main health effects of Noise?
5. How does the occupational environment of the worker affect the health of his or her families and the general population?
6. What are the criteria to state that substances are hazardous or dangerous?
7. What are the advantages of hazard warning symbols or signs?
8. Give two examples each for task, human and environmental variables
9. What are hazards in hospital environment?

Note to the Instructor

Please take your students to an occupational setting (industries, factories, workshops, hospitals, classrooms, laboratories etc) and ask them to indicate health and safety hazards in the work environment. Discuss their findings and your observation with the students. The assignment in the setting could be in teams. If so, ask the group leaders to present their findings to a plenary in the classrooms.

CHAPTER THREE

OCCUPATIONAL ANATOMY AND PHYSIOLOGY

3.1. Learning objectives

At the end of this chapter, the student will be able to:

1. Discuss the functionality of human physiology
2. Explain the principles of occupational anatomy and physiology anatomy.
3. Identify the occupational physiology related problems

3.2. Introduction

Before we attempt to assess the effect of work on the health of man, it is expedient to summarise briefly our knowledge of the human body and the working of its organs. Of Course, all the organs of the body take part in the life, and hence in the work, of human. However, certain parts of the body that determine working capacity are more particularly involved; they can therefore be considered as representative, and only they need to be studied.

3.3 Anatomy and physiology

Muscles

All physical work is done by muscles, in which the necessary energy is created. The first task of the muscles is to maintain the body in the required posture (upright, seated, kneeling, and so on) and then to effect the various movements. It is through them that useful work is finally done.

Muscles work by alternating contraction and relaxation of the component fibres, resulting from chemical action. Muscle fibres, which are mostly arranged in groups or bundles in different parts of the body, cause various movements by acting on the bones. Muscles also cause movements in internal organs.

The energy required to contract the muscle fibres is provided by the oxidisation of glucides. The combustion residues include lactic acid, water and carbon dioxide. Since the chemical reactions take place within the fibres themselves, it becomes necessary for the oxygen and the fuel to be brought to these fibres and for the waste products of combustion to be removed, either to be discharged outside or to be reintroduced in a regeneration cycle. The working capacity of muscle therefore depends on the number of fibres (musculature), the capacity of the transport routes (arteries and veins), the speed of the transport (blood flow), the functioning of the regulatory system which has to harmonise the physiological phenomena with the effort exerted, and the pulmonary function which ensures the renewal of the oxygen in the blood and the elimination of gaseous waste.

Bones and joints

To effect movements of the body, muscles require a firm anchorage; bones may therefore be considered as being practically rigid. To a certain extent they are also elastic, especially in young persons. This elasticity, however, does not play any part in work, it is needed to take the strain of heavy loads. If the elasticity is insufficient, as is often the case in accidents, a bone will break. Most bones in the body are connected by joints (such as the knee, the hip and the elbow), or they are semi-rigidly connected by ligaments or cartilage (as the ribs are to the upper part of the spinal column), or they are fastened together like the bones of the skull, whose purpose is to protect the brain. The spinal column has quite a special structure. The vertebrae are so shaped that the upper part of the body can assume the most widely differing positions in relation to the lower part, and it can also rotate independently. There is a special reason for this structure, in that the spinal column protects the abdominal organs. Since it can only move by arching and cannot bend like the knee, these organs always have enough room. It does happen that in certain positions of the torso some organs are slightly compressed, but their functions are only very slightly impaired on this account. In order to leave the organs with the space that they require and to maintain the torso in a suitable position, the vertebrae are connected by joints that are only slightly mobile and by ligaments called meniscuses or intervertebral discs. Because of their inelasticity, the meniscuses are very sensitive to repeated jolts, such as those caused by the bumping of a vehicle that has neither springs nor shock absorbers.

The spinal column protects only the hinder part of the abdomen; the rest is protected by a wall of ligaments and muscles. The muscles are superimposed and the fibres are criss-crossed so as to constitute an envelope that is both elastic and strong. This enables the body to bend forwards and sideways, and hence allows it to work in a bent position. When the abdominal wall is overloaded, especially when heavy weights are lifted, the weakest points may give way and this may lead to hernias.

The thorax, which can move only a little, protects not only the vital organs-the heart and the lungs-but also the top of the stomach, the liver, the gall bladder and the spleen. The vertebrae are connected by muscles and ligaments, and the shoulder-bones and collar-bones are connected to the chest by the same means. The back muscles play an important part in maintaining the position of the body. The less they are developed, the more the vertebrae are pressed together, and consequently the greater the risk of deformation of the spinal column. The back muscles are also needed to compensate for the efforts made when the arms are working.

The strength of bones is invariable over a good part of a person's life span, and it is wrong to suppose, as often happens, that because old people are particularly subject to bone fractures they have soft and weak bones. In fact, a predisposition to bone fractures is the result of poor musculature that is no longer able to hold the bones together adequately, coupled with vagueness and lack of co-ordination of movements.

Circulation of the blood and respiration during work

One of the principal determinants of the power of muscles is the amount of blood flowing through them. The total amount of blood may be considered as a personal constant because normally it is subject to only slight variations. The amount of red pigment (haemoglobin) determines the amount of oxygen that can be fixed in the blood. The velocity of the bloodstream and the volume of the vessels (arteries and veins) govern the quantity of oxygen available in muscles. The blood is moved by the heart, first through the lungs where it fixes the oxygen, and then through the muscles and the organs where part of the oxygen is consumed. From these it returns to the heart and lungs. It is not only the size of the heart but also, and directly, the rate at which it beats (pulse) that determines the blood flow. Hence, measurement of the rate of beating or pulse is of great importance in assessing the strength required to perform a given job. Naturally, the amount of oxygen consumed is directly proportionate to the muscular energy produced. It is, however, more difficult to measure this than the heart rate. All that is usually done is to compare the oxygen content of the inhaled and exhaled air, whereas at the same time it is necessary to measure the respiration, which is proportionate to the effort expended.

During inhalation the lungs fill with fresh air, rich in oxygen; this air passes through the membranes of the alveoli of the lungs, enters the blood stream and is fixed by the haemoglobin. Each cell can fix and transport only a certain amount of oxygen. Muscular work depends on the amount of oxygen that the blood can convey to the muscles; similarly, the rate of elimination of carbon dioxide depends on the blood flow through the body. Consequently, good circulation and respiration are of essential importance to working capacity.

The heavier the demands made on muscle power, the faster the blood must flow and the faster the human must breathe, because the concentrations of energising substances and cells transporting oxygen are almost constant. When the composition of the blood is normal, the amount of oxygen that it transports is sufficient for combustion. However, if it is too poor in haemoglobin the oxygen flow is insufficient and the muscle cannot do as much work; if, in such a case, it is desired to intensify muscular work, the circulation of the blood must be accelerated and the shortage of haemoglobin must be compensated by an acceleration of the rate of oxygen exchange in each muscle. In a person whose blood is poor in haemoglobin, the amount of muscular work will be less than in a person whose blood contains a normal amount of haemoglobin. The requirements of a muscle considered in isolation naturally depend on the work it has to do.

During periods of rest, at each heart beat the pumped blood is distributed among the different organs in accordance with a fixed pattern. During work, an additional flow of blood must irrigate the regions producing the energy so as to feed the muscles and remove the waste products. The regulatory mechanism of the circulatory system works with extraordinary precision and sensitivity. Its reaction to change must be almost instantaneous, because the movements of the body alter very quickly. One needs only to think, for example, how quickly the different muscles of the legs act in turn when one is walking; and the same, of course, applies to the muscles of the arms and legs, or the hands and arms, in other movements. The blood flow per minute is regulated by the rate at which the heart pumps; this can be measured by the pulse, and is only slightly influenced by variations in the size of the heart. The quantity of blood flowing towards any particular part of the body depends on the cross-section of the blood vessels concerned. The blood arrives through the arteries and leaves through the veins. When the blood supply to a certain region has to increase, the arteries carrying it have to dilate in order to increase their carrying capacity, as do the veins when the blood is returning to the heart.

When certain regions of the body need intense irrigation, the arteries and veins contract in other regions, in which irrigation is thereby reduced so that the circulation can meet the increased needs of the first-mentioned regions. It is true that the vital organs continue to receive just enough blood to enable them to function, but in these conditions they are not particularly active. It is, however, very important to maintain the irrigation of the brain. Of course, the amount of blood required there is small in comparison with that required by the large muscles, such as those of the thighs when they are working at full capacity. But the brain needs blood that is rich in oxygen, and its activity declines when the demand for blood becomes too high in other parts of the body. Naturally, other organs, such as those of the digestive system, may compete with the muscles for blood supply. After meals the digestive system needs a large quantity of blood, not only to make its own muscles work but also to transport and distribute the products of digestion. Man should therefore stop working during and immediately after meals so as not to hinder the working of the digestive tract. This is also the reason why the zeal for work declines even before the meal break. This changing blood distribution between organs and muscles is also due to the regulation of circulation. The system is so responsive to the variations with which it has to deal that it can work for several decades without breaking down. Thus, working capacity depends also on the proper working of the regulatory mechanism of the circulation.

Basal metabolism

A minimum expenditure of energy is always required, independently of any activity, and even during sleep. This is "basal metabolism". It is the minimum energy exchange that is essential for the maintenance of life. Basal metabolism (measured in calories) depends on the weight of the body and its surface area (temperature regulation) and varies slightly with sex and age. Such determinations of basal metabolism as may be necessary for medical reasons or for work study must be carried out in a specially equipped laboratory.

Static work

So far we have spoken only of dynamic muscular work-that is, work done by movements of the body. There is, however, another kind of work: static work, or the work of maintaining a position. Such work entails constant effort by the muscles that maintain certain parts of the body in particular positions (crouching, kneeling, sitting, and so on). Carrying loads on outstretched arms or on the head are examples of static work. If the body is to maintain a certain posture, the first requirement is that the head is in such a position that the functioning of the brain is not hampered. Second, the posture should be such that the reactions of dynamic work (for instance, when walking or making tractive effort) can be absorbed without loss of balance.

As we have discussed, muscles work by alternating contraction and relaxation of their component fibres. However, the work of maintaining a position cannot be accomplished by continuous contraction, since muscular relaxation is indispensable to irrigation by the blood and to the removal of the waste products of oxidisation. In static work, the contraction phase of each fibre is much longer than the relaxation phase, and there are therefore always more contracted than relaxed muscles. Consequently, the time available for removing waste products is much shorter than in dynamic work, and static work causes fatigue much more quickly -indeed, a given group of muscles produces 15 per cent less effort in static than in dynamic work. Carrying an object with outstretched arms soon causes fatigue, and standing still for a long time may cause fainting due to imbalance of the circulation. Work done by the hand in static contraction, on a tool, a work-piece, a pen or other object often causes pain, indicating an accumulation of waste products in the muscles. Posture during work and the manner of working therefore have a considerable effect on output.

Thermal regulation

If all the vital functions of the human body are to remain unimpaired, the body's internal temperature must be maintained at or about 37°C. If a human lives in a cool or cold environment, he/she is constantly dissipating a certain amount of heat. This leads to the intensification of basic combustion in order to make up for the constant loss of calories. In adults, the basal metabolism needed for the functions of the various organs represents between 1,200 and 1,600 kcal per day, or between 0.85 and 1.1 kcal per minute. But this amount of heat is not enough to compensate for the losses unless the environmental temperature is at least 20°C. In agricultural work it is practically impossible to regulate the environmental temperature, and the clothing must therefore be adapted to the working conditions.

The additional heat produced by physical work is sometimes very great and may amount to several times that of basal metabolism. For an eight-hour day, depending on the effect required, the expenditure of energy ranges from 2,000 to 3,000 kcal. The average is therefore 4-6 kcal/min, with peaks which may reach 12 kcal/min. This great amount of heat has to be eliminated as quickly as possible. The body dissipates heat by radiation, convection or evaporation (sweat). Radiation and convection, by which the body can dissipate only 2-2.5 kcal/min, are restricted by clothes. The heat losses by radiation and convection depend primarily on the difference in temperature between the skin and the environment, and this is regulated to a certain extent by the circulation of the blood.

The greater the amount of excess heat to be removed, the more the circulation increases at the level of the skin and the faster the heat exchange with the environment becomes. The thermal conductivity of the skin is different in the two sexes, being lower in women than in men. This is why women can generally bear to be more lightly clothed than men. The dissipation of body heat increases in a draught, which is constantly bringing cooler air into the vicinity of the skin.

If the work generates more heat than can be dissipated by radiation and convection, sweat is produced, which evaporates on the skin. The phenomenon of sweat evaporation enables large quantities of heat to be dissipated in the environment. The larger the sweating area of the skin and the drier the environmental air, the greater the dissipation of heat by sweat. While for light work the humidity of the air is of no great significance, intensive work can be done only if the air is not saturated with humidity (that is, if it is comparatively dry), as otherwise the sweat cannot evaporate. Sweat can remove excess calories only by evaporating, and this is why streaming sweat represents a useless waste of energy.

As evaporation depends on the environmental temperature and air movements, clothing is an important factor here too. Since sweating is not uniform over the whole surface of the body, underclothes may facilitate the dissipation of heat if they are completely soaked with sweat. Thus underclothes should rapidly absorb sweat, distribute it and ensure uniform and regular evaporation. The larger the surface of the garments, the more effectively will they fulfil these tasks. Natural fibres such as wool and cotton are impregnated more slowly than synthetic fibres. Closely woven materials are less effective than loose materials, such as knitted garments.

Equatorial and tropical countries are normally regarded as "hot countries". They may nevertheless have temperate seasons and cool upland regions (for instance, the east central African plateau, which is at an average altitude of 1,500 m and has intensively cultivated areas up to an altitude of about 3,000 m near the equator). As a rule, workers in hot climates cannot be expected to have the same output as those in temperate countries.

Co-ordination of physiological functions

The foregoing very brief description of some physiological functions suggests the existence of a very precise regulatory system for the necessary harmonisation of these functions. This regulation is controlled by the nerves, which receive their impulses from widely differing centres, most of them in the brain. It is almost entirely unconscious and involuntary, and depends on the physiological automation that keeps the body alive. The over-all co-ordination of the maintenance of body balance, the adaptation of respiration and circulation and the dissipation of heat are automatic reflex functions that do not require any voluntary interference. Automatic regulation is surer and more precise than conscious regulation and also seems to need a smaller expenditure of energy. This is in fact the reason why, whenever possible, man tends to replace certain processes, movements and actions by reflexes. Advantage is taken of this fact in training and working. However, this natural tendency, imposed on man as it were by his physiology, has as its counterpart an attitude, varying in degree, of inertia towards changes in working habits. In fact every new process has first to be controlled by the will; only later does it come within the province of reflexes, which, if necessary, will succeed and replace reflexes controlling the processes adopted hitherto.

The precision of regulatory functions varies with the importance of each in the maintenance of vital equilibrium, health and welfare. While internal temperature is regulated very precisely, the oxygen content of the blood is less so, and the water content of the body still less. Some types of regulation, such as that of blood supply to muscle, are almost instantaneous; others, such as the reconstitution of energy reserves, sometimes take several hours. Some have a daily rhythm-for instance, the alternation of activity (day) and rest (night)-and others have a periodicity of a year or more (duration of sleep in summer and winter, variation of activity with age). The organs can retain their vitality only by functioning regularly; they have no need of prolonged rest. On the contrary, inaction may atrophy them and put an end to the corresponding regulatory function.

The proper working of the regulatory system depends on healthy development in childhood and adolescence, suitable training during growth and continuous exercise later.

Adaptation to environment

The co-ordination of the different functions of the body is not the sole task of physiological regulation; it must also ensure the correct adaptation of the individual to the environment. This is of capital importance for the maintenance of maximum working capacity in face of the enormous variations that may occur in the nature and place of work. For example, the muscular energy must correspond to the effort demanded, and the dissipation of heat to the environmental temperature. This adaptation can be easily observed: if the intensity of the effort increases, the pulse and breathing rates will steadily increase too. The eye adapts itself automatically to the luminosity and distance of objects. These are only a few of the countless regulatory activities induced by stimulation from the environment.

Working capacity

State of health and working capacity

Human's working capacity depends on the sum total of his physiological functions. It is based to some extent on a certain natural predisposition, but more on the development and training of the body, muscles and regulatory organs and centres. A person's working capacity is thus closely bound up with his state of health. Physical work calls for certain qualities that human, if he enjoys good health, can develop fully by training. It requires well developed muscles, a robust skeleton, sound organ (circulatory, respiratory, renal, digestive, etc.) and a good neuro-endocrinian regulatory system.

Diet and work

An adequate and balanced diet is one of the indispensable conditions of satisfactory working capacity. The more muscular work a human does, the greater must be his consumption of the substances required for chemical combustion. Energy reserves must therefore be replenished by a diet rich in carbohydrates. Most of the carbohydrates in a diet come from cereals: wheat in Europe and North America, rice in Asia and maize in Latin America.

Human other plants are rich in carbohydrates, such as sorghum, manioc and potato. In making bread and paste, cereals must be treated to make them more digestible; they also undergo transformation in the body. On the other hand, sugar can be absorbed without any preparation and quickly passes into the blood, so that it is a very important food in intensive work.

When a human does less strenuous work, his diet should contain correspondingly fewer carbohydrates. It is a problem peculiar to modern nutrition in industrial countries (in which muscular work is steadily declining and consequently the consumption of carbohydrates should decline to the same extent) that because of habit or appetite people still consume large quantities of carbohydrates. This leads to obesity, which is not only inimical to work but is also at the origin of human diseases. In addition to carbohydrates, food should contain proteins and fats, the latter contributing to the energy balance, more especially in the internal organs. Protein is needed in the formation of cell tissue, which is constantly being renewed; this is why muscle too needs a supply of protein. It is obvious that an adolescent whose muscular growth is not completed will need more protein than an adult; but the adult must have a certain minimum amount to maintain his energy balance. The body needs various proteins, and if a diet is to be balanced it must be adequate in quantity and quality. If it is not, there will be a food deficiency. Above all, there must be a minimum proportion (about 30 per cent) of animal protein for persons doing heavy, difficult or intellectual work.

All food is transformed in the digestive tract before being conveyed to the organs for which it is intended. Digestion is a cyclic and not a continuous process, but since requirements in muscular energy are either continuous (in the heart muscle, for example) or spread evenly over the hours of the day (as in the muscles of locomotion), reserves have to be constituted. Thus food can be absorbed and digested at the intervals fixed by meals. In healthy persons the body has sufficient reserves to enable it to burn, over a period of several days, more substance than is supplied by the food consumed during those days. In the long run, however, the food intake must restore the balance or exhaustion will ensue. The more energy the work demands, the richer and more frequent the meals should be; but meals should be spaced out if the work falls off. Thus a human doing heavy work needs five meals a day, while a tractor driver, for example, if he is comfortably seated, is so little affected by eight hours of work that he should easily be able to manage with three meals a day. The proper working of the digestive system is just as important for working capacity as are the soundness of the skeleton and the development of muscles.

Training

Working capacity is determined by muscular development as well as by food and by the adaptation of the circulatory and respiratory systems and their regulatory mechanisms. It is possible to develop individual predispositions by training, up to an advanced age, and to maintain them at a high level.

In physical training stimulations are produced by muscular work, the maximum stimulation corresponding to overwork up to the limit of fatigue. A short spell of overwork-from two to five minutes, for example-is the best form of physical training. Naturally, persons suffering from pathological changes or disorders should avoid such efforts.

The stimulation produced by training may be deliberate, as in sport, and be intended to develop the muscles of a particular part of the body, but it occurs automatically in all work. The greater the amount of work required of the different parts of the body, the better will be the physical condition. Thus varied muscular work, as encountered in many agricultural activities, is one of the best means of achieving a harmonious development of the body. The physical development of adolescents should therefore be promoted systematically, by means of work suited to their body strength and their age. Muscular stimulation that is due to training and causes muscles to develop also strengthens certain organs that participate indirectly in muscular work. Both the heart muscle and the regulatory mechanism of circulation benefit from the training constituted by steady work.

The functions of each are decisive for the maintenance of a person's working capacity. The regulation of the circulation is a very good example of the organisation of an aggregate of physiological reflexes designed to produce the requisite effect at any point and moment.

Physiological regulation operates at two different levels. One is independent of the will and is essentially concerned with the maintenance of life. It comprises the regulation of the heart, the circulation and the respiration, the regulation of the digestive system, the co-ordination of circulation and respiration, and so on. The other consists of regulatory mechanisms that depend on the will and govern processes bound up with voluntary action. But as a result of exercise and training, the control of work very soon passes into the domain of automatic reflexes. It must be supposed that unconscious regulation is more economical, and at the same time quicker and more precise, than conscious regulation. The performance of any job requires a rapid and precise system of regulation. This system also is subject to the laws of training: the more it is used, the better it is trained and the more serviceable it becomes.

There are limits in both directions to these biological processes. The science of work has long concerned itself with discovering human's optimum working capacity. The permanent optimum rate is attained when the energy supply just balances the loss.

There is also a lower limit to physical work. We all know that after a long spell in bed the body has lost strength and must be laboriously retrained for work. This is because the stimulation of training has been absent for too long, and consequently the muscles, muscular movements and organic regulation have all become too weak. The optimum working capacity lies between insufficient work and excessive work; however, frequent alternation of working intensities-light work, normal work, heavy work-is, within certain limits, probably more beneficial to the body than working at uniform intensity for a very long spell.

If training is to be effective, the same exercises must be repeated often and correctly. In simple work the effects of training are felt very soon, generally after a few hours. It is not necessary to repeat the exercises without a break; they can be performed on alternate days.

This is very important in agricultural operations, some of which cannot be carried on for long without a break. However, in all the repetitions the course of the process must be identical. Operations calling for very close co-ordination of various movements or perceptions, and those involving analogous but very varied actions, need longer training periods (up to 50 or 60 hours). Here too, however, one may count on a sufficient degree of assimilation, which means that the work is performed correctly under the control of the unconscious.

This sufficiency of assimilation of operations is particularly important for the agricultural worker, who can rarely concentrate on the actual work, being frequently obliged to watch the results so as to control quality. The farmer, acting both as the head of an undertaking and as a worker, is even more bound to watch the result of the work, so that he has no time to see how the work is actually being carried on. Thus, for the farmer, the introduction of new processes means a heavy psychological strain, and attempts should be made to lighten it by all possible means.

Age and aptitude for work

If the individual limits for these various factors are not exceeded, working capacity can be maintained over the whole span of active life. With age, it is true, many functional capacities decrease, as well as aptitude for training, but this does not matter much if the work done remains fairly constant. Moreover, the elderly worker often replaces failing strength by greater skill. Retraining elderly persons for new and arduous operations is difficult, but a man of 60 can do most field work just as well as a man of 30, except for those operations wherein man reaction time may be critical. If ability to work is to be measured by age, it may be said that it can equally well begin relatively early and continue well beyond 65 years. The quality declines only slowly with age if activity is regularly maintained. There is practically no wear on muscles and organs, as was once thought. However, the effects of illness increase with the years, because the aptitude of the body and its functions for training continuously decline. This is why convalescence in old people is more prolonged than in the young.

Curve of physiological work and biological rhythm

The working capacity of an individual varies in the course of the day, and does so in a rhythm that is independent of the actual work. It increases in the morning from 6.30 to 8 a.m., reaches its maximum about 10 a.m. and declines towards 11 a.m. In the middle of the day, between noon and 1 p.m., it is low, whatever the meal taken, and then it rises again. The afternoon maximum, between 2:00 and 3:00 p.m., is a little lower than the morning maximum. After 4 p.m. working capacity falls rapidly. At night it is always lower than in the daytime. No training can alter this natural rhythm. It persists even among persons who have worked only at night for several years; their working capacity remains greater during the day than during the night.

Fatigue

Whatever the tempo of work, human tires in the course of the day. Fatigue is a complex physiological condition entailing a reversible lowering of working capacity. In addition to muscle fatigue due to work, which is the more acute the more the work is concentrated in a few muscle groups, human usually experiences general fatigue.

There are days when a person feels very tired after work; there are others when after the same work he is less tired. Fatigue is thus a subjective phenomenon that depends on both physiological and psychological factors. Normal fatigue occurring at the end of the day is usually overcome by sleep, so that when a human wakes up he is ready to resume work. However, matters are not always so simple; after the night's rest some fatigue may remain, but this may be eliminated one or two days later by a good night's sleep. On the average, daily fatigue due to work should not exceed the maximum that can be overcome by a night's sleep. If overwork persists, fatigue accumulates and may cause serious trouble, or at least reduce working capacity. Even purely muscular fatigue is overcome by rest, chiefly by nightly rest. However, local phenomena may also occur in muscles; they are mostly due to insufficient elimination of waste products, which is often the result of the manner of working as much as of the intensity of the work.

Static effort is always particularly arduous and tiring, and this is why attempts should always be made to eliminate it from methods of working. If this is impossible, spells of static work must be shortened and interrupted by spells of dynamic work. If static work lasts too long, the minimum results will be local cramp (for example, tractor drivers suffer from cramp in the right calf when the accelerator pedal is badly placed and requires excessive effort by the foot).

Intense muscular fatigue and stresses on the brain and the sense organs (eye, ear and so on) lead to considerable strain on the central nervous system and consequently to general fatigue, which in turn is characterised by a general lowering of working capacity. It will even affect body organs that have taken scarcely any part in the effort.

The working environment can also affect the functioning of the central nervous system and contribute to the development of fatigue. This is more particularly so in workplaces that are dark, noisy and hot to an unhealthy extent.

Monotonous work causes drowsiness and can lead to extremely serious problems in many kinds of work.

Measurement of physical work

- **Oxygen consumption**

Since the degree of fatigue is not always directly proportionate to the work done, and since even today it cannot be measured, other criteria have been sought for measuring human work. One that has been applied for a long time, and is very suitable for measuring dynamic work, is the amount of oxygen consumed. This amount is in fact directly related to the energy consumed, so that the amount of oxygen consumed is a direct indication of the intensity of the work. Naturally, it can be used only to measure dynamic muscular work, to the exclusion of static work and intellectual work which consume comparatively little oxygen.

The consumption of oxygen is measured as follows: the subject, whose nose is pinched, has in his mouth a valve that allows him to inhale fresh air. All the exhaled air passes through a volumetric counter which gives a reading of the amount of air breathed. Part of the exhaled air is collected in a vessel and then analysed in the laboratory. The carbon dioxide content and the oxygen content are determined and compared with the content of the inhaled air. This latter content need not be specially determined unless the air has been contaminated by exhaust or other gases, but can be taken from tables. The difference between the oxygen content multiplied by the volume of air inhaled gives the oxygen consumption, from which, with the aid of tables, the calorie production can be found. To find the number of calories produced by the work, the number due to basal metabolism must be deducted from this result. Although the apparatus used is much less cumbersome than formerly, the valve for breathing does inconvenience the subject and he needs a certain time to get used to it before exact measures can be taken.

Table 3-1. Work classification according to oxygen uptake and calorie expenditure

Physiological variables	**Work intensity**	
Very light	(1/min)	Cal/min
Light	<0.5	< 2.5
Moderately heavy	0.5-1.0	2.5-5.0
Heavy	1.0-1.5	5.0-7.5
Very heavy	1.5-2.0	7.5-10
Extremely heavy	2.0-2.5	10.0-12.5
Oxygen uptake	> 2.5	> 12.5

Source: E. H. Christensen: human at work: studies on me application of physiology to working conditions in a subtropical country, Occupational safety and health series, No.4 (Geneva, ILO, 1964).

- **Heart rate**

As the intensity of physical work gradually diminished, it became necessary to find another method of measurement independent of oxygen consumption. A good indicator of work is the pulse. Since the amount of blood delivered by each heart beat is almost constant for an individual, within certain limits, the pulse rate is a direct indication of the amount of blood demanded by a particular part of the body. Measuring instruments are used for pulse counting during work. In simple investigations integrating instruments count the pulsations during a minute or a number of minutes. For more precise investigations instruments that record each pulsation are used. Some have a small lamp which is placed under the lobe of the ear and the light of which is momentarily dimmed as each surge of blood passes. The variation in the light is converted into electric impulses that are shown on the recording instrument. Other instruments pick up the nervous impulses directly by means of electrodes. Heartbeats can be recorded electrically on magnetic tape or mechanically on paper reels. It is essential to obtain recordings that are as accurate as possible, for it is not at all easy to interpret them. In fact, the pulse rate does not depend solely on the oxygen consumption, and hence on the amount of dynamic work. Static effort will accelerate the pulse, and hence measuring the heart rate usefully supplements the measurement of oxygen consumption. Mental and intellectual activities also affect the heart rate, as do many other factors, especially psychological factors such as anguish, bad temper, joy and mental effort. Their influence is seen in the circulation.

Moreover, regulation of the heart rate is subject to quite precise laws that are related to work. For example, the rate increases before work begins; during work it decreases to correspond with the intensity of the work. When the work is finished, the rate decreases slowly until it corresponds to the rest conditions prevailing before the work began. If this does not occur, it must be supposed that some fatigue remains after the work. To measure this, the method just described can be used. When it is desired to measure the pulse rate during work, the rest rate must be subtracted from the rate measured. The rest rate can be measured when the subject has rested for a sufficient time lying down. It varies greatly from one person to another, and so must be determined not only for each person separately but also several times for the same person, before and after work. In many measurements it is better to count only the pulsations above the number corresponding to the period immediately preceding the work; for example, for work done in a sitting position the pulse rest rate in that position would be subtracted, for work done in a standing position the rest rate would be subtracted, and so on. This "starting rate" is useful in most effort tests. The "effort" pulse rate is the difference between the aggregate rate during work and the rest rate or starting rate.

Table 3-2. Classification of physical work by heart beat

Degree of effort	Heart rate (pulse/min)
Very light	<75
Light	75-100
Moderately heavy	100-125
Heavy	125-150
Very heavy	150-175
Extremely heavy	>175

Source: Adapted from Christensen.

Measurement of the heart rate, rather than measurement of the oxygen consumption, makes it possible to determine the limit of continuous work (see table 2). If the pulse remains constant during the work, this is within normal limits; but if the pulse rate continuously rises while the work remains constant, the work is exceeding the limits of normal effort. This test often brings to light organic defects or functional troubles that render a person unfit for heavy work.

3.4 Review Questions

1. Discuss the functionality of human physiology
2. Explain the principles of occupational anatomy and physiology and anatomy.
3. Identify the occupational physiology related problems

CHAPTER FOUR

INDUSTRIAL TOXICOLOGY

4.1. Learning objectives

At the end of this chapter, the student will be able to:

1. Define toxicology
2. Describe toxicological health problem.
3. Explain dose-Response Relationships

4.2. Introduction

Toxicology is the study of harmful interactions between chemicals and biological systems. Man, the other animals and plants in the modern world are increasingly being exposed to chemicals to enormous variety. These chemicals range from metals and inorganic chemicals to large complex organic molecules, yet they are all potentially toxic.

There are now many thousands of chemical substances used in industry ranging from metals and inorganic compounds to complex organic chemicals. The people who work in the industries which use them are therefore at risk of exposure. Fortunately, exposure is often minimized by using chemicals in closed system so that operators do not come into contact with them, but this is not always the case. In third world countries, however, some of which are rapidly industrializing, exposure levels are higher and industrial diseases are more common than in the fully developed countries.

Consequently exposure to toxic substances in the workplace is still a very real hazard. Furthermore even in the best regulated industrial environment, accidents may happen and can lead to excessive exposure to chemicals.

Industrial diseases have existed ever since man began manufacturing on a large scale, and during the industrial revolution occupational disease became common. Some were well known to the general public and are still known by their original, colloquial names. These diseases were, and some still are of great importance socially, economically and medically. Many occupations carry with them the risk of a particular disease or group of disease. Thus, mining has always been a hazardous occupation and miners suffer silicosis, while asbestos workers suffer asbestosis and mesothelioma, and paper and printing workers are prone to disease of the skin. A man spends on average one-third of his life at work and, therefore, the environment in that workplace can be a major factor in determining his health. Although the working environment has improved immeasurably over the last century, some occupations are still hazardous despite legislation and efforts to improve conditions.

4.3 Routes of Entry into the Body

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

1. **Inhalation.** For industrial exposure, a major, if not predominant route of entry is inhalation. Any airborne

substance can be inhaled. The total amount of a toxic compound absorbed via the respiratory pathways depends on its concentration in the air, the duration of exposure, and the pulmonary ventilation volumes, which increase with higher work loads.

2. **Skin Absorption.** An important route of entry for some chemicals is absorption through skin. Contact of a substance with skin results in these four possible actions.

- The skin can act as an effective barrier
- The substance can react with the skin and cause local irritation or tissue destruction
- The substance can produce skin sensitization
- The substance can penetrate skin to reach the blood vessels under the skin and enter the bloodstream

a. **Ingestion.** The problem of ingesting chemicals is not widespread in the industry; most workers do not deliberately swallow materials they handle. Nevertheless ,workers can ingest toxic materials as result of eating in contaminated work areas; contaminated fingers and hands can lead to accidental oral intake when a worker eats or smokes on the job

b. **Injection.** Although infrequent in industry, a substance can be injected into some part of the body. This can be done directly into the bloodstream, peritoneal cavity, pleural cavity, skin, muscle, or any other place needle or high-pressure orifice can reach

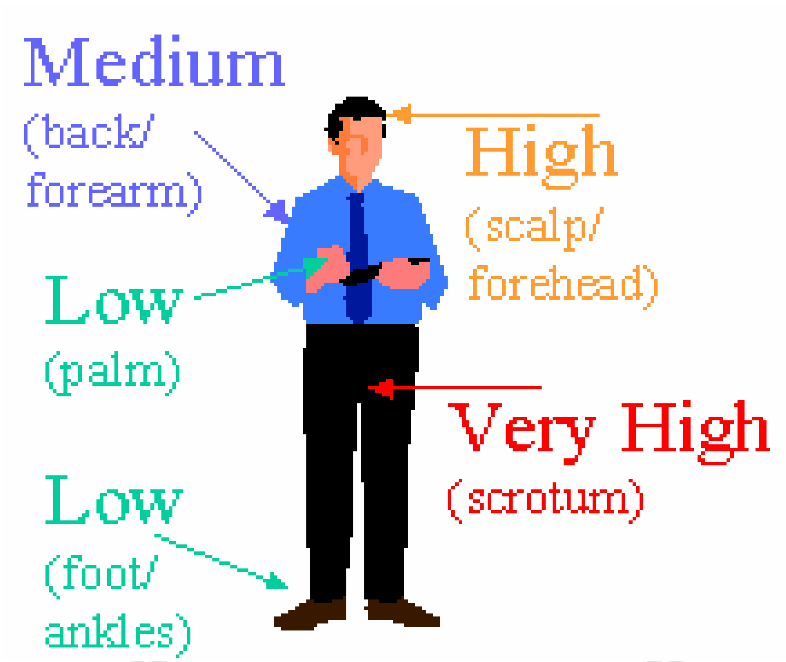


Figure 4-1: Routes of entry into the body

4.4. Dose-Response Relationships

Dose

The dose is the actual amount of a chemical that enters the body. The dose received may be due to either acute (short) or chronic (long-term) exposure. An acute exposure occurs over a very short period of time, usually 24 hours. Chronic exposures occur over long periods of time such as weeks, months, or years. The amount of exposure and the type of toxin will determine the toxic effect.

What is dose-response?

Dose-response is a relationship between exposure and health effect that can be established by measuring the response relative to an increasing dose. This relationship is important in determining the toxicity of a particular substance. It relies on the concept that a dose, or a time of exposure (to a chemical, drug, or toxic substance), will cause an effect (response) on the exposed organism. Usually, the larger or more intense the dose, the greater the response, or the effect. This is the meaning behind the statement "the dose makes the poison."

Threshold dose

Given the idea of a dose-response, there should be a dose or exposure level below which the harmful or adverse effects of a substance are not seen in a population. That dose is referred to as the ‘threshold dose'. This dose is also referred to as the no observed adverse effect level (NOAEL), or the no effect level (NEL). These terms are often used by toxicologists when discussing the relationship between exposure and dose. However, for substances causing cancer (carcinogens), no safe level of exposure exists, since any exposure could result in cancer.

Individual susceptibility

This term describes the differences in types of responses to hazardous substances, between people. Each person is unique, and because of that, there may be great differences in the response to exposure. Exposure in one person may have no effect, while a second person may become seriously ill, and a third may develop cancer.

Sensitive sub-population

A sensitive sub-population describes those persons who are more at risk from illness due to exposure to hazardous substances than the average, healthy person. These persons usually include the very young, the chronically ill, and the very old. It may also include pregnant women and women of childbearing age. Depending on the type of contaminant, other factors (e.g., age, weight, lifestyle, sex) could be used to describe the population.

Dose Response Assessment

The characteristics of exposure to a chemical and the spectrum of effects caused by the chemical come together in a correlative relationship that toxicologists call the **dose-response relationship**. This relationship is the most fundamental and pervasive concept in toxicology. To understand the potential hazard of a specific chemical, toxicologists must know both the type of effect it produces and the amount, or dose, required to produce that effect.

The relationship of dose to response can be illustrated as a graph called a dose-response curve. There are two types of dose-response curves: one that describes the graded responses of an individual to varying doses of the chemical and one that describes the distribution of responses to different doses in a population of individuals. The dose is represented on the x-axis. The response is represented on the y-axis. The following graph shows a simple example of a dose-response curve for an individual with a single exposure to the chemical ethanol (alcohol), with graded responses between no effect and death.

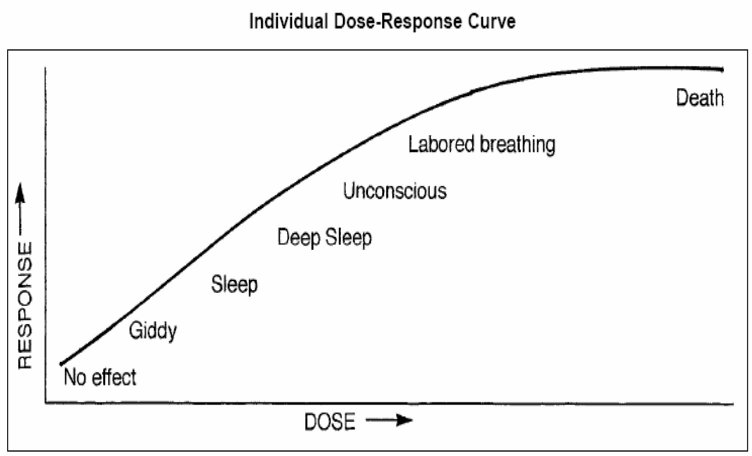


Figure 4-2. Individual Dose-Response Curve

[Source: Institute for Environmental Toxicology, Michigan State University]

A simple example of a dose-response curve for a population of mice in a study of a carcinogenic chemical might look like the following graph:

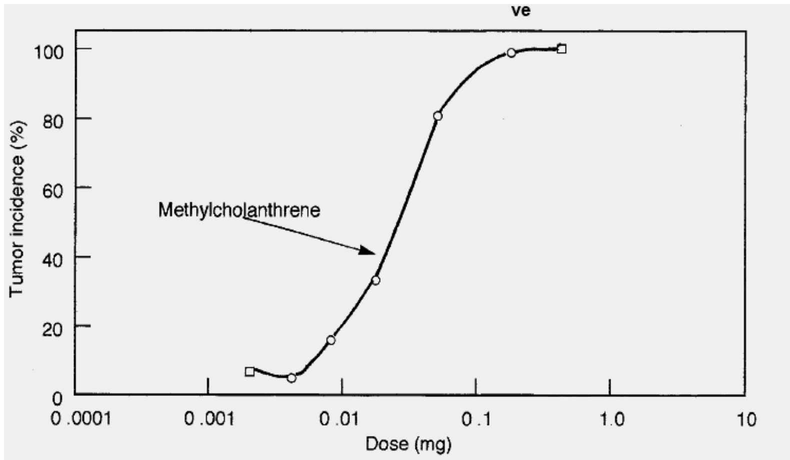


Figure 4-3. A dose-response curve for a population of mice in a study of a carcinogenic chemical

[Adapted from: Eaton, D.L., and Klaassen, C.D. 1996. Principles of toxicology]

An important aspect of dose-response relationships is the concept of **threshold**. For most types of toxic responses, there is a dose, called a threshold, below which there are no adverse effects from exposure to the chemical. The human body has defenses against many toxic agents. Cells in human organs, especially in the liver and kidneys, break down chemicals into nontoxic substances that can be eliminated from the body in urine and feces. In this way, the human body can take some toxic insult (at a dose that is below the threshold) and still remain healthy.

The identification of the threshold beyond which the human body cannot remain healthy depends on the type of response that is measured and can vary depending on the individual being tested. Thresholds based on acute responses, such as death, are more easily determined, while thresholds for chemicals that cause cancer or other chronic responses are harder to deter-mine. Even so, it is important for toxicologists to identify a level of exposure to a chemical at which there is no effect and to determine thresholds when possible.

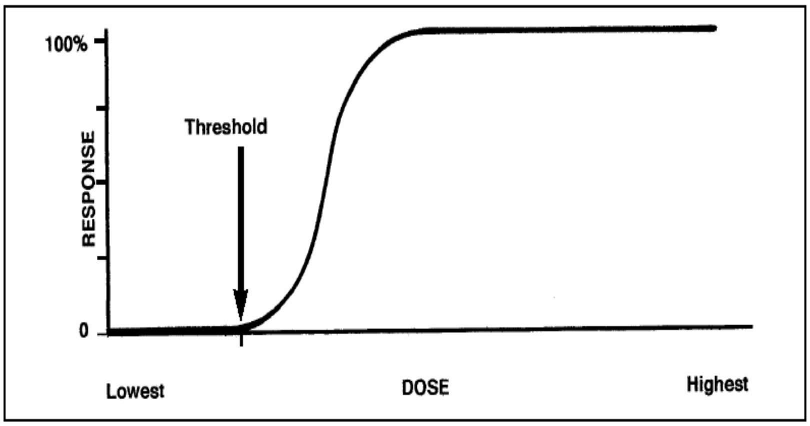


Figure 4-4. Dose-response curves for a chemical agent administered to a uniform population of test animals
Source: adapted from Ref.4

When a threshold is difficult to determine, toxicologists look at the slope of the dose-response curve to give them information about the toxicity of a chemical. A sharp increase in the slope of the curve can suggest increasingly higher risks of toxic responses as the dose increases.

A comparison of dose-response curves among chemicals can offer information about the chemicals as well. A steep curve that begins to climb even at a small dose suggests a chemical of high potency. The **potency** of a chemical is a measure of its strength as a poison compared with other chemicals. The more potent the chemical, the less it takes to kill. In the previous dose-response graph, line A describes a chemical that is more potent than the chemical described by line B, as can be seen by the relative positions of the lines along the dosage axis and their slopes.

Dose Estimates of Toxic Effects (LD, EC, TD)

Dose-response curves are used to derive dose estimates of chemical substances. A common dose estimate for acute toxicity is the **LD50** (**Lethal Dose** 50%). This is a statistically derived dose at which 50% of the individuals will be expected to die. Other dose estimates also may be used. LD0 represents the dose at which no individuals are expected to die. This is just below the threshold for lethality. LD10 refers to the dose at which 10% of the individuals will die.

For inhalation toxicity, air concentrations are used for exposure values. Thus, the LC50 is utilized which stands for **Lethal Concentration** 50%, the calculated concentration of a gas lethal to 50% of a group. Occasionally LC0 and LC10 are also used.

Effective Doses (**EDs**) are used to indicate the effectiveness of a substance. Normally, effective dose refers to a beneficial effect (relief of pain). It might also stand for a harmful effect (paralysis).

Toxic Doses (**TDs**) are utilized to indicate doses that cause adverse toxic effects.

The knowledge of the **effective** and **toxic dose** levels aides the toxicologist and clinician in determining the relative safety of pharmaceuticals. As shown above, two dose-response curves are presented for the same drug, one for effectiveness and the other for toxicity. In this case, a dose that is 50-75% effective does not cause toxicity whereas a 90% effective dose may result in a small amount of toxicity.

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

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

4.5 Health Effects

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

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

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

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

Cumulative poisons are characterized by materials that tend to build up in the body as a result of chronic exposure. The effects are not seen until a critical body burden is reached.

Example: heavy metals (such as Lead).

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

Types of Interactions

There are four basic types of interactions. Each is based on the expected effects caused by the individual chemicals. The types of interactions are:

1. **Additivity:** is the most common type of interaction. Examples of additivity reactions are:
   - Organophosphate insecticides interfere with nerve conduction. The toxicity of the combination of two organophosphate insecticides is equal to the sum of the toxicity of each.
   - Chlorinated insecticides and halogenated solvents both produce liver toxicity. The hepatotoxicity of an insecticide formulation containing both is equivalent to the sum of the hepatotoxicity of each.
2. **Antagonism:** is often a desirable effect in toxicology and is the basis for most antidotes. Examples include: The same combination of chemicals produces a different type of interaction on the central nervous system. Chlorinated insecticides stimulate the central nervous system whereas halogenated solvents cause depression of the nervous system. The effect of simultaneous exposure is an antagonistic interaction.
3. **Potentiation**: occurs when a chemical that does not have a specific toxic effect makes another chemical more toxic.

Examples are: The hepatotoxicity of carbon tetrachloride is greatly enhanced by the presence of isopropanol. Such exposure may occur in the workplace.

4. **Synergism**: can have serious health effects. With synergism, exposure to a chemical may drastically increase the effect of another chemical. Examples are:
   - Exposure to both cigarette smoke and radon results in a significantly greater risk for lung cancer than the sum of the risks of each.
   - The combination of exposure to asbestos and cigarette smoke results in a significantly greater risk for lung cancer than the sum of the risks of each.

Factors Influencing Toxicity

The toxicity of a substance depends on the following:

- form and innate chemical activity
- dosage, especially dose-time relationship
- exposure route
- species
- age
- sex
- ability to be absorbed
- metabolism
- distribution within the body
- excretion
- presence of other chemicals

Systemic Toxic Effects

Toxic effects are generally categorized according to the site of the toxic effect. In some cases, the effect may occur at only one site. This site is referred to as the **specific target organ**. In other cases, toxic effects may occur at multiple sites. This is referred as **systemic toxicity**. Following are types of systemic toxicity:

1. **Acute Toxicity**

   Acute toxicity occurs almost immediately (hours/days) after an exposure. An **acute exposure** is usually a single dose or a series of doses received within a 24 hour period. Death is a major concern in cases of acute exposures. Examples are: In 1989, 5,000 people died and 30,000 were permanently disabled due to exposure to methyl isocyanate from an industrial accident in India. Many people die each year from inhaling carbon monoxide from faulty heaters. Non-lethal acute effects may also occur, e.g., convulsions and respiratory irritation.

2. **Sub-chronic Toxicity**

   Subchronic toxicity results from repeated exposure for several weeks or months. This is a common human exposure pattern for some pharmaceuticals and environmental agents. Examples are: Ingestion of coumadin tablets (blood thinners) for several weeks as a treatment for venous thrombosis can cause internal bleeding. Workplace exposure to lead over a period of several weeks can result in anemia.

3. Chronic Toxicity

Chronic toxicity represents cumulative damage to specific organ systems and takes many months or years to become a recognizable clinical disease. Damage due to subclinical individual exposures may go unnoticed. With repeated exposures or long-term continual exposure, the damage from these subclinical exposures slowly builds-up (cumulative damage) until the damage exceeds the threshold for chronic toxicity. Ultimately, the damage becomes so severe that the organ can no longer function normally and a variety of chronic toxic effects may result.

Examples of chronic toxic affects are:

- cirrhosis in alcoholics who have ingested ethanol for several years
- chronic kidney disease in workmen with several years exposure to lead
- chronic bronchitis in long-term cigarette smokers
- pulmonary fibrosis in coal miners (black lung disease)

4. Carcinogenicity

Carcinogenicity is a complex multistage process of abnormal cell growth and differentiation which can lead to cancer. At least two stages are recognized. They are initiation in which a normal cell undergoes irreversible changes and promotion in which initiated cells are stimulated to progress to cancer. Chemicals can act as initiators or promoters.

The initial neoplastic transformation results from the mutation of the cellular genes that control normal cell functions. The mutation may lead to abnormal cell growth. It may involve loss of suppresser genes that usually restrict abnormal cell growth. Many other factors are involved (e.g., growth factors, immune suppression, and hormones).

A tumor (neoplasm) is simply an uncontrolled growth of cells. Benign tumors grow at the site of origin; do not invade adjacent tissues or metastasize; and generally are treatable. Malignant tumors (cancer) invade adjacent tissues or migrate to distant sites (metastasis). They are more difficult to treat and often cause death.

5. Developmental Toxicity

Developmental Toxicity pertains to adverse toxic effects to the developing embryo or fetus. This can result from toxicant exposure to either parent before conception or to the mother and her developing embryo-fetus.

6. Genetic Toxicity (somatic cells)

Chemicals cause developmental toxicity by two methods. They can act directly on cells of the embryo causing cell death or cell damage, leading to abnormal organ development. A chemical might also induce a mutation in a parent's germ cell which is transmitted to the fertilized ovum. Some mutated fertilized ova develop into abnormal embryos.

Genetic Toxicity results from damage to DNA and altered genetic expression. This process is known as **mutagenesis**. The genetic change is referred to as a **mutation** and the agent causing the change as a **mutagen**. There are three types of genetic change: If the mutation occurs in a germ cell the effect is **heritable**. There is no effect on the exposed person; rather the effect is passed on to future generations. If the mutation occurs in a **somatic** cell, it can cause altered cell growth (e.g. cancer) or cell death (e.g. teratogenesis) in the exposed person.

Types of organ specific toxic effects are:

Blood and Cardiovascular Toxicity results from xenobiotics acting directly on cells in circulating blood, bone marrow, and heart. Examples of blood and cardiovascular toxicity are:

- hypoxia due to carbon monoxide binding of hemoglobin preventing transport of oxygen
- decrease in circulating leukocytes due to chloramphenicol damage to bone marrow cells
- leukemia due to benzene damage of bone marrow cells

Dermal Toxicity may result from direct contact or internal distribution to the skin. Effects range from mild irritation to severe changes, such as corrosivity, hypersensitivity, and skin cancer. Examples of dermal toxicity are:

- Dermal irritation due to skin exposure to gasoline
- Dermal corrosion due to skin exposure to sodium hydroxide (lye)

- Skin cancer due to ingestion of arsenic or skin exposure to UV light

Eye Toxicity results from direct contact or internal distribution to the eye. The cornea and conjunctiva are directly exposed to toxicants. Thus, conjunctivitis and corneal erosion may be observed following occupational exposure to chemicals. Many household items can cause conjunctivitis. Chemicals in the circulatory system can distribute to the eye and cause corneal opacity, cataracts, retinal and optic nerve damage.

For example:

- Acids and strong alkalis may cause severe corneal corrosion
- Corticosteroids may cause cataracts
- Methanol (wood alcohol) may damage the optic nerve

Hepatotoxicity is toxicity to the liver, bile duct, and gall bladder. The liver is particularly susceptible to xenobiotics due to a large blood supply and its role in metabolism. Thus it is exposed to high doses of the toxicant or its toxic metabolites.

Immunotoxicity is toxicity of the immune system. It can take several forms: hypersensitivity (allergy and autoimmunity), immunodeficiency, and uncontrolled proliferation (leukemia and lymphoma). The normal function of the immune system is to recognize and defend against foreign invaders. This is accomplished by production of cells that engulf and destroy the invaders or by antibodies that inactivate foreign material. Examples are: immunosuppression by cocaine

Nephrotoxicity The kidney is highly susceptible to toxicants for two reasons. A high volume of blood flows through it and it filtrates large amounts of toxins which can concentrate in the kidney tubules. **Nephrotoxicity** is toxicity to the kidneys. It can result in systemic toxicity causing:

- decreased ability to excrete body wastes
- inability to maintain body fluid and electrolyte balance

Neurotoxicity represents toxicant damage to cells of the central nervous system (brain and spinal cord) and the peripheral nervous system (nerves outside the CNS). The primary types of neurotoxicity are:

- neuronopathies (neuron injury)
- axonopathies (axon injury)
- demyelination (loss of axon insulation)
- interference with neurotransmission

Reproductive Toxicity involves toxicant damage to either the male or female reproductive system. Toxic effects may cause:

- infertility
- interrupted pregnancy (abortion, fetal death, or premature delivery)
- infant death or childhood morbidity
- chromosome abnormalities and birth defects
- childhood cancer

Respiratory Toxicity relates to effects on the upper respiratory system (nose, pharynx, larynx, and trachea) and the lower respiratory system (bronchi, bronchioles, and lung alveoli). The primary types of respiratory toxicity are:

- pulmonary irritation
- asthma/bronchitis
- reactive airway disease
- emphysema
- allergic alveolitis
- Pneumoconiosis
- lung cancer

4.6 Review Questions

1. What is occupational toxicology
2. Discuss toxicological health problem.
3. Explain dose-Response Relationships

CHAPTER FIVE

RECOGNITION OF OCCUPATIONAL DISEASES AND DISORDERS

5.1. Learning Objectives

At the end of this chapter, the student will be able to:

1. Identify the magnitude of the problems due to occupational injuries, disorders and diseases.
2. List epidemiological descriptions of Occupational related health problems.
3. List possible determinants of work related injuries.
4. Discuss the difference types of occupational disorder and diseases.
5. Explain prevention and control methods of Occupational disorders .
6. Describe the principles of disability evaluation methods.

5.2. Introduction

It is difficult to estimate the number of workers involved in meeting the energy requirements of communities. As noted, in poor communities much of this work is carried out by family members, particularly women, who are not formally employed. In addition, much of this work is carried out by small industries that are not always recorded in national employment statistics.

Occupational mortality rates in energy jobs in industrialized countries are generally 10-30 times lower than in developing countries (Kjellstrom, 1994; ILO, 1998), indicating that more effective prevention programs could eliminate more than 90 percent of the deaths referred to above. Still, energy-related jobs have inherent health risks that need to be considered when assessing the full impact of energy production and distribution.

Although too often ignored in discussions of environmental health risks, the burden of occupational disease and injury is substantial on a global scale. It is conservatively estimated that with well over 1 million deaths a year, nearly 3 percent of the global burden of ill health is directly attributable to occupational conditions (Leigh and others, 1996). This is substantial, accounting for more than motor vehicles, malaria, or HIV and about equal to tuberculosis or stroke. Although the fraction due directly to supplying energy is unclear, energy systems employ many millions of people worldwide in jobs substantially riskier than average-particularly in jobs producing solid fuels.

In the early days of the development of employment injury protection, attention was concentrated on accidents at work. It was only later that protection was widened to include diseases contracted during work processes. It proved difficult to define the diseases which ought properly to be within the protection of the employment injury law, while excluding common conditions which are prevalent among the general population.

Usually the national legislation contains a list of diseases which are, beyond dispute, of an occupational origin, at least when they are contracted by a person who has worked in a process, or in contact with a substance, which can cause the listed disease. In 1925 the International Labour Conference was able to agree on only three diseases which could be so prescribed - lead poisoning, mercury poisoning and anthrax. But research establishes new criteria of proof, and the accelerating development of industrial chemistry and physics brings in its train new hazards. Thus, the Employment Injury Benefits Convention, 1964 (No. 121), contained a list of 15 occupational diseases and the list was further revised in 1980 to include a total of 29.

In Ethiopia there is no systematized recording and reporting on work related injuries organized the national level. If there is, then only few manufacturing industries provide some information to the Ministry of Labour and Social Affairs. Hence, the data gathered from these few industries are incomplete and neither represents all industries nor show the actual magnitude of work related injuries of the country. The few studies carried out by individuals in Textile industries in 1991, 1988, and in tobacco factories, revealed an accident rate of 200/1000 person/ year, and 183/1000/year respectively. The only reliable study which can represent all the manufacturing industries in the one carried out in January 1988 in 105 manufacturing industries by the occupational health and safety sector, In this study, 11 corporations each representing a group of factories were studied for a year, using standardized work related injury reporting system adopted from ILO. In one year, a total of 13,796 accidents were reported making an over all work related accident rate of 178/1000 person/ year with a range varying from 10-390/1000 person/year, depending on the nature of industries. The highest work related accident rate was detected to be among the sugar plantation workers, followed by workers in Beverage, Textile and metal work industries. Out of these 0.08% were fatal, 46.2% moderate (injuries that required sick leave of a day or more) and 53.7% mild (injuries that did not require sick leave).

5.3. Epidemiology

1. Part of body affected, type, causes and day of the week of work related injuries

- Among the parts of body affected Brazilian steel workers, the commonest were hands; arms and eye.
- The commonest part of body affected among eleven industrial workers in Addis Ababa was fingers (37.3%) and hands (11.6%).
- In textile factory study in Addis Ababa, the most common part of body affected by work-related injuries were fingers (42%), lower leg (18.95), and hands (13.3%).
- Reports from Department of Environmental Health of Ministry of Health of Ethiopia listed eye, hand and finger as the most affect parts of the body.

Different studies have shown different causes of work-related injuries.

- According to the study done in eleven urban industries in Addis Ababa, hit by or against object and fall were the commonest causes of work-related injuries.
- Findings from textile factory study in Addis Ababa, demonstrated that the most frequent causes of work-related injury were machinery 42(29.4%), hit by or against objects 29 (20.3%).
- Department of Environmental Health of Ministry of Health of Ethiopia reported that striking (25.5%), falling (12.8 %) and flying objects from machines (8.5%) were the major causes of work-related injury.

Regarding the distribution of work-related injuries by the days of the week, most studies revealed:

- The highest injury rates occurred on Monday's and the lowest on Thursday's and Friday's.
- Absenteeism is higher on Monday's than other days of the week in most industrialized countries, which results in workers to stand in for absent workers and undertake unfamiliar jobs on that day.
- The most common time of injury is from 8 am to 10 am.

2. Factors related to work related injuries

- Many authorities believe that work-related injuries result from a complex interplay of multiple risk factors.

- Exposure to physical, mechanical and chemical hazards and the performance of unsafe practices by workers are the leading causes of work-related injuries.
- Similarly, psychosocial factors, work organization, socio demographic characteristics of workers and environmental and social conditions are other potentially risk factors
- Reports form France, U.S and China revealed that men have the highest rates of work-related injuries than women.
- Study done in eleven urban factories in Addis Ababa revealed that the highest rate of work-related injury was observed in the age group 15-19 years.
- Age groups less than 30 years were more affected by work-related injuries according to textile factory study in Addis Ababa (9).
- Ministry of Labour and Social Affairs of Ethiopia has reported that the majority (18 %) of work related injuries were observed in the age group of 25-29(27).These studies emphasized that work-related injuries in young subjects were more common due to lack of experience, lack of job knowledge and know-how than in other subjects. Furthermore, many workers begin working at an early age and often without safety training.

- Different investigations reported that low education status, low monthly salary, low working experience (5 years or less) in present job, lack health and safety training, sleep disorders, job category and alcoholic drink consumption were common risk factor for work-related injuries.

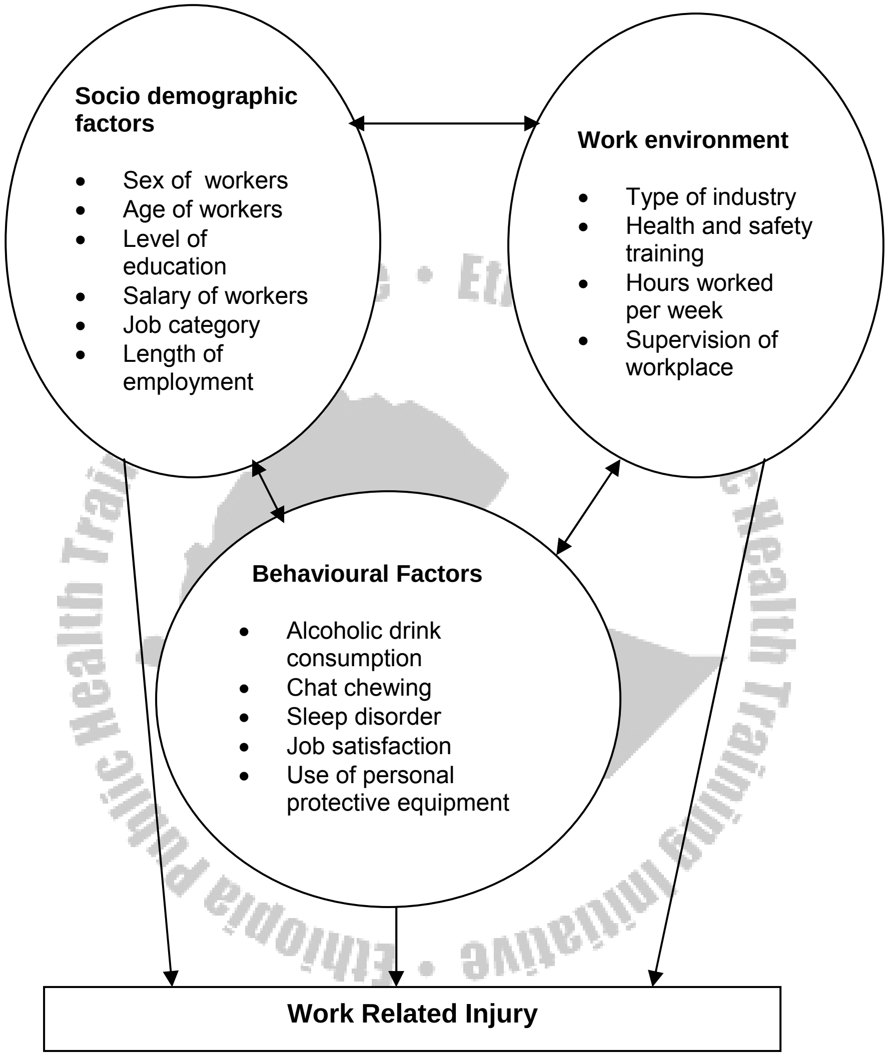


Figure 5-1. Determinants of work-related injuries-A Conceptual Framework for study of Work-related injury prevalence.

Source: Adapted from Ref.1

5.4. Occupational disorder by system

Respiratory Disorders

Work-related respiratory disease is frequently a contributory cause- and commonly a primary cause-of pulmonary disability. The clinical evaluation of pulmonary disease includes a minimum of four elements: 1/a complete history including occupational and environmental exposures, a cigarette-smoking history, and a careful review of respiratory symptoms; 2/ a physical examination with special attention to breath sounds; 3/ a chest x-ray with appropriate attention to parenchymal and pleural opacities, and 4/ pulmonary function tests.

Table 5-1 Major types of occupational pulmonary disease

Pathophysiologic process	Occupational disease example	Clinical history	Physical examination	Chest x-ray	Pulmonary function pattern
Fibrosis	Silicosis	Dyspnea on exertion, shortness of breath	Clubbing, cyanosis	Nodules	Restrictive or mixed obstructive and restrictive DLCO normal or decreased
	Asbestosis	Dyspnea on exertion, shortness of breath	Clubbing cyanosis, rales	Linear densities, pleural plaques, calcifications	
Reversible airway obstruction (asthma)	Byssinosis, isocyanate asthma	Cough, wheeze, chest tightness, shortness of breath, asthma attacks	Respiratory rate ↑, wheeze	Usually normal	Normal or obstructive with bronchodilator improvement Normal or high DLCO
Emphysema	Cadmium poisoning (chronic)	Cough, sputuma, dyspnea	Respiratory rate ↑ ↑ expiratory phase	Hyperaeration bullae	Obstructive low DLCO
Granulomas	Beryllium disease	Cough, weight loss, shortness of breath	Respiratory rate ↑	Small nodules	Usually restrictive with low DLCO
Pulmonary edema	Smoke inhalation	Frothy, bloody sputum production	Coarse, bubbly rales	Hazy, diffuse air-space disease	Usually restrictive with decreased DLCO, hypoxemia at rest

DLCO= diffusing capacity; ↑= increased.

Musculoskeletal disorders

Work-related musculoskeletal disorders commonly involve the back, cervical spine, and upper extremities. Understanding of these problems has developed rapidly during the past decade. Prevention of a low back pain is a complex challenge. Low back pain prevention in work settings is best accomplished by a combination of measures, such as: a/ Job design (ergonomics); b/ Job placement (selection); Training and education (training of workers, managers, labour union representatives and health care providers).

Prevention and Control

Job design (ergonomics)

- Mechanical aids
- optimum work level
- Good workplace layout
- Sit/stand workstations
- Appropriate packaging

Job placement (selection)

- careful history
- Through physical examination
- No routine x-ray
- Strength testing
- Job-rating programs

Training and education

Training workers

- Biomechanics of body movement (safe lifting)
- Strength and fitness
- Back schools

Training managers

- Response to low back pain
- Early return to work
- Ergonomic principles of job design

Training labour union representatives

- Early return to work
- Flexible work rules
- Reasonable referrals

Training health care providers

- Appropriate medication
- Prudent use of x-rays
- Limited bed rest
- Early return to work (with restrictions, if necessary)

Skin disorders

Any cutaneous abnormalities or inflammation caused directly or indirectly by the work environment is an occupational skin disorder. Work-related cutaneous reaction and clinical syndromes are as varied as the environments in which people work. Skin disorders are the most frequently reported occupational diseases. A basic understanding of occupational skin disorders is therefore essential for everyone involved in occupational health. Occupational skin diseases are often preventable by a combination of environmental, personal, and medical measures.

Eye disorders

Every working day, there are over 2,000 preventable job-related eye injuries to workers in the United States. Occupational vision programs, including pre-placement examinations and requirements for appropriate eye protectors in certain occupations, can prevent many of these injuries.

Symptoms and signs of serious eye injury

Symptoms of serious eye injury indicating immediate referral are the following:

1. Blurred vision that does not clear with blinking.
2. Loss of all or part of the visual field of an eye
3. Sharp stabbing or deep throbbing pain
4. Double vision

Signs of eye injury that require ophthalmologic evaluation are the following:

1. Black eye
2. Red eye
3. An object on the cornea
4. One eye that does not move as completely as the other
5. One eye protruding forward more than the other
6. One eye with an abnormal pupil size, shape, or reaction to light, as compared to the other eye
7. A layer of blood between the cornea and the iris (hyphema)
8. Laceration of the eyelid, especially if it involves the lid margin.
9. Laceration or perforation of the eye

Disorders of the Nervous System

The nervous system comprised of the brain, spinal cord, and peripheral nerves, is a complex system responsible for both voluntary and involuntary control of most body functions. These are accomplished through a process of receiving and interpreting stimuli as well as transmitting information to the effectors organs. The adverse impacts of stressors from the work environment (physical, chemical, and psychological) are experienced in a variety of ways. Of the many means by which these effects can be categorized, somewhat like arbitrary distinctions between neurology and behavioural effects on the one hand, and psychiatric effects on the other, to organize this information for the reader-ed

Prevention

Because work-related psychological disorders have been identified as a leading occupational health problem, NIOSH has proposed a national strategy to protect and promote the psychological health of workers. The strategy focuses mainly on reducing job stress and providing employee mental health services (see Annex 1).

Efforts to prevent stress-related disorders focus on ameliorating major areas of job stress; providing job security and career opportunity, a supportive social environment, and meaningful, creative, rewarding work; and making every effort to ensure worker participation in decision making and control of the work environment.

Reproductive disorders

The prevention of reproductive disorders is an important public health priority. These problems include abnormalities that affect the reproductive function of both men and women as well as a wide range of unwanted pregnancy outcomes. In the United States, approximately one in seven married couples is involuntarily infertile. On the same area among newborns, approximately 7 percent are of low birth weight (<2,500gm), and 3 percent have major congenital malformations.

There are two ways by which occupational specialists can prevent or reduce work-related health risks. The first is through patient education and counselling. The second is by intervening in the work place to reduce or eliminate deleterious exposures.

Cardiovascular disorders (CHD)

Risk factors associated with CHD can be divided into three categories: personal, hereditary and environmental. Personal risk factors include sex, age, race, high serum cholesterol, high blood pressure, and cigarette smoking. There are strong interactions between these factors that act synergic ally, such that a smoker with high blood pressure and high serum cholesterol is eight times more at risk developing CHD than a non smoker who has normal serum cholesterol and blood pressure.

While the association between personal risk factors and CHD is well documented, our knowledge of the role of occupational risk factors is still limited. Several chemical and physical agents have been suspected of causing CHD in workers chronically exposed to them.

However scientific evidence indicates a direct causal relationship for every few of them. For most of these agents, the evidence is based on isolated case reports or on a few unconfirmed studies.

Table 5-2. Personal risk factors associated with CHD

Risk factor	Feature
Sex	Mortality for women lags behind that of men by about 10 years
Age	Risk increases with age
Race	Before age 60, white men have lower death rates than non white men; the inverse is true after 60
High serum cholesterol	Risk estimated at 1.7-3.5
High blood pressure	Risk estimated at 1.5-2.1
Cigarette smoking	Risk estimated at 1.5-2.9

Hepatic Disorders

High-Risk Occupations

Occupations with exposure to hepatotoxins are found in huhumany different industries including munitions, rubber, cosmetics, perfume, food processing, refrigeration, paint, insecticide and herbicide, pharmaceutical, plastics, and synthetic chemicals. Usually these workers are exposed by inhalation of fumes. Most hepatotoxins have pungent odors that warn of their presence, preventing accidental oral ingestion of large amounts; however, ingestion of imperceptible amounts of hepatotoxins over long periods of time may cause injury. Skin over long periods of time may cause injury. skin absorption has been a significant cause of disease only with trinitrotoluene (TNT) exposure in munitions workers and with methylenedianiline exposure in epoxy resin workers.

Table 5-3 some causes of occupational liver disease

Disease produced	Type of agent	Example	Types of workers exposed
ACUTE HEPATITIS			
Acute toxic hepatitis	Chlorinated hydrocarbons	Carbon tetrachloride Chloroform	Solvent workers, degreasers, cleaners, refrigeration workers
	Nitroaromatics	Dinitrophenol (DNP)	Chemical indicator workers
		Dinitrobenzene	Dye workers, explosives workers
	Ether	Dioxin	Herbicide and insecticide workers
	Halogenated aromatics	Polychlorinated biphenyls (PCBs)	Electrical component assemblers
		DDT Chlordecone (kepone)	Insecticide workers, fumigators, disinfectant workers
		Chlorobenzenes	Solvent workers, dye workers
		Halothane	Anesthesiologists
Acute cholestatic hepatitis	Epoxy resin	Methylenedianiline	Rubber workers, epoxy workers, synthetic fabric workers
	Inorganic element	Yellow phosphorus	Pyrotechnics workers
Acute viral hepatitis, type B	Virus	Hepatitis B	Health care workers (see Chap. 18)
Subacute hepatic necrosis	Nitroaromatic	TNT	Munitions workers
HCRONIC LIVER DISEASE Fibrosis/cirrhosis	Alcohol	Ethyl alcohol	Imbibing bartenders, wine producers, whiskey producers
	Virus	Hepatitis B and C	Day care workers, health care workers (see Chap.18)
			Vintners, smelter workers
	Inorganic element	Arsenic	Vinyl chloride workers
	Haloalkene	Vinyl chloride	Vinyl chloride workers
Angiosarcoma	Haloalkene	Vinyl chloride	Rubber workers
Biliary tree carcinoma	Unknown agents	-	

Renal and Urinary Tract Disorders

The kidney is a target organ for a number of toxic chemical compounds. Renal excretion is the major route of elimination for many toxic compounds. The relatively high renal blood flow, about one-fourth of total cardiac output, exposes the renal structures to a relatively high toxic burden. Concentration of toxins in the glomerular ultra-filtrate through active re-absorption contributes further to the intensity of toxic exposures. The considerable endothelial surface represented by the extensive capillary network in the kidney, the presence in renal tubular cells of numerous important enzyme systems, the local synthesis of active peptides (for example, rennin and prostaglandin), and the generally high metabolic rate of the organ are additional factors increasing the vulnerability of the kidneys to chemical toxins. These agents can adversely affect the delicate balance between blood flow, glomerular filtration, tubular re-absorption, and filtrate concentration.

5.5. Disability evaluation and ability to work

Over the years, industrialized societies have taken two basic approaches to dealing with the problems of poverty and social isolation that frequently befall people with disabilities who have been unable to achieve gainful employment. One approach, disability compensation, provides income support for those who are unable to work because of a disability.

An increasingly popular approach seeks to promote the independence of people with disabilities to obtain rehabilitation services intended to facilitate or maintain employment and remove barriers to employment by regulating employment practices and workplace conditions that have tended to exclude people with disabilities.

Clinicians' effectiveness in dealing with work ability and disability evaluations will be enhanced by a clear understanding of (1) key definitions related to the evaluation process, (2) common features of insurance plans and antidiscrimination legislation affecting disabled workers, (3) the clinician's role in the evaluation of work ability, and (4) unresolved controversies and potential role conflicts for the clinician.

In reviewing the variety of compensation plans and the associated roles for the health care provider, it is important to recognize a few key concepts. Most important is the distinction between impairment and disability.

Impairment is commonly defined as the loss of function of an organ or part of the body compared to what previously existed. Ideally, impairment can be defined and described in purely medical terms and quantified in such a way that a reproducible measurement is developed (for example, severe restrictive lung disease with a total lung capacity of 1.6 litres).

Disability, on the other hand, is usually defined in terms of the impact of impairment on societal or work functions. A disability evaluation would therefore take into account the loss of function (impairment) and the patient's work requirements and home situation. Certain agencies use a more restrictive definition of disability; for example, the Social Security Administration defines disability as "inability to perform any substantial gainful work." Often, private disability insurance defines disability as an "inability to perform the essential tasks of the usual employment." However, the determination of disability is always predicated on an assessment of impairment, followed by a determination of the loss in occupational or societal functioning that result from the impairment. In general, the determination of impairment is performed by a health care professional (usually a physician); most often, non-physician administrators use this information to determine the presence and extent of disability.

Disability compensation systems frequently request a determination of the extent and permanence of a disability condition. An injured worker who cannot do any work because of a medical condition is considered to be totally disabled. If this person can work but has some limitations and cannot do his or her customary work, a partial disability exists. Either type of disability is considered to be temporary as long as a resolution of the disability is expected. When no significant functional improvement is expected, or a condition has not changed over a one-year period, it is inferred that a medical end-result (sometimes called maximal medical improvement) has been achieved. A temporary (partial or total) disability would then be regarded by most systems as a permanent disability.

Workers' compensation insurance systems usually require determination of the work-relatedness of a disability. A work-related injury or disease refers to conditions; however, it may be difficult to be certain of the relationship of the injury to the workplace is usually clear. In chronic conditions, however, it may be difficult to be certain of the relationship between work and disease. It is recommended that the physician's determination of work-relatedness should be based on the evidence of disease, the exposure history, and the epidemiologic evidence linking exposure and disease.

Health professionals must be aware, however, that the legal definition of cause may be less exacting than the medical definition, and that most disability systems are based on the legal standard. One legal definition of a work-related condition is one "… arising out of or in the course of employment" or "caused or exacerbated by … employment". Thus, a pre-existing condition, unrelated to work, that becomes substantially worse because of work may legally be work-related. A typical legal standard of proof is that a condition is work-related if it is "more likely than not" that the condition would not have been present or would have been substantially better had the work exposure not occurred.

Disability compensation systems

Some of the confusion regarding disability assessment stems from the multitude of disability compensation systems and plan, since each may have its own definition of disability and criteria for assessing impairment. Different countries have designed verifying approaches to providing income security to those who find their wage-earning capacity compromised by injury or disease.

Occupational physicians are most familiar with workers' compensation insurance, which provides coverage of most federal, state, and private employees. These plans compensate for medical expenses and lost wages due to work-related conditions.

The federal government sponsors the major compensation programs for the severely disabled, through Social Security Disability Insurance. These programs pay a limited amount of compensation to those who are unable to achieve any gainful employment, regardless of the cause of disability.

Private disability insurance is often purchased by individuals or provided as an employer or union benefit and is designed to provide compensation for those who are unable to work at their regular jobs regardless of the cause of disability, or to supplement Social Security benefits.

Thus, a patient who can no longer work because of injury or illness might receive support from his or her employer's insurer, a federal or state agency, and /or an insurance policy that has been purchased privately.

Although each plan has different eligibility criteria and levels of payment, all share a few common features:

1. Every plan incorporates shared risk. Many people or employers at risk of financial losses contribute to a pool, from which a few individuals are reimbursed. The cost of entering the pool is partially determined by the actuarial risk of future events for that person or insured group. Thus, private disability insurance is much more expensive per year for a 55-year-old than for a 20-year-old, since the older worker has a higher risk of disabling medical illness. Workers' compensation insurance is more expensive per employee for a construction company (higher risk of injury to employees) than for a stock brokerage firm.
2. Because payments into the pool are predictable, finite resources are available to all potential recipients of each plan. Therefore, eligibility criteria are structured so that the limited resources go to those in greatest need. Workers' compensation plans often do not replace lost wages for fewer than 6 days of absence from work, since doing so might greatly increase the cost of the program. Many private disability insurance plans do not begin coverage until 30 days to 6 months of illness absence has occurred.
3. Before medical evaluation of impairment, a potential recipient of benefits must first demonstrate legal eligibility. The basis for eligibility is different in each plan. One must have worked and contributed to Social Security for 5 of the past 10 years. Workers' compensation covers only regular

employees, not consultants or subcontractors. Private disability insurance often does not cover illness that occurs during the first 60 to 90 days of enrolment.

4. Medical information on impairment is requested once a legal basis for a claim has been established. In every system, a medical diagnosis is necessary; in the worker's compensation system, physicians are often asked their opinions on the work-relatedness of employees' conditions, the prognosis for eventual return to work, and the restrictions or job accommodations that might be necessary to return the worker to employment.
5. The information from the physician, however, does not determine whether benefits are awarded or how much is paid; all of these systems are under administrative control. In the Social Security system, an administrator-physician team reviews medical information from the evaluating physician and compares it with specific criteria for eligibility. In the worker's compensation systems, if there is a significant discrepancy between the employer's report of an injury and the physician's report, benefits may be withheld pending an investigation by the insurance company.
6. Benefits are limited and are intended to provide only a proportion of lost wages, medical expenses related to the specific impairment, and vocational rehabilitation. Only in rare circumstances are worker's compensation benefits intended to punish gross negligence by an employer in causing the injury; in all other instances, fault has no bearing on benefit levels.

7. Applicants generally have a right of appeal of an administrative or medical decision, with review by a third party. In the Social Security system, applicants who are initially denied benefits can appeal to a second administrator-physician team, then to an administrative law judge, and finally to the federal courts, if desired. In most worker's compensation plans, the claimant can request an administrative hearing and be represented by an attorney. The agencies that provide benefits also conduct periodic reviews of cases to verify that continued eligibility (disability) exists.
8. Recently, there has been an increased emphasis on developing resources for retraining and rehabilitation, closely allied with each system. Beneficiaries are often required to participate in programs to maximize their potential for return to alternative, gainful employment.

The purpose of each plan is to reimburse workers for medical expenses, rehabilitation expenses, and lost wages that result from a work-related injury or illness. Plans are generally designed to be non-adversarial so that, in most cases, limited benefits are paid to injured workers without the necessity of a formal hearing. In most cases of acute traumatic injuries (for example, fractures or lacerations occurring at work), the relationship to work is unquestionable and the system works reasonably well at compensating the injured worker. In many cases, however, the relationship to work is less clear, and the demand on the clinician more complicated, as the following case illustrates.

A 50-year-old truck driver followed by his physician for 6 years because of chronic low back pain came to the physician stating "I cannot take it anymore." Although he could not recall a specific injury, he found that the requirements of driving a long-haul tractor trailer caused him severe discomfort that was no longer relieved by rest or analgesics. His back discomfort generally improved while he was on vacation but was clearly aggravated after more than 2 hours of driving or after any heavy lifting (at home or at work). He had been out of work for one week because of his discomfort and required a note from the physician before returning to work. Physical examination revealed a mild decrease in forward flexion. X-rays were consistent with osteoarthritis of the spine. The patient wanted to know the physician's opinion on whether his back problems were due to his work as a truck driver, whether he should change his vocation because of his discomfort, and whether he should file a workers' compensation claim for work-related injuries.

The case illustrates some of the difficulties in evaluating and treating the patient with work in capacity. The patient went to the physician because his back discomfort was interfering with his ability to do his job. Like most patients with chronic low back pain, his symptoms and examination findings were non-specific. The standard recommendations of rest and avoidance of exacerbating activities met with transient success, but his symptoms reappeared with his return to work. It is logical at this point to explore with the patient any opportunity for job accommodations at work, and, if no alternatives are available, for him to seek employment that would not exacerbate the symptoms. The patient, for a variety of reasons, however, may be reluctant to consider changing to another line of work, despite the discomfort associated with the current job.

With regard to causality, the high prevalence of non-specific low back pain in the general population and the multi-factional etiology of this common condition make it impossible to say with medical certainty that this patient's back discomfort was caused in its entirety by his work. Several epidemiologic studies, however, have linked truck driving with a higher incidence of chronic disabling low back pain and have attributed this increase to excessive vibration, sitting, and heavy lifting. Despite medical uncertainty, it is likely that most compensation systems would recognize this patient's low back pain as a condition that is aggravated by work and that the patient's medical bills and lost wages related to his back pain would be converted by workers' compensation insurance.

A patient with severe chronic lung disease was being evaluated for disability under Social Security. His exposure history was significant for occupational exposure to asbestos and non-occupational exposure to cigarette smoke. His physical examination, chest x-ray, and pulmonary function tests were consistent with diagnoses of (1) severe obstructive lung disease and possible restrictive lung disease, and (2) asbestos-related pleural plaques.

The patient's occupational exposure to asbestos might have played a small etiologic role in the development of pulmonary insufficiency.

It is worth noting, however, that this would have no effect on the patient's application for SSDI.

Steps in the Disability Evaluation Process

The following questions are involved in disability evaluation:

1. What is the patient's medical diagnosis?
2. Does the individual have any impairment is present, is it temporary or permanent?
3. What is the extent of any impairment?
4. Is the patient's impairment or disease caused or aggravated by work?
5. What is the impact of this impairment on the individual's ability to obtain employment in specific occupations and to perform specific jobs? Might accommodations allow for employment?
6. What other sources of information on work capabilities or possible accommodations should be considered?
7. In consideration of the answers to the previous questions, to what, if any, economic benefit is the individual entitled?

In workers' compensation and in private insurance disability cases, the physician is often asked whether the impairment is disabling and to describe how the impairment impedes the performance of usual job tasks. A clear job description is the basis for evaluating whether the employee can perform the essential functions of the job. Often, this cannot be determined without knowing what accommodations at work might be available. Thus, in the second case, it cannot be determined whether the patient is totally disabled until it is known whether any alternate work or accommodations are available. The same considerations apply to determining disability for private insurance. A visit to the workplace usually will resolve the lack of clarity that frequently is present in standard job descriptions and may have an important role in encouraging an employer to provide accommodations for the disabled employee.

Most insurance systems reimburse individuals for loss of earning capacity caused by objective impairment. It is often difficult to determine whether sufficient impairment exists for one to qualify for benefits under a given plan. Physicians usually lack the experience, technical facilities, and ability to accurately estimate vocational potential; in these situations, early involvement with a qualified vocational rehabilitation specialist is worthwhile. Specialized skills and a broad database are required to predict residual caring capacity when an employee is no longer able to return to previous work. For example, factors related to worker autonomy, such as the availability of self-paced work, educational and experience levels, and self employment, have been shown to be more important in determining disability status in patients with rheumatoid arthritis than the extent of medical findings.

In workers' compensation plans and in most private disability plans, the treating or reviewing physician is required only to determine that the impairment is sufficient to prevent work. However, in the Social Security, Veteran's Administration, and Black Lung programs, there are often specific criteria for impairment that determine whether one is eligible for benefits, which vary from plan to plan. For example, the Black Lung and Social security programs have threshold pulmonary function values; if an applicant's lung function is better than the threshold, then he or she does not qualify for disability. In the veteran's Administration system, the degree of lost function is expressed as a percentage of total lung function. Benefits are assigned based on the percentage of function lost; in contrast, the Social Security and Black Lung programs usually provide a fixed amount of benefits only if a worker is totally disabled according to the threshold criteria. Physicians are often frustrated with the arbitrary nature of the determination process. Under these criteria, some individuals with truly disabling impairments will be refused compensation, while others capable of gainful employment will receive benefits.

5.6. Review Questions

1. What variables would you use to measure the magnitude of the problems due to occupational health?
2. What are the determinant factors for work related injuries?
3. Describe what occupational disorders mean?
4. Describe what occupational diseases mean?
5. Explain the principle of disability evaluation?
6. List the challenges of disability evaluation
7. List the preventive and control measure of Occupational disorders?

CHAPTER SIX

SMALL-SCALE ENTERPRISES AND INFORMAL SECTORS IN ETHIOPIA

6.1. Learning objectives

At the end of this chapter, the student will be able to:-

1. Define small-scale enterprises and informal sectors
2. Describe the common problems of SSE and IS
3. Discuss the general actions to be taken on SSE and IS

6.2. Introduction

Most workers in developing countries like Ethiopia are employed in small industrial or agricultural setting. Small-scale industrial and service enterprises often have few resources, heavy workloads and multiple tasks for each worker. Work usually takes place in an environment that does not always meet required standards. Family members of the entrepreneurs and workers, including children, pregnant women and elderly people, share the work in small-scale enterprises, such as home industries, small farms and cottage industries, particularly in developing countries. In such situations, most workplace exposures also affect family members because most of the time is spent in the combined home and work environment.

The ccommon features of these enterprises and informal sectors are:

- There is no clear boundary between the working and the living environment
- Unsafe building or work places which are often associated with poor working designs, which may have inadequate light and ventilation
- Unsatisfactory hygiene and sanitation facilities
- Cramped and ergonomically inadequate work spaces and safety
- The work processes involve often low technology and budget which are operated by employees with limited training and education
- Protective clothing such as respirators, gloves, apron, boot and other safety equipment are seldom available or used
- Inappropriate working hand tools and equipment
- Poor access to information, lack of knowledge about hazards, their effects and control measures, low degree of mechanization
- Majority of them have no permit.
- Employment and insurance polices are nil.
- Management of health is absolutely unknown.
- Vocation and salary is absolutely unknown.
- Low capital resources
- Not followed for compliance by regulation.

6.3. Types of small scale enterprises and informal sectors

Examples of some small-scale enterprises and informal sectors where the inspection, education and evaluation of the Sanitarian is needed are. However, some of these could also be considered large enterprises in some areas.

1. Tannery (SSE)
2. Pottery (IS)
3. Wickery (wickerwork) (IS)
4. Bakery (SSE)
5. Weaver (IS)
6. Oil-seed crushers (SSE)
7. Blocket, pipe, tile makers (IS)
8. Stone crushers (IS)
9. Brick-makers (IS)
10. Carpentry (IS)
11. Welders (IS)
12. Miller (IS)
13. Garage (SSE)
14. Glass cutters (IS)
15. Butchers (IS)
16. Blacksmith (IS)
17. Charcoal producers ((IS)
18. Carpet makers (IS)
19. Dairy farm (IS)
20. Chicken farm (IS)

21. Soap makers (IS)
22. Bee farm (honey) (SSE)
23. Animal fattening farm (SSE)
24. Mining (SSE)
25. Foundries (SSE)
26. Grinding (IS)
27. Boiling (IS)
28. Painting and paint making (IS)
29. Dying and dye products (SSE)
30. Quarrying (IS)
31 Cutting (IS)
32. Burning (IS)
33. Cleaning (IS)
34. Digging a hole (shallow well)(IS)

Example :health hazards associated with pottery

a. Clay soil digging

- Falling
- Mechanical accidents
- Land sliding (collapse)
- Diseases from soil such as Tetanus, URTI, Pneumoconiosis, Silicosis, Asbestosis
- Poisoning - Arsenic, lead, silica.

b. Clay preparation

- The raw clay prepared by burning as the result there may be
- Air pollution
- Heat
- Dust
- Fume.

c. Clay forming (shaping)

Since they do have direct contact with water

- Water related disease
- Food borne diseases

d. Clay drying

- Heat
- Burn
- Cram
- Rash (excessive heat)

e. Firing and glazing

- Air pollution
- Accidents (falling)
- Psychological problem.
- Poisoning
- Lack of transportation for market is the cause for fatigue and other health problems.
- Low selling price.
- Deforestation

6.4. General action on small-scale enterprises and informal sectors.

1. Survey must be made on
   - Types
   - Numbers
   - Potentiality of resources in terms of money
   - Problem
   - Economical
   - managerial
2. What type of
   - Organization
   - Establishment
   - Cooperation
   - Communication
   - Transportation
3. On job and off job training
4. Provision of health facilities.
   - Basic environmental sanitation.
   - Hospitals, Health center, clinics /health post/
   - Nutritional counseling.
5. General and Health education on
   - Scientific facts
   - Technologies
   - Production and marketing.
   - Salary and transaction
   - Employment

6.5. Review Questions

1. What are the main differences between small-scale enterprises and informal sectors?
2. What are problems of SSE and IS?
3. What are actions to be taken to improve the status of SSE and is in Ethiopia?
4. Mention the health hazards associated with pottery and tannery?
5. Prepare a checklist and conduct survey on small scale enterprise and informal and

CHAPTER SEVEN
EVALUATION OF OCCUPATIONAL HEALTH AND SAFETY HAZARDS

7.1. Learning objectives

At the end of this chapter, the student will be able to:

1. Define the objectives of hazard evaluation in workplace.
2. Explain methods used to evaluate workplace hazards
3. Discuss types of sampling
4. Interpreter the results

7.2. Introduction

The previous chapters briefly traced the concepts of occupational health and safety. Moreover, the type of hazards in the workplace and how they happen were discussed. Following this it will be logical to discuss in s how we can actually evaluate the hazards in the work place. In this chapter we will discuss instrumentation and scientific or non scientific methods of evaluating the nature and extent of some health problems arising in occupational setting.

Health and safety issues are concerned with the evaluation of the human workforce, and the design of the working environment to obtain maximum satisfaction in productivity, and workers' health, safety and well being. The recognition and subsequent identification of the specific contaminants (dust, fume, gas, vapor, mist, microorganisms, and sound pressure level etc) is the first stage in the sequence. A number of spot check devices are used such as detector stain tubes for gases, or in the case of noise, a sound pressure meter.

Once the contaminants have been identified, it is necessary to measure the extent of the contamination. Evaluation is an important part of the procedure for measurement. Measured level of contamination must be compared with existing hygiene standards (always assuming there is such a standard applicable to the material in question), such as exposure limits, control limits and recommended limits. In addition, the duration and frequency of exposure to the contaminants must be taken into account. Following a comprehensive evaluation, a decision must be made as to the actual degree of risk to workers involved. This degree of risk will determine the control strategy to be applied.

7.3. Evaluation of occupational hazards

The basic principles to evaluate occupational health and safety hazards, and the philosophical basis for establishing safe levels of exposure to chemical, physical and biological agents is based on evaluation of occupational environment.

Evaluation can be defined as the decision making process that results in an opinion as to the degree of risk arising from exposure to chemical, physical, biological, or other agents. It also involves making a judgment of the magnitude of these agents and determines the levels of contaminants arising from a process or work operation and the effectiveness of any control measures used.

- **Method of sampling**

Grab Sampling Vs integrated Sampling

Air sampling can be conducted for long or short periods depending upon what type of information is needed.

Instantaneous or grab Sampling is the collection of an air sample over a short period whereas longer period of sampling is called integrated sampling.

1. Grab samples represent the environmental concentration at a particular point in time. It is ideal for following cyclic process and for determining air- borne concentration of brief duration but it is seldom used to estimate eight-hour average concentration.
2. In integrated sampling, a known volume of air is passed through a collection media to remove the contaminant from the sampled air stream. It is the preferred method of determining time weighted averages exposure(.explain)

- **Types of sampling**

Area or environmental sampling Vs personal sampling

Environmental sampling includes sampling for gases, vapors, aerosol concentrations, noise, temperature etc. Which are found on the worker or the general work area or environment.

Area or general room air samplings are taken at fixed locations in the work place. This type of sampling does not provide a good estimate of worker exposure. For this reason it is used mainly to pinpoint high exposure areas, indicate flammable or explosive concentrations, or determine if an area should be isolated or restricted to prevent employees from entering a highly contaminated area.

Personal sampling

The objective of personal sampling is to see the extent of exposure of the person working on a particular contaminant while he/she is working at a location or work place. For example, if the worker is working in a garage where cars are painted the area as a whole is sampled to see how much lead which is present in all car paints, is on the air but with personal sampling one can determine how much are inhaled by the person performing the work or those who are working near by. In short it is the preferred method of evaluating workers exposure to air contaminants.

Health surveillance

The Occupational Health and Safety act requires medical surveillance of workers for the protection of worker's health At its simplest health surveillance might just be to keep medical records but there is also sophisticated tests that can be used

Biological measurements

Biological effect measurements

- Medical tests e.g. Kidney function tests, Lung function tests, Chest x-rays, etc.
- Biological Sampling

Biological sampling provides us with different information than air sampling. It indicates exactly what has been absorbed into the body rather than what is in the environment. Biological Sampling can be defined as the measurement of a substance or it's metabolites in body tissues or fluids to assess the working environment or the risk to exposed workers.

7.4 Measurement of occupational hazards

a. Particulate matter measurement

To measure dust exposure, it is necessary to determine the composition of dust that are suspended in the air where workers breathe. Operation that involves the crushing, grinding, or polishing of minerals or mineral mixtures frequently do not produce airborne dusts that have the same size composition.

When air samples are collected in the immediate vicinity of dust producing operation, larger particles that have not yet had time to settle from the air may be collected. If a larger number of these particles appear in the dust sample, the effect of their presence may have to be evaluated separately.

To evaluate either the relative hazard to health posed by dusts or effectiveness of dust control measures, one must have a method of determining the extent of the dust problem. Ideally the method employed should be as closely related to the health hazard as possible. The basic methods are briefly discussed below.

1. Count Procedure

The concern of industrial hygienists has been to measure the fraction of dust that can cause pneumoconiosis. Since it has been recognized that only dust particle smaller than approximately 10 micrometer are deposited and retained in the lung method were sought to measure the concentration of these tiny particles. Microscopic counting of dust collected has long been used for this purpose.

2. " Total" Mass Concentration Method

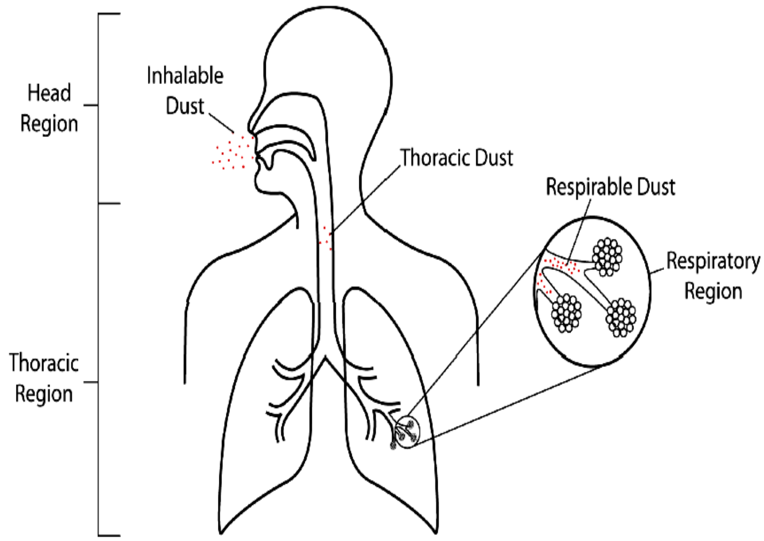
The simplest method of measuring dust concentration is to determine the total weight of dust collected in a given volume of air. The "total" mass, however, is determined to a considerable extent by the large dust particle, which can not penetrate to the pulmonary space and cause adverse health effect. Thus the total dust concentration by weight is not a reliable index of "respirable" dust concentration. This is because in this method of measurement the proportion of dust that is small enough to penetrate into the pulmonary space (respirable dust 2.5-micrometer) is extremely variable ranging from 5 percent to 60 percent.

3. Respirable Mass Size Selection Measurement (Personal sampling)

When measuring respirable dust the method now commonly used is personal or breathing zone respirable mass sampling? Dust collection devices now available for this method of sampling also provide a means for a size frequency analysis of the collected dust.

Respirable mass samples are preferably taken over a full 8 hour shift. However, multiple, shorter period samples (over a 2-4 hour period) may be collected during an individual full shift period.

In general, any dust particle producing activity will have respirable dust. For example road construction, cotton ginning, stone crushing and milling site, farm sites etc all produce same amount of dust. By practice 30-40% of dust are respirable. Even if we cannot measure the particle size using instrument, we can tell by the mass produced in a certain work site that the worker is exposed to respirable dust particle.



Air sampling instruments

The sampling instruments are geared to the type of air contaminants that occur in the work place that will depend upon the new materials used and the processes employed.

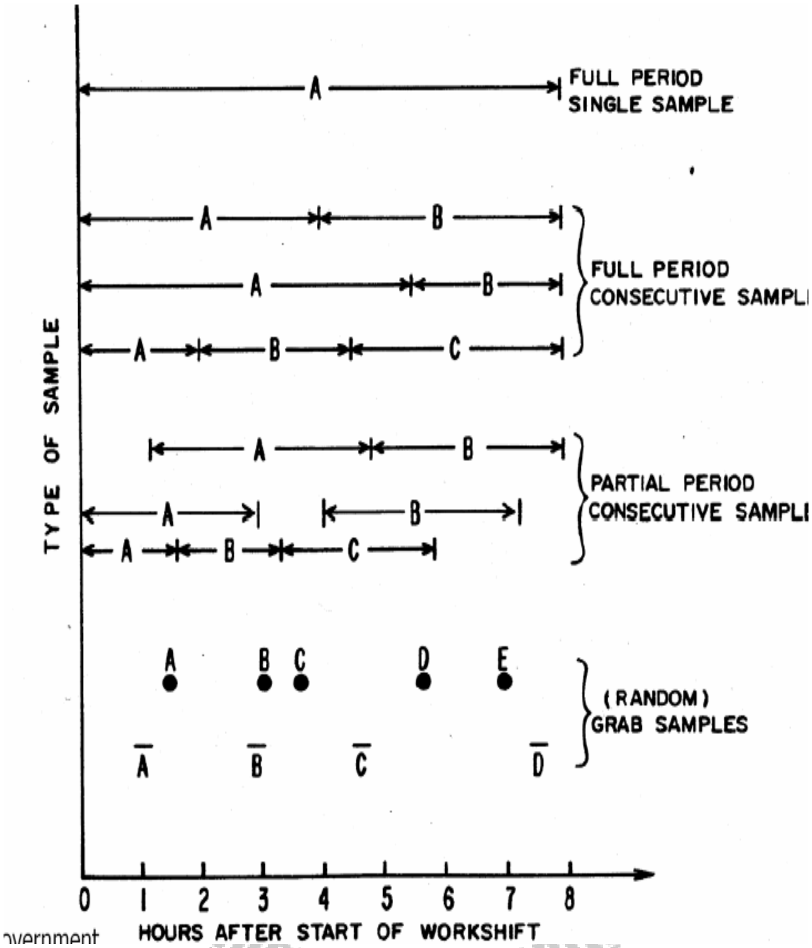
Air contamination can be divided into two broad groups depending upon physical characteristics.

- Gases and vapors
- Particulate

Type of Air Sampling

The type of air sampling to be used depends upon a number of factors.

- The type of sampling
- The equipment available
- The environmental condition
- The nature of the toxic contaminants


FULL PERIOD
SINGLE SAMPLE
FULL PERIOD
CONSECUTIVE SAMPL
PARTIAL PERIOD
CONSECUTIVE SAMPL
(RANDOM)
GRAB SAMPLES
TYPE OF SAMPLE
0 1 2 3 4 5 6 7 8
HOURS AFTER START OF WORKSHIFT

b. Noise Evaluation

The purposes of a detailed noise survey are:

1. To obtain specific information on the noise levels existing at each employee Workstation
2. To develop guidelines for establishing engineering and/or administrative Controls.
3. To define areas where hearing protection will be required.
4. To determine those work areas where audiometric testing of employees is desirable and/or required.

Surveys will help us to determine:

- Whether noise problems exist or not;
- How noisy is created in each work place or station,
- What equipment or process is producing the noise,
- Which employees are exposed to the noise often,
- Duration of exposure to the noise, etc.

Therefore, for evaluation purposes noise measurement is conducted using such strategy such as:

1. Measuring noise levels using area measurement methods
2. Work station measurement

Sound Survey

Sound measurement falls into two broad categories.

1. Source measurement
2. Ambient-noise measurement

Source measurement involves the collection of acoustical data for the purpose of determining the characteristics of noise radiated by a source.

Ambient noise measurement ranges from studying a single sound level to making a detailed analysis showing hundreds of components of complex variations.

Because of the fluctuating nature of many industrial noise levels, it would not be accurate or meaningful to use a single sound level meter reading. For this reason a preliminary and a detailed noise survey has to be conducted in the industry.

There are wide assortments of equipment available for noise Measurement. Some of these instruments are:

1. Sound Survey meter / Sound level meter/
2. Octave band analyzers
3. Narrow band analyzers
4. Tape and graphic level recorders
5. Impact sound level meters

6. Dosimeter

For most noise problems encountered in industries, the sound level meter and octave band analyzer, and if available noise dosimeter provide ample information.

Sound level Meter/Sound survey meter/

This is one of the basic instruments used to measure sound pressure variations in air. This instrument contains a microphone, an amplifier with a calibrated attenuator, a set of frequency response networks, and an indicating meter. It is an electronic voltmeter that measures the electrical signal emitted from a microphone attached to the instrument. Exposure duration at workstation where the regular noise levels varies above 85 dBA.

Assessing the thermal environment Heat stress

This is a real challenge as there is not only one but four environmental parameters which must be considered. The extent of stress suffered depends on:

Air temperature: commonly what we would call the room temperature. At its simplest we could measure it with ordinary mercury in glass thermometer.

Radiant Temperature: This is measured by using a globe thermometer. This consists of a hollow copper sphere measuring about 15cm in diameter, and painted black. A mercury-in-glass thermometer is inserted into the sphere to a point such that the bulb of the thermometer is at its center. Radiant heat is absorbed by the sphere, which gives this as a higher reading.

Humidity:

The classical instrument for determining humidity is the whirling hygrometer. It contains two thermometers side by side. The bulb of one thermometer is covered with a wetted fabric, whereas that of the other is left dry. As the instrument is whirled the water evaporates from the fabric and the evaporative effect cools the thermometer bulb referred to as the wet-bulb thermometer. The wet bulb reading is usually lower than the dry bulb reading. The differences between these two thermometers depend upon the amount of moisture already in the air. The greater the difference between the thermometers the drier the air and the greater the potential to cool down through sweating.

Air movement

This is commonly measured with hot wire anemometers and vane anemometers. The older but still very accurate instrument is the kata thermometer.

Kata thermometer: This is an alcohol filled thermometer with a large bulb coated with silvery material. When used, the bulb is heated in warm water until the alcohol rises into the upper reservoir. Then the bulb is dried with a clean dry cloth and suspended in the air. The time the alcohol takes to fall from the upper limit to the lower limit on the stem is timed using a stopwatch. From the cooling time, the dry-bulb temperature and the kata factor, which is usually printed on the stem, air speed can be read from the monogram provided with the instrument.

Illumuinance

Use photocells based upon silicon or selenium and they also incorporate colour-correcting filters to match the sensitivity of the human eye. The photocell also needs to be cosine corrected. Without this, light arriving at glancing angles is underestimated.

7.5. Questions and Exercises

1. What variables would you use to determine the level of safety in a given Occupational settings?
2. Take a walk around your college or university. Assess the safety of your campus. Look at traffic, lighting, accessibility, indoor air, obstruction, classroom conditions, sanitation, and related factors. Make suggestions to improve the safety of campus and submit the suggestions to the responsible body in your campus.
3. Explain the difference between grab sampling and integrated sampling?
4. How can you evaluate the level of noise in occupational setting?
5. Mention the occupational exposure to noise in your college or university "Community".
6. Evaluate your classroom in terms of biological hazard, noise, dust, ergonomic and other physical hazards.

CHAPTER EIGHT

PREVENTION AND CONTROL OF OCCUPATIONAL HEALTH AND SAFETY HAZARDS

8.1. Learning objectives

At the end of this chapter, the student will be able to

1. Describe the objectives of prevention and control of occupational health and safety hazards.
2. Explain the prevention and control methods of Occupational hygiene.
3. List types and importance of personal protective equipment
4. Discuss the difference between local exhaust ventilation and general ventilation
5. Explain the reasons for misutilization of personal protective equipment.

8.2. Introduction

Occupational diseases and injuries are, in principle, preventable. Among the approaches to prevent these include, developing awareness of occupational health and safety hazards among workers and employers assessing the nature and extent of hazards, introducing and maintaining effective control and evaluation measures. These approaches are undertaken by employers, workers and the government. This can range from encouragement by appropriate individuals or agencies outside the specific workplace to the promulgation and rigorous enforcement of occupational health and safety regulations. Working conditions, type of work, vocational and professional status, and geographical location of the workplace also have a profound impact on the social status and social wellbeing of workers. Historically, occupational health programmes have been developed hand-in-hand with the improvement of social conditions for underserved and unprivileged workers.

The classic occupational hygiene model of controlling a hazard, indicates that the ideal situation is to prevent exposure altogether. This is known as control at the source and utilizes substitution or enclosure of the hazard, as well as other means. If this can not be achieved, exposure should be reduced along the path, through ventilation, protective barriers, or related measures, only thirdly, should exposure be controlled at the person, using personal protective equipment, administrative controls, or other primary prevention measures such as training or even biological measures such as immunization. The final measure of controlling a hazard is secondary prevention, i.e. early detection of effects of exposure and subsequent remediation.

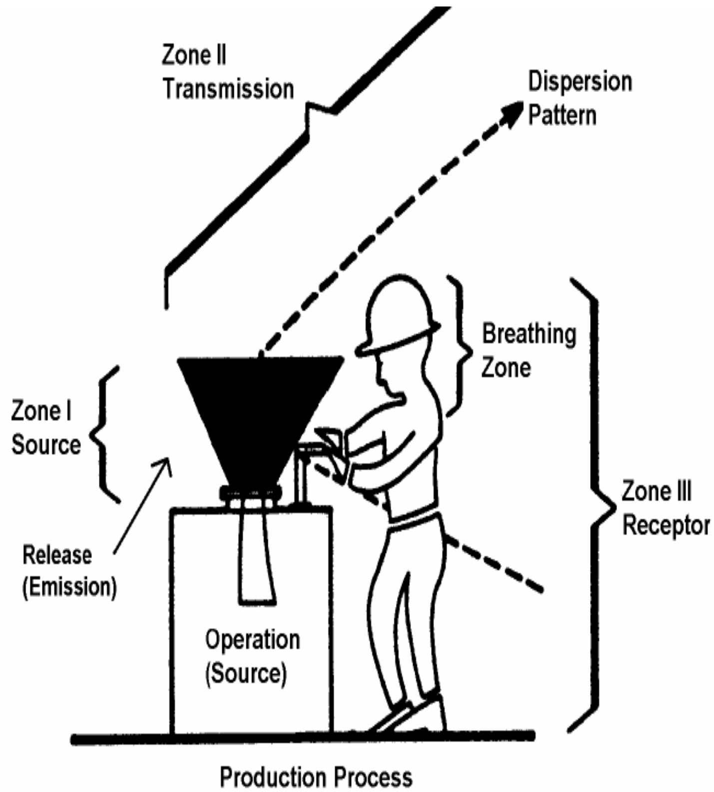

Zone II
Transmission
Dispersion
Pattern
Breathing
Zone
Zone I
Source
Zone III
Receptor
Release
(Emission)
Operation
(Source)
Production Process

Table 8-1: General diagram of methods of control

Source	Air path	Receiver
1. Substitution with a less harmful material (water in place of organic solvent) 2. Change of process(Airless paint spraying) 3. Enclosure of process (Glove-box) 4. Isolation of process space of time. 5. Wet methods (hydro Blast) 6. Local exhaust ventilation(capture at source) 7. Adequate maintenance program	1. House Keeping (immediate clean up) 2. General exhaust ventilation (Roof fans) 3. Increase distance between source and receiver (semi automatic or remote control) 4. Dilution ventilation (supplied air) 5. Continuous area monitoring (pre-set alarms) 6. Adequate maintenance program	**1. Training and education** 2. Rotation of workers (split up dose) 3. Enclosure of workers (air conditioned crane cabs) 4. Personal monitoring devices (Dosimeters) 5. Personal protective devices9respirators) 6. Adequate maintenance program.

Source: Barbara, A.P. Fundamental of industrial hygiene united States of America: National Safety Council, 1988.

To determine the extent of the exposure, locate the contaminant source, its path to the employee, and the employee's work pattern and use of protective equipment.

8.3. Hierarchy of Prevention and control methods

Generally, there are five major categories of prevention and control measures: elimination, substitution, engineering controls, administrative controls and personal protective equipment.

1. Elimination

Eliminating the hazard completely is the ideal solution, but it is seldom easy to achieve. Usually there are good reasons why a process or operation has to be carried out and why it has to be done in a certain way. Elimination therefore challenges to find an alternative method of achieving the same goals. Some of the barriers commonly encountered are as follows:

The quality of the product may have a service life of many years, and even a small defect in quality could cause it to fail in use. This might lead to liability claims. Sometimes quality standards may also have been set or approved by the customer or a regulatory authority. Applications to change the production method may then be difficult or expensive.

The cost of the product may be increased. Raw materials or energy costs may be higher or the production time may be increased if the new method is slower.

It is important to consider workers health and safety when work processes are still in the planning stages. For example, when purchasing a machine, safety should be the first concern but not cost.

Machines should confirm to national safety standards – they should be designed with the correct guard on them to eliminate the danger of a worker getting caught in the machine while using it. Machines that are not produced with the proper guards on them may cost less to purchase, but cost more in terms of accidents, loss of production, compensation, etc. Unfortunately, many machines that do not meet safety standards are exported to developing countries, causing workers to pay the price with accident, hearing loss from noise, etc.

1. Substitution

If a practically dangerous chemical or work processes cannot be completely eliminated, then it should be applied with a safer substitute. This could involve, for example, using less hazardous pesticides such as those based on pyrethrins (prepared from natural product), which are considered to be less toxic to humans than some other pesticides. This particular substitution is practiced in some countries because the substitute chemicals do not leave residues on food and therefore reduced long-term costs. The substituted materials may cost more to buy and may cause resistance in insects. So you can see there are many factors to be considered when choosing a chemical or chemical substitute?

It is not easy to find safer chemical substitute (in fact, no chemical should be considered completely safe). It is important to review current reports every year on the chemicals used in the work places so that safe chemicals could be considered for the future.

When looking for safer substitute a less volatile chemical is selected of a highly volatile one or solid, instead of liquid. Other examples of substitutions include using:

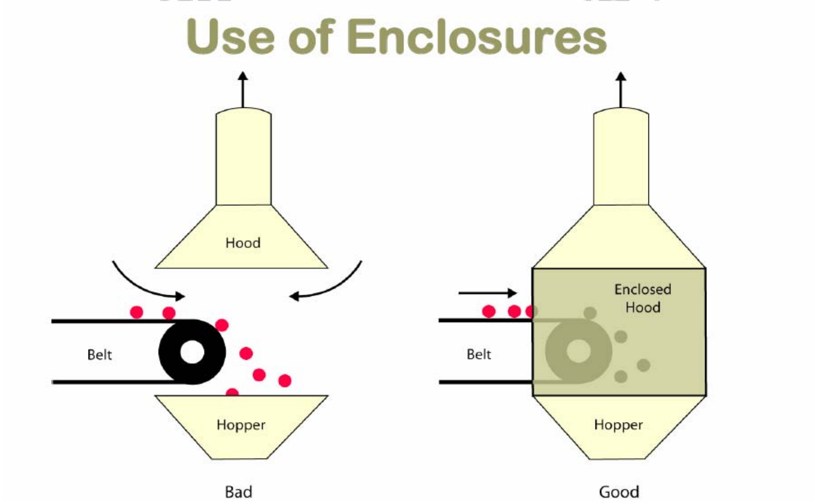
- Less hazardous instead of toxic ones.
- Detergent plus water cleaning solutions instead of organic solvents
- Freon instead of methyl bromide chloride as a refrigerant
- Leadless glazes in the ceramics industry
- Leadless pigments in paints
- Synthetic grinding wheels (such as aluminum oxide, silicon carboide) instead of sandstone wheels.

3. Engineering controls

An engineering control may mean changing a piece of machinery (for example, using proper, machine guards) or a work process to reduce exposure to a hazard; working a limited number of hours in a hazardous area ; and there are number of common control measures which are called engineering control. This includes enclosure, isolation and ventilation.

3.1 Enclosure

If a hazardous substance or work process cannot be eliminated or substituted, then enclosure the hazard is the next best method of control. Many hazards can be controlled by partially or totally enclosing the work process. Highly toxic materials that can be released into the air should be totally enclosed, usually by using a mechanical handling device or a closed glove system that can be operated from the outside.



The plant can be enclosed and workers could perform their duties from a control room. Enclosing hazards can minimize possible exposure, but does not eliminate them. For example, maintenance workers who serve or repair these enclosed areas can be still exposed. To prevent maintenance workers from being exposed, other protective measures (such as protective clothing, respirators, proper training, medical surveillance, etc) must be used as well as safety procedures.

Machine guarding is another form of enclosure that prevent workers coming into contact with dangerous parts of machines. Workers should receive training on how to use guarded machine safely.

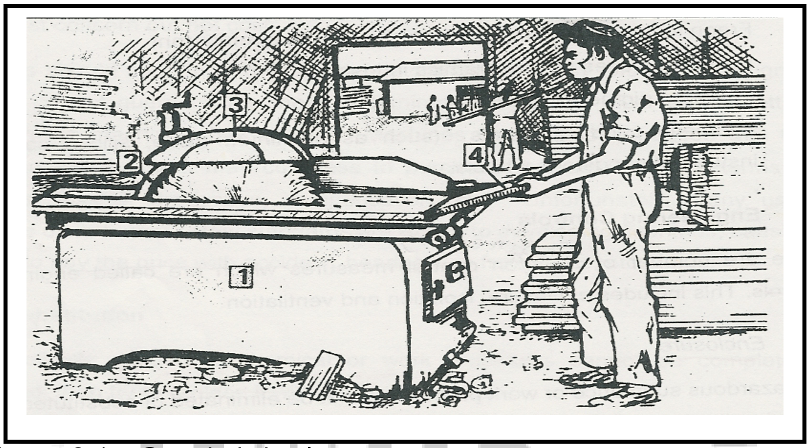


Figure 8-1. Guarded circular saw

Source: Deglaville etal. Occupational Health, a huhumanual for health workers in developing countries.

3.2 Isolation

Isolation can be an effective method of control if a hazardous material can be moved to a part of work place where fewer people will be exposed, or if a job can be changed to a shift when fewer people are exposed (such as weekend or midnight shift). The worker can also be isolated from hazardous job for example by working in an air-conditioned control booth.

Whether it is the job or the worker that is isolated access to the dangerous work areas should be limited to few people as much as possible to reduce exposures. It is also important to limit the length of time and the amount of substance (s) to which workers are exposed if they must work in hazardous area. For example, dust producing work should be isolated from other work areas to prevent other worker from being exposed. At the same time, workers in the dusty areas must be protected and restricted to only a short time working in those areas.

Remember: isolating the work process or the worker does not eliminate the hazard which means workers can still be exposed.

3.3 Ventilation

Ventilation in work place can be used for two reasons: 1) to prevent the work environment from being too hot, cold, dry or humid. 2) to prevent contaminates in the air from getting into the area where workers breathe.

Generally there are two categories of ventilation.

1. General or dilution Ventilation
2. Local Exhaust ventilation

1. General or dilution Ventilation

This adds or removes air from work place to keep the concentrations of an air contaminant below hazardous level. This system uses natural convection through open doors or windows, roof ventilators and chimneys, or air movement produced by fans or blowers.

It is recommended to use the general ventilation system if the following criteria are fulfilled.

1. Small quantities of air contaminants released into the workroom at fairly uniform rate.
2. Sufficient distance between the worker and the contaminant source to allow sufficient air movement to dilute the contaminant to a safe level.
3. Only contaminant of low toxicity are being used
4. No need to collect or filter the contaminants before exhaust air is discharged into the community environment.
5. No corrosion or other damage to equipment from the diluted contaminants in the workroom area.

2. Local Exhaust Ventilation

Local exhaust Ventilation is considered the classical method of control for dust, fumes, vapors and other airborne toxic or gaseous pollutants. The ventilation system captures or contains the contaminants at their source before they escape into the workroom environment. A typical system contains one or more hoods, ducts, air cleaners and a fan. Such systems remove but do not dilute like general exhaust ventilation although removal may not be 100 percent complete. This method is very useful especially for the chemical or contaminants that cannot be controlled by substitution, changing the process, isolation or enclosure. One other major advantage in such system requires less airflow than dilution ventilation system.

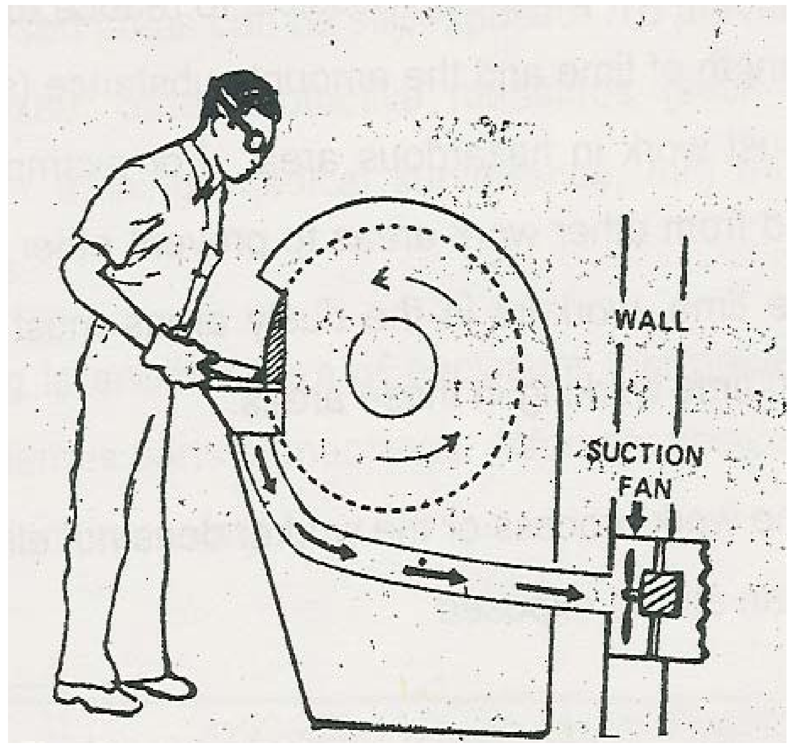


Figure 8-2. Local exhaust ventilation

Source: Deglaville etal. Occupational Health, a manual for health workers in developing countries

4. Administrative Controls

Administrative controls limits the amounts of time workers spend at hazardous job locations. Administrative control can be used together with other methods of control to reduce exposure to occupational hazards.

Some examples of administrative controls include:

- Changing work schedules, for example two people may be able to work 4 hours each at a job instead of one person working for 8 hours at that job.
- Giving workers longer rest periods or shorter work shits to reduce exposure time
- Moving a hazardous work process so that few people will be exposed
- Changing a work process to a shift when fewer people are working
- Workers promotion
- Provision of health and sanitation facilities

An example of administrative controls being used together with engineering controls and personal protective equipment is: a four-hour limit for work in a fully enclosed high noise area where ear protectors are required.

Remember: administrative controls only reduce the amount of time you are exposed to hazard – they do not eliminate exposure.

5. Personal protective equipment

Personal protective equipment (PPE) is the least effective method of controlling occupational hazards and should be used only when other methods cannot control hazards sufficiently. PPE can be uncomfortable, may decrease work performance and may create new health and safety hazards. For example, ear protectors can prevent hearing warning signals, respirators can make it harder to breathe, earplugs may cause infection and leaky gloves can trap and spread hazardous chemicals against the skin.

Personal protective equipment includes:

a. Eye protection

Eye protection embraces spectacles, goggles and handled screens. No eye protection is effective if it is not worn. Common complaints from users are:

- discomfort
- restricted vision
- impaired vision (caused by misting or scratching)

1. Safety goggles

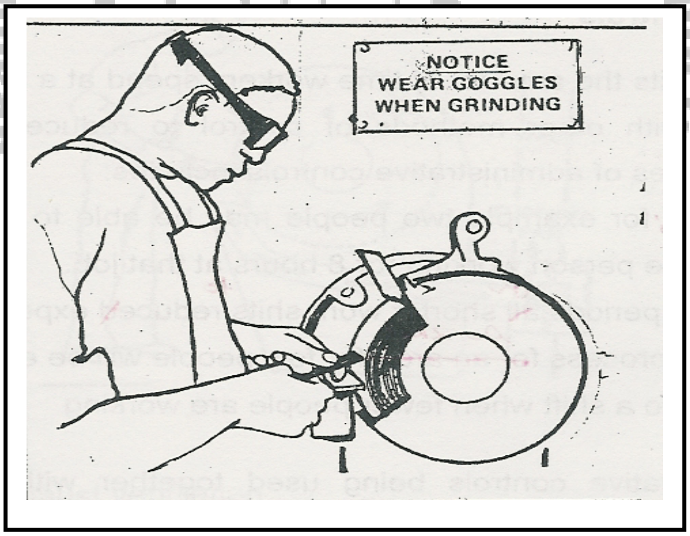


Figure 8-3. Safety goggles protects the eyes

Source: Deglaville etal. Occupational Health, a manual for health workers in developing countries

2. Face shield and gloves

Gloves are perhaps the most common personal protective equipment, being an almost automatic reaction to the idea of a hazardous agent in contact with the hands. Selection should take into account a wide range of parameters.

- The dexterity required to perform the work
- Physical protection against cuts, grazes and bruises
- Whether the wrist and arm needed protection as well.
- Permeability to chemicals
- Dust retention characteristics

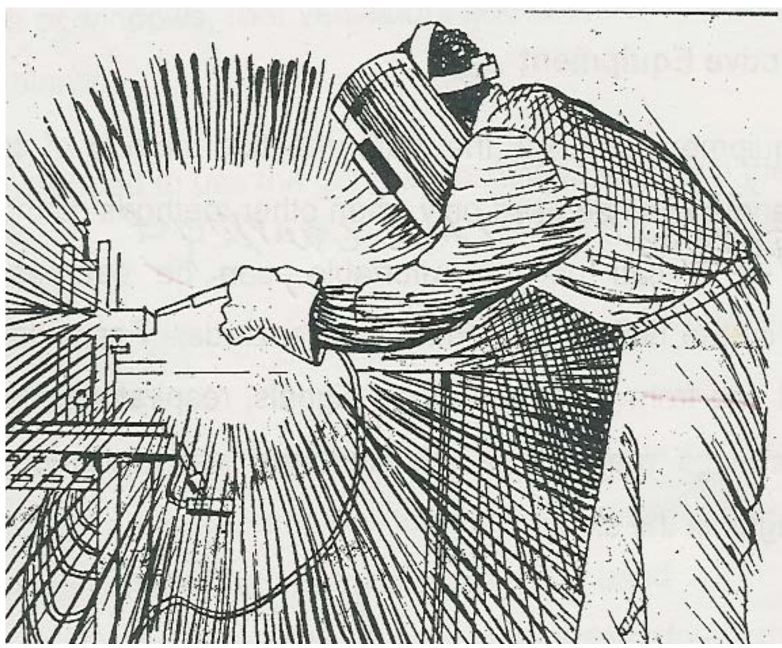


Figure .8-4.protective face shield and gloves

Source: Deglaville et.al. Occupational Health, manual for health workers in developing countries

2. Helmet

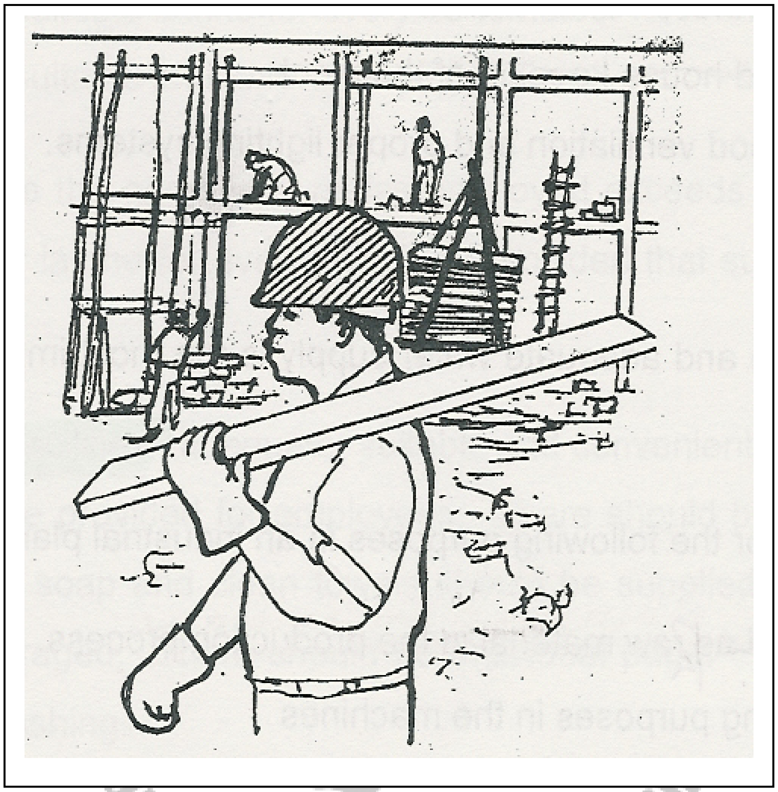


Figure 8-5. A safety helmets protects the head from possible injury.

Source: Deglaville etal. Occupational Health, a manual for health workers in developing countries

Protective clothing

At its simplest term protective clothing means overalls or lab coats for general-purpose use. They are intended to protect the user (or the user's own clothing) from everyday wear, tear or dirt. There are a number of special hazards that may be encountered against which such basic clothing may not be adequate:

Corrosive liquids: could soak into the clothing and so come in contact with the skin, causing serious damages. Impermeability is an important factor here.

Dust retention: When working with powders, a fabric that holds dust could generate an airborne exposure hazard as the person moves around.

Thermal environment: normal clothing may be too warm or too cold for a particular environment. In extremes cases, chemical protective clothing might be necessary. Typically this comprises a one-piece suit made from an impervious material.

Respiratory protective Equipment (RPE)

In selecting RPE you should take into account:

- The physical nature of contaminant- whether it is gaseous or particulate
- The chemical nature of the contaminant – whether it is reactive or corrosive
- Wearability and comfort factors

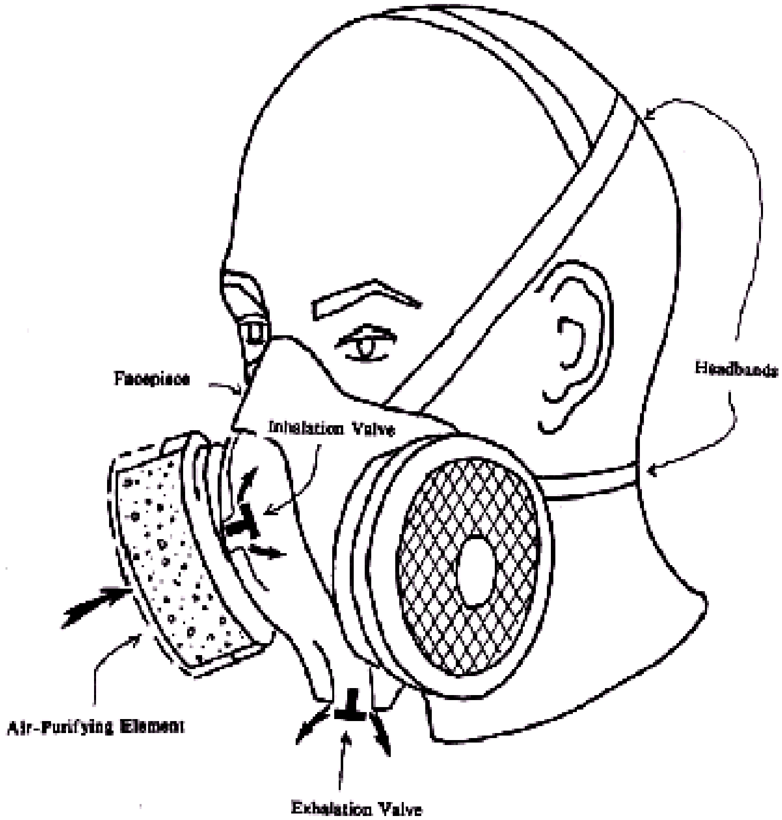


Figure 8-6. Respiratory protective equipment

Hearing Protection

Hearing protection is perhaps a more descriptive term than the commonly used ear defenders since it is the hearing that is at risk, not the ears. Protection can take two forms.

Ear muffs- fit over and around the ears. A fluid of foam filled cushion seals them against the head.

Earplugs – fit snugly inside the ear. There are a variety of types, including foam and soft rubber plugs.

As the noise is produced over a range of frequencies the choice of hearing protection must be based on the measured spectrum of the noise to be attenuated. Choosing hearing protection is only partly a matter of finding protectors with the right attenuation. It is equally important to find ones that are comfortable and practicable for the work.

Other administrative services

Provision of health and sanitation facilities

Workers health, physical and psychological developments are associated with the working and the external environment.

The general sanitation of the industry and the healthful conditions are necessary for conserving health or to ensure the protection of occupational health safety and hygiene and measuring or providing the efficiency of the work place.

Therefore, an industrial plant should satisfy the following conditions and facilities.

- The provision of safe potable and adequate water supply.
- Proper collection and disposal of liquid waste.
- The provision of adequate sanitary facilities and other personal services.

- General cleanness and maintenance of industrial establishment of protecting good house keeping of the plant.
- Maintaining good ventilation and proper lighting systems.

Water Supply

The provision of safe and adequate water supply is the most important element in industrial settings.

Water can be used for the following purposes in an industrial plant:

- It may be used as raw material in the production process.
- Used for cooling purposes in the machines
- Used for cleaning and washing of equipment
- Used by employees to keep their personal hygiene
- Serve as a means for waste disposal in water carrying systems
- For drinking and cooling purposes

In general the water supply should be safe, adequate and wholesome and which satisfy public health standards. The number of taps or fountains required varies from 1 for 50 men to 1 for 200 men, depending upon the plant arrangement. However the standard is an average of 1 tap or fountain for 75 persons.

Sanitary Facilities

Excreta disposal facilities: observation of many plants or industries indicated that latrines and toilets used by the workers are of a primitive and unsanitary nature or in some cases there are none at all.

In some countries the public health services and labor legislation lay down regulations concerning sanitary facilities to be provided including the number for male and female workers.

Example. - At least 1 suitable latrine for every 25 females
- At least 1 suitable latrine for every 25 males

In a factory where the number of males employed exceeds 500, it is sufficient to provide 1 toilet or latrine for every 60 males provided that sufficient urinals are provided.

Washing Facilities: adequate, suitable and conveniently accessible washing facilities should be provided for employees. There should be a supply of running water; in addition soap and clean towels should be supplied and common towels should be discouraged as much as possible.

The recommended standards:-

- 1 wash basin for every 15 workers for clean work
- 1 wash basin for every 10 workers doing dirty work
- 1 wash basin for every 5 workers handling poisonous substances or engaged in handling food stuffs

The walls of washing rooms should preferably be glazed tiles and the floor made of the same tiles or hard asphalt. The washing basin should be preferably of vitreous china.

Points to be considered in providing shower services.

- All showers should be separated for male and female workers to guarantee privacy
- Emergency facilities must be available where there is a danger of skin contamination by dangerous or poisonous substances
- Emergency shower or eye wash facility
- Accessory materials

Refuse disposal

Proper solid waste management starting from the source to generation to the final disposal site is highly required in industries where different kinds of wastes are generated.

Industrial solid wastes may contain hazardous materials that required special precaution and procedures. But combustible solid wastes except poisonous and flammable or explosive materials can be handled in the convenient manner.

Liquid waste collection and disposal

Industrial liquid wastes if not properly disposed could pollute rivers, lakes, environment and drinking water supply.

Toxic liquid wastes should be diluted, neutralized and filtered, settled or other wise chemically treated before being discharged into a stream or river or on open land. Under no circumstances should be toxic, corrosive, flammable or volatile materials be discharged into a public drainage system.

Illumination/lighting

The intensity of light source is measured by the standard candle. This is the light given by a candle, which has been agreed upon so that it is approximately uniform.

The intensity of illumination is measured by the foot-candle. This is the illumination given by a source of one candle to an area one foot away from the source.

For checking illumination, the foot-candle meter is very useful. Inspectors in determining and measuring illumination at the factory workers bench can use it.

The window glass area of the workroom should be (usually) 15-20 % of the floor area.

Advantage of good lighting

- Safeguards eye sight
- Reduce accident and hazards
- Saves the workers time and cut down the amount of spoiled work and therefore it is economically profitable.

Good Housekeeping and Maintenance

This includes cleanliness of the work place, waste disposal and adequate washing, adequate toilet, clean eating facilities, and independent cloakroom. Good housekeeping play a key role in the control of occupational health hazard.

Immediate cleanup of any accidental spill of toxic materials is a very important control measure. A regular clean up schedule preferably using vacuum cleaners or using wet methods when vacuum is not available is an effective method of removing dirt that is probably laden with harmful substances form the work area.

Good house keeping is essential where solvents are store, handled and used. It is also very important to provide a cleaning and maintenance schedule to any work place so that harmful dust may not accumulate on ceilings, pipes, and other objects within the work area.Highly trained individuals under strict supervision must carry out disposal of hazardous materials.

8.4. Review Questions

1. What are the principles of prevention and control of occupational health and safety problems?
2. What does health promotion mean in the workplace and who is responsible to deliver it?
3. What are the reasons for misutilization of personal protective devices among the workforce?
4. Discuss on the roles of safety rules in a certain occupational settings.

GLOSSARY

Acute. Health effects that show up a short length of time after exposure.

Administrative control. Methods of controlling employee exposures by job rotation, work assignment or training in specific work practices designed to reduce exposure.

Aerosols. Liquid droplets or solid particles dispersed in air that is fine enough particle size (0.01-100mm) to remain so disposed for a period of time.

Asbestos. A hydrated magnesium silicate in fibrous form.

Asbestosis. A disease of the lungs caused by inhalation of fine airborne asbestos fibres.

Asphyxia. Suffocation from lack of oxygen.

Asphyxiate. A gas whose primary or most acute health effect is asphyxiation.

Biohazard. organisms or products of organisms that present a risk to humans.

Chronic. Persistent, prolonged, repeated.

Contact dermatitis. Dermatitis caused by contact with a substance gaseous liquid or solid

Climatic stressor: heat radiation problems from tin-roof shed of the factory and other source.

Confounding factor: factors those are not directly visible but have risks at workplace, an endpoint determinant that is not under primary consideration but is correlated in the data with the determinant under study and it may thus confound or bias the estimated effect
of determinant (or exposure).

Contributing factor: more visible factors that are long lasting risks at workplace due to poor workplace layout, old equipment, critical posture, excessive muscle exertion, heat, noise, vibration, smokes, dusts, and other hazards.

Determinant: risk factors that include exposure level and influences probability of cumulative exposures, peak or remote exposures, recent or lagged exposures according to duration, place, environment, etc.

Ergonomics: preventative measures, which help in designing workstations, work processes, tools or equipment to fit the individual worker, and an innovative tool for increasing safety, efficiency, and productivity.

Excessive heat: heat is recorded as excessive if a worker is found sweating when naked or with light clothing; if investigator feels as sudden heat wave when entering into the industry.

Excessive noise: noise that makes it difficult to communicate with your neighbour without shouting

Good workplace: ergonomic workplace with the potential to increase workers' health, safety and work performance or productivity.

Hazard: occupational or environmental exposure sometimes to individual susceptibility that increase risk, a source of possible injury to workers or damage to the environment or material assets, and disturb work process.

Hazardous workplace: workplaces in which a worker interacts with hazards.

Heat stress: a situation when human body feels thermal discomforts (e.g., heat load) in dissipating excess heat and sweating to the surrounding (nearby) environment.

Heat strain: result of heat load or physiological response to heat stress, differences between internal or metabolic heat production and heat loss due to a hot and humid climate, or occurrence of heat exhaustion with change of excessive sweating, heart rate, body temperature, high blood pressure, feeling of thirst, etc.

Hours of exposure: total number of hours worked in a particular job task, shift or time spent (how many hours) in a specific work environment.

Implementation: carry out various steps to provide health and hygiene measures, as well as safety and ergonomic applications for workplace improvement or intervention.

Industrial hygienist. are occupational health professionals who are concerned primary with the control of environmental stress or occupational health hazards that arise as a result of or during the course of work.

Information system: system that provides the data needed for decisions relating to safety, health and the work environment.

Intervention: an instrument of something that enhances way of modification, increase work value and control measures to minimize work-related problems, and/or to find some changes for improvement in the workplace.

Job-safety analysis: a series of logical steps to enable systematic assessment of job tasks for implementing health, safety and hygiene measures as well as ergonomic applications.

Management system: organizational structure, procedures, processes and resources needed to implement health and safety management.

Medium scale industry: any industry that uses power driven machine and employ more than 10 workers.

Monitoring: systematically testing, measuring or observation aspects of working conditions over a certain period of time in order to find some changes (improve) in the workplace.

Nonergonomic condition: poor manipulation (incorrect use) of machinery or tools, intense work with frequent movement of arms, legs or trunks, handling of heavy materials or carrying a heavy load without using ergonomic aid such as lifting device, wheel barrows, push or pull carts.

Occupation: when a person engages in a job-task that brings livelihood (salary, fringe benefits or other facilities), or work experience, the identity of a profession, designation or employee status.

Occupational health: workers' physical, social, and cognitive elements for better efficiency in job-tasks.

Occupational safety: working situations where injury risks or production loss have not begun, or unsafe act, poor work environment, or non-ergonomic practices are minimised by safety measures and adopting ergonomic means to control work hazards.

Occupational health/safety: competence of a healthy work force, safe handling operation, clean or hygienic workplace, suitable work schedule, provision of labour welfare through a maintaining of work regulation and labour legislation.

Physical fatigue: the result in muscle pain, postural discomfort, symptoms of musculoskeletal disorders from heavy physical work, or tired from long working hours without enough food or nutrition, drinking of water, tea or coffee, and sufficient rest.

Physical stress: results from a relatively high work exposure (heavy manual work or strenuous tasks, muscle force without using powered hand tools), physically tired from poor working posture, or from long working hours without sufficient rest, etc.

Poor workplace: when the work environment is hazardous, non-hygienic, unsafe, non-ergonomic and/or unproductive.

Psychosomatic symptom: symptom arises from a situation of poverty, poor salary, family burden, mental fatigue, working on a non-suitable shift, lack of cognition, bad relation with co-workers, factory owners and managers, for instance.

Prevention: the act of reducing work-related problems and work injuries or hindering the obstacles (physical or chemical hazard, radioactive substance, or biological exposure) in the workplace.

Risk: probability of an adverse endpoint (cumulative risk of hazards in workplace, for instance).

Severity of injury: characterized by death, hospitalization more than 24 hours and absence from work over three days in the last one year.

Shift design: making the shift schedule in some way (course or direction of time) or replace a worker that it brings less work stress (both from physical and mental), minimize sleep debts and fatigue.

Shift work: activity carried out by several workers in different periods of day or night, a portion of an extended production process covered by two or more teams for an equal number of working hour per shift that relieve each other over a period of 24 hours by day and night.

Small scale industry: any industry that uses power driven machine and employ less than 10 workers .

Symptom: a deviation of the normal health of workers due to abnormal environment, condition or hazardous system at workplace.

Strenuous task: hard work, intolerable task, and a heavy workload for excessive physical exertion (e.g., stressful manipulation with nonergonomic tools) in hot and humid work environment.

Sustainable workplace: poverty alleviation through gradual improvement of workplace safety and health since it contributes to clean or hygienic work environment as well as productivity and welfare.

Thermal comfort: a state when a worker feels comfortable in a climate or specific environment without any change of a worker's physiological or metabolic parameters such as sweating rate, variation of oral temperature, heart rate, etc.

Thermal discomfort: feeling of heat exhaustion and thirst, heat cramps from the effects of excessive heat-load either from direct heat source, or radiation temperature at workplace.

Thermoregulatory response: physiological response within a hot and humid working climate that results in the greater sweat loss, or evaporation of sweat to the local environment or change in oral temperature or heart rate increase.

Threshold Limit value. is concentration by volume in air under which it is believed that nearly all workers may be repeatedly exposed day after day without adverse effect.

Permissible Exposure Limit. is amount permitted for a specific period within a working day

Variety: type and number of state or situation of a system/environment

Workplace: a location, place or environment where a worker normally performs his/her job tasks, or spends a reasonable time working in that place, location or environment.

Workplace assessment: a systematic investigation of job-tasks or evaluation of work related factors in order to find ergonomic solution to reduce and control of accidents and injuries, or ill health, or to improve health, hygiene and safety.

Working condition: a job, task, machinery, tools, layout, factory premises or working climate that covers factory environment. It can be also workers' physical, social and mental workload, psychosocial and organizational context of job-tasks under which job-task has to be performed or influences the work (or job tasks), or work environment.

Working environment: work space, illumination, noise, dust, fumes, or humidity level at workplace, climate or environment inside factory premises.

Work hazard: source of risks of an activity, conditions of a system, or other local situations that result in a work injury, damage to or loss of equipment, materials, etc.

Workplace improvement: process of improving workplace or the state of improved work environment, or the act of and process of improving working conditions (e.g., task, activity, tools).

Workplace intervention: improved health, safety and ergonomic applications through collaborative efforts from all the parties concerned, or an efficient use of local resources for good work, increased productivity and less injuries in the workplace.

Work-related injury: an accident that gives rise to poor health, musculoskeletal disorders or other bad symptoms that results in sick leave production losses or increased compensation claims.

Work-related risk: the incidence rate combined with the severity of work hazard, probability or possibility of a mishap in terms of hazard severity, activation of a hazard that can result injury in workplace, or result in accident or loss of production.

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ANNEXES

Annex 1: Points of Reference *measured in dBA or decibels

- 0 The softest sound a person can hear with normal hearing
- 10 normal breathing
- 20 whispering at 5 feet
- 30 soft whisper
- 50 rainfall
- 60 normal conversation
- 110 shouting in ear
- 120 thunder

Annex 2: Personal Monitoring Equipment

- Fold-down earmuff
- Minor's lamp
- Lamp cord
- Hard hat
- Safety glasses
- Thermoluminescent (TLD)badge
- Gloves
- Reflective stripes
- Gamma meter
- Safety belt
- Radio
- Lamp battery
- Radon dust pump
- Coveralls
- Rubber steel-toed boots

Annex:-3 NIOSH Pocket Guide to Chemical Hazards First Aid Procedures

Code	Definition
Eye: Irrigate immediately	If this chemical contacts the eyes, immediately wash the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.
Eye: Irrigate promptly	If this chemical contacts the eyes, promptly wash the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention if any discomfort continues. Contact lenses should not be worn when working with this chemical.
Eye: Frostbite	If eye tissue is frozen, seek medical attention immediately; if tissue is not frozen, immediately and thoroughly flush the eyes with large amounts of water for at least 15 minutes, occasionally lifting the lower and upper eyelids. If irritation, pain, swelling, lacrimation, or photophobia persist, get medical attention as soon as possible.
Eye: Medical attention	Self-explanatory
Skin: Blot/brush away	If irritation occurs, gently blot or brush away

	excess.
Skin: Dust off solid; water flush	If this solid chemical contacts the skin, dust it off immediately and then flush the contaminated skin with water. If this chemical or liquids containing this chemical penetrate the clothing, promptly remove the clothing and flush the skin with water. Get medical attention immediately.
Skin: Frostbite	If frostbite has occurred, seek medical attention immediately; do NOT rub the affected areas or flush them with water. In order to prevent further tissue damage, do NOT attempt to remove frozen clothing from frostbitten areas. If frostbite has NOT occurred, immediately and thoroughly wash contaminated skin with soap and water.
Skin: Molten flush immediately/solid-liquid soap wash immediately	If this molten chemical contacts the skin, immediately flush the skin with large amounts of water. Get medical attention immediately. If this chemical (or liquids containing this chemical) contacts the skin, promptly wash the contaminated skin with soap and water. If this chemical or liquids containing this chemical penetrate the clothing, immediately remove the clothing and wash the skin with soap and water. If irritation persists after washing, get

	medical attention.
Skin: Soap flush immediately	If this chemical contacts the skin, immediately flush the contaminated skin with soap and water. If this chemical penetrates the clothing, immediately remove the clothing and flush the skin with water. If irritation persists after washing, get medical attention.
Skin: Soap flush promptly	If this chemical contacts the skin, promptly flush the contaminated skin with soap and water. If this chemical penetrates the clothing, promptly remove the clothing and flush the skin with water. If irritation persists after washing, get medical attention.
Skin: Soap promptly/molten flush immediately	If this solid chemical or a liquid containing this chemical contacts the skin, promptly wash the contaminated skin with soap and water. If irritation persists after washing, get medical attention. If this molten chemical contacts the skin or nonimpervious clothing, immediately flush the affected area with large amounts of water to remove heat. Get medical attention immediately.
Skin: Soap wash	If this chemical contacts the skin, wash the contaminated skin with soap and water.
Skin: Soap wash	If this chemical contacts the skin, immediately

immediately	wash the contaminated skin with soap and water. If this chemical penetrates the clothing, immediately remove the clothing, wash the skin with soap and water, and get medical attention promptly.
Skin: Soap wash promptly	If this chemical contacts the skin, promptly wash the contaminated skin with soap and water. If this chemical penetrates the clothing, promptly remove the clothing and wash the skin with soap and water. Get medical attention promptly.
Skin: Water flush	If this chemical contacts the skin, flush the contaminated skin with water. Where there is evidence of skin irritation, get medical attention.
Skin: Water flush immediately	If this chemical contacts the skin, immediately flush the contaminated skin with water. If this chemical penetrates the clothing, immediately remove the clothing and flush the skin with water. Get medical attention promptly.
Skin: Water flush promptly	If this chemical contacts the skin, flush the contaminated skin with water promptly. If this chemical penetrates the clothing, immediately remove the clothing and flush the skin with water promptly. If irritation persists after

	washing, get medical attention.
Skin: Water wash	If this chemical contacts the skin, wash the contaminated skin with water.
Skin: Water wash immediately	If this chemical contacts the skin, immediately wash the contaminated skin with water. If this chemical penetrates the clothing, immediately remove the clothing and wash the skin with water. If symptoms occur after washing, get medical attention immediately.
Skin: Water wash promptly	If this chemical contacts the skin, promptly wash the contaminated skin with water. If this chemical penetrates the clothing, promptly remove the clothing and wash the skin with water. If irritation persists after washing, get medical attention.
Breath: Respiratory support	If a person breathes large amounts of this chemical, move the exposed person to fresh air at once. If breathing has stopped, perform mouth-to-mouth resuscitation. Keep the affected person warm and at rest. Get medical attention as soon as possible.
Breath: Fresh air	If a person breathes large amounts of this chemical, move the exposed person to fresh air at once. Other measures are usually unnecessary.

Breath: Fresh air, 100% O_2	If a person breathes large amounts of this chemical, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. When breathing is difficult, properly trained personnel may assist the affected person by administering 100% oxygen. Keep the affected person warm and at rest. Get medical attention as soon as possible.
Swallow: Medical attention immediately	If this chemical has been swallowed, get medical attention immediately.

Annex 4: Checklist for observation of working environment

Checklist identification number: ______________

Identification

Name of industry ____________Type of industry(by size) ________.

Major hazardous raw material in use_______________________

Final product______________________________

Address: Kebele__________________

Total number of employees directly involved in production processes_______________

Hazards in working environment

1 Is there excessive heat in the workplace? 1. Yes 2. No: A yes requires that a worker is found sweating when naked or with light clothing; if investigator feels as sudden heat wave when entering into the industry.

2 Is there excessive dust in the workplace? 1. Yes 2. No. A yes requires if the investigator experiences sudden sneezing upon entering the industry or if the worker's eye brows, hair, nostrils and cloths is observed by investigators to be covered with dust particle.

3 Is there excessive noise in the workplace? 1. Yes 2. No. A yes requires that it difficult to communicate with nearby worker without shouting.

4 Is there warning signs or safety rules? 1. Yes 2. No. A yes requires no lack of such arrangement at inspection around.

5 Do the employees use the necessary personal protective equipment? 1. Yes 2. No. A yes requires no lack in use of safety devices seen at inspection around.

6 Does all production equipment have the appropriate protective arrangements?

1. Yes 2.No .A yes requires no lack of such arrangement (poorly installed electric wire or unguarded machine or equipment) at inspection around.

7 What is the most dangerous incident in the industry during the last 12 months, and any preventive measures been implemented? 1. Yes 2. No. Attainment of yes requires specification of the incident and preventive measures.

8 Does the industry have copy of the most important safety and health regulations?

1. Yes 2.No. A yes requires a copy of the regulation.

9. Does the industry have of health and safety personnel? 1. Yes 2.No. Attainment of yes requires either implementation as result of initiative from heath and safety personnel or written programme for action worked out with them.

10. Does the industry follow written health and safety plan for action in the workplace?

1. Yes 2.No.A yes requires completion of at least one of the measures in the plan.

11. Does the industry have meetings to discuss safety and health factors with the employees in the last six months? 1. Yes 2.No. A of yes requires minutes with written conclusions.

12. Are training needs considered in connection with new employment, equipment or other changes? 1. Yes 2.No. A

yes requires an example of training given as a consequence of a change.

13. Does the industry have first aid equipment? 1. Yes 2.No. A yes requires that first –aid equipment be available in the production area and that content be as prescribed

Name of inspector ____________________

Signature____________________Date___________________