UNIT 1 PHYSICAL HAZARDS

Structure

1.0 INTRODUCTION

Physical hazards are the hazards which liberate energy in various forms like noise, vibration, pressure, temperature, ionizing and non-ionizing radiations. Noise is the most common physical hazard. Constant noise or impulses can damage the ear and sometimes cause even deafness. Vibration in any of the form affects respective body parts. Pressure becomes a physical hazard at above or below atmospheric pressure, in occupations like aviation and diving. Occupations that are associated with extreme temperatures alter the mechanism of natural temperature regulation. Exposure to ionizing radiation either electromagnetic or particle ionizing radiation causes tissue damage and cancer in prolonged exposures. Ionizing and non-ionizing radiation with longer wavelengths brings physical changes in cells band causes sunburn and prolonged exposure causes cataracts and skin cancer.

1.1 OBJECTIVES

After studying this unit you will be able to:

- define various physical hazards;
- understand how to identify physical hazards;
- identify hazards by extreme temperature;
- identify hazards by noise and vibration;
- identify hazards by ionizing and non-ionizing radiation and
- explain the effects of physical hazards.

1.2 PHYSICAL HAZARDS - DEFINITION

Physical hazards are type of hazards that derived from energy, matter and a combination of the two. Physical hazards in the workplace are categorized

into worker–material interfaces, the physical work environment, and energy and electromagnetic radiation. Physical hazards are based on common principles of basic physics and worker safety. Physics is the science of energy and matter and is studied in various fields such as acoustics, optics, mechanics, thermodynamics, and electromagnetism. In a broader sense physical hazards are primarily hazards of energy, temperature, pressure, or time that can cause injury to human beings with or without touching. Physical hazards are grouped under occupational or environmental hazards.

1.3 TYPES OF PHYSICAL HAZARDS

Physical hazards are broadly classified into ergonomic hazards, radiation hazard, extreme temperature hazard, vibration hazards, and noise hazards. Engineering controls are required to reduce physical hazards. In this unit we will discuss about few physical hazards in detail.

1.3.1 Extreme Temperature

Temperature is a physical quantity demonstrating hot and cold. It is a proportional standard to estimate the average kinetic energy of the matter in a system. The temperature is measured by using the Celsius scale denoted as °C, Fahrenheit scale denoted as °F, and Kelvin scale denoted as K. Extreme temperatures can cause reduction in the ability to work by affecting the health in humans and considered it as physical hazard. Dear learner, in this unit we will discuss about severe cold and high temperature. Decrease in indoor and outdoor temperatures can cause physical discomfort, decrease in working capabilities, energy and in extreme conditions it may cause to death. The physical hazard of this type is depending on climate, production tendency of body heat and vapor and finally clothing.

Response of Human Body towards Cold Temperature

The range of cold temperature is below 10^0C-22^0C and if a person feel the sensation of cold is also consider an indication of coldness. Human body has an ability to regulate body heat by the mechanism of thermoregulation in which generating the heat and releasing produced heat at the same rate to balance the overall body temperature. This process is depends on change in temperature, clothing and physical activity all together alter the regulation process. For example, body parts like finger tips, nose and ears experienced the callosity and loss of feeling because in the thermoregulation process to stabilize the inner body temperature the blood circulation reduced to the outer surface. Another example is shivering and occurs when there is a drop in temperature. It is one of the body's protective operations where by the rapid movement of the muscle heat generates to maintain inner body temperature.

Along with the coldness there is a combination of different air temperature and wind speed known as wind-chill factor which affects the health. For example, at 1^0C temperature in a calm air environment body feels cool, whereas at the same temperature with 30km/h wind speed produces frozen coldness. This is because the insulator of thin cover of air between the skin and the outer atmosphere blown away by the wind. Driving a vehicle or working near air-blower raises the wind chill factor above the normal conditions thus causes potential physical hazards.

There are two types of health problems arise in cold weather work. They are:

1. Frostbite 2. Hypothermia.

1. Frostbite

Frostbite means freezing of tissues. Frostbite can happen at temperatures above 0°C depend on the situation. If the clothing of a worker is wet or damp and the skin directly contact with objects below the freezing point causes reduction in the blood circulation then frostbite can occur. It occurs commonly to the body parts like cheeks, nose, fingers, toes and earlobes that are poorly insulated and often left exposed.

In frostbite the body tissues will damage with the formation of ice crystals in them. The tissue detritus blocked the small blood vessels thereby retard the blood supply to the small blood vessels. The effect of frostbite is loss of feeling and paleness. On prolonged exposure tissue necrosis will occur.

2. Hypothermia

Hypothermia occurs when the loss of body heat is greater than the heat produced. Insufficient clothing, poor insulation and exhaustion from physical work are the factors for hypothermia. In this case shivering begins as the temperature of human body decreases, and in further decrease in body temperature shivering also decreases with slow heart rate. These symptoms leads to unconsciousness and finally death will occur.

In cold weather there are other associated problems like immersion foot, pneumonia, arthritis etc. The immersion of feet in cold water for long durations or damp footwear can cause trench foot or immersion foot. In this accumulation of fluid in foot tissues developed swelling, pain and spasm in blood vessels that damage the foot muscles. In some cases gangrene may also develop.

Response of Human Body towards Hot Temperature

Heat related ailments are common in those occupations where the employees are exposed to heat environments, high humidity conditions either indoors or out door. For example, working in iron and steel plants, ceramic industry, brick furnace, boiler rooms in electrical work shops, laundries, bakery and chemical plants are some of the indoor work places where the hot conditions exist. Many workers working in outdoor environment like construction, hazardous waste, agricultural farming, oil and gas plants are facing severe heat related illness. When a worker exposed to extreme heat the body should eliminate excess heat that absorbed to maintain the normal body temperature without any adverse effect. This will happen by natural body mechanism either through blood circulation to the skin or by sweating. Sometimes the temperature of the air is hotter than normal body temperature the body cooling mechanism is difficult by blood circulation to the skin process and it is done by sweating only. In humid conditions the sweating is also difficult and the excess heat will be stored in the body. As the body accumulates the heat continuously the body temperature will rise up with increase in the heart rate. With this the person become sick and loses concentration, focus on work. The health indications may vary from heat rash, muscle cramps to heat stroke and exhaustion and finally unconscious which leads to death.

Check Your Progress 1

Note: a) Write your answer in about 50 words.
b) Check your progress with possible answers given at the end of the unit.

1. Explain the following terms:

a. Frostbite b. Hypothermia

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1.3.2 Noise and Vibration

Noise and vibration are associated with each other since physics behind these are similar but the health effects are different.

Noise is defined as any sound that is potentially harmful to the health or safety of a person. According to WHO, noise is present in every human activity, and when assessing its impact on human well being it is usually classified either as occupational noise (i.e. noise in the work place), or as environmental noise. This includes noise in all other settings, whether at the community, residential or domestic level.

Vibration is defined as oscillatory motion of a body emanate from automatic source where a body has a physical contact. The vibration may be a body shake or by a machine or by transport or by industrial process. Sometimes the vibration may be hand-arm only based on the tools at the work place.

Basic Acoustics: Sound comprises very little changes in pressure that are overlap on the atmospheric pressure. There is a momentary compression and rarefaction of the air pressure developed by pendulum motion of air molecules. By this movement spreading of energy of air molecules on a larger area occurs, that is perceived by the eardrum and vibrates in response. These vibrations are transmitted by middle ear to the fluid filled inner ear. The small hair cells which one present in the inner ear convert the vibrations into electric impulses and send them to the brain, there by the brain process them into meaningful sounds. The prime indicator where the noise is to be hazardous to hear is when any human being talks loudly to somebody that is away at arm length in a clamorous occupation. A risk assessment could be conducted to assess a worker's exposing.

The noise assessment can be carried out by sound level meter (SLM) or noise dose meter (NDM)

Effects: Noise induced hearing loss is the main ailment observed and following are different types of noise induced health effects.

1. Noise of an explosion causes structural damage known as acoustic trauma with little hearing loss. Roaring noise originally exhaust the fragile hair cells in the inner ear produce a shift in hearing threshold known as temporary threshold shift. This will be recovered overnight.

2. If the regular exposure to extremely loud noise, the effect is cumulative. There is a permanent damage caused to the hair cells causes permanent threshold shift, the damaged hair cells are irreparable and the loss of hearing is permanent.

Noise induced hearing loss occurs when the noise high-pitched frequency range in 4000-6000 Hz. Where as in the other forms of hearing loss, a person is unable to understand the words with the following sounds

a) 'fff'

b) 'th'

c) 'shh'

d) 's'

e) 't'

f) 'k'

g) 'c'

This creates misunderstanding in conversations.

3. **Social and Community Noise**: In the history many studies looked into the effects of community noise and manifested related health effects like sleep disorder, stress, displeasure, and high BP and ischemic heart disease. In addition to the noise in the social activities MP3 sound systems is one of the contributing sources.

4. **Noise Stress**: Some noise levels that are below 85dbdo not harm hearing but shows adverse health effects. This low level noise observed in call centers, hospitals and open places. This type of noise develops persistent noise stress, fatigue and heart related diseases. The permissible noise levels without any health effects are

   i. Noise levels below 50 dB-for effortless concentration.

   ii. Noise levels below 70 Db for carrying routine work.

5. **Acoustic Shock:**

The health effects of acoustic shock are classified into three categories:

1. **Primary Symptoms**: Fullness in the ear, severe pain, nausea, burning sensation, tinnitus numbness

2. **Secondary Symptoms**: fatigue, headache, a feeling of unbalanced, and anxiety.

3. **Tertiary Symptoms:** Hypersensitivity to all kinds of noise (previously tolerated sounds also) and hyper vigilance.

Control strategies for acoustic environment:

- Acoustic requirements should consider in workplace design
- Setting up systems of work, monitoring of working performance of workers, conducting training and stress management, working systems to

measure for reporting and measures for dealing with acoustic incidents and shock

- Setting up technical control systems in compliance with telecommunication system, scream rejection devices, and uninterrupted power supply (UPS) systems to prevent power break out.

Vibration

Vibration is made up of oscillation of molecules in solid, liquid or gas at their equilibrium and in the range of < 20 Hz of infrasound region and up to 1500 Hz frequency in the audible sound.

Vibration occurs in the audible frequency range of air and experience with sound.

Health Effects of Vibration

The whole-body vibration may cause damage the lower spine and internal organs too. The vibration of the whole body increases the heart rate by increasing uptake of oxygen thereby increase in the rate of respiration. This develops changes in the blood and urine and complete body illness that decreases performance of workers. The vibration occurs in the 0.1–1 Hz frequency range arises the health issues like motion sickness and damages the mechanism of centers for orientation and posture and the vestibular cortex.

The hand-arm vibration disrupts the supply of blood and oxygen to the fingers resulting in damage to blood vessels and nervous systems. The other health effects are

- tingling and numbness
- Prolonged exposure at 40–300 Hz frequency structural changes and damage to the peripheral blood supply and nervous systems in the fingers observed.
- Damage to bones, tendons and joints may occur at long-term regular exposure.
- A reflex sympathetic vasoconstriction action of the cochlea blood vessels occurs with a synergistic effect in the hearing loss.

Indian occupational permissible exposure limit for 8 h time is 90 dBA. Textile, printing, saw mills, mining, etc are some industries where the workers exposure to the hazardous noise is at maximum level. According to the National Institute of Occupational Health, India, noise levels in various industries are presented in table 1.

Table 1.1 Noise levels in different industries

Industries	Range (dBA)
Textile industries	102-114
Pharmaceutical firms	93-103
Fertilizer plants	90-102

Oil and natural gas complex in Bombay high	90-119
Road traffic in Ahmedabad city	60-102
Surface rail traffic	90-102
Metro rail	70-111
Air traffic	90-112

According to the WHO, on the basis of the pure tone audiogram taking for frequencies of 500, 1000, 2000 and 4000 Hz, the average hearing thresholds are:

Grade of impairment	Corresponding audiometric ISO value	Performance	Recommendation
0-No imairment	25dBbetter hearing problems	No/very slight	
1 - Slight impairment	26-40 dB (better ear)	Able to hear and repeat words spoken in normal voice at 1 m	Counseling. Hearing aids may be needed
2-Moderate impairment	41-60 dB (better ear)	Able to hear and repeat words spoken in a raised voice at 1 m	- Hearing aids usually recommended.
3-Severe impairment	61-80 dB (better ear)	Able to hear some words when shouted into the better ear.	Hearing aids needed. If no Hearing aids available, lipreading and singing shluld be taught.
4-Profound impairment including deafness	81 dB or greater (better ear)	Unable to hear and understand even a shouted voice	Hearing aids may help understand words. Additional rehabilitation needed. Lipreading and sometimes signing essential

Control of Noise hazards:

- It is necessary to phase out the noise source wherever workers are exposed by implementing administrative control measures.
- When work practices and engineering controls are not feasible for reducing noise exposure to safe levels, personal hearing protection devices should be provided to the workers. Personal hearing protector is a device which

is designed to reduce the level of sound reaching the eardrum. Ear muffs, ear plugs and ear canal caps are some of the hearing protectors.

- Training programmes should be conducted to bring awareness among workers about the adverse health effects of noise on hearing.

Check Your Progress 2

Note: a) Write your answer in about 50 words.
b) Check your progress with possible answers given at the end of the unit.

1) Match the following

i.	Noise assessment	a.	fullness in the ear
ii.	Hearing loss	b.	sound level meter
iii.	Acoustic shock	c.	tingling and numbness
iv.	Vibration	d	.90dBA
v.	Noise permissible limit	e.	4000-6000Hz
		f.	20dBA

1.3.3 Radiation (ionizing, non-ionising)

Radiation is significantly used in many fields like food preparation, medicine, the military, power generation, and industry. Many radioactive events experienced by general public like nuclear weapon detonations over Hiroshima and Nagasaki during World War II, the 1979 Three-Mile Island accident in the 1986 Chernobyl accident and the 2011 tsunami impacted Fukushima reactor, a general fear of radioactivity and radiation exists in the human community because of inadequate knowledge about the radiation.

Scope of the Problem

It is very difficult to estimate the extent of damage from workplace exposure to radiation at low level. The adverse effect of radiation is caused by chronic exposures which are dose-related, the cumulative effects, and a long latency period of many years before illness or injury is observed.

Radiation

Radiation is nothing but emission of high energy as electromagnetic wave either in the form of particle or wave travelling through space. The radiation is of two types-ionizing and non-ionizing. In the process of Ionization, a stable atom or a molecule loses or gains an electron(s), by acquiring an electric charge. Any atom or molecule with an electric charge is called an ion. Ion has different chemical, electrical properties and change in the release of energy than parent atom or molecule. This change in the properties may lead to changes in the structure or behavior of cells in the human body. Ionizing radiation comprises of energetic subatomic particles, ions or atoms propagating at high speeds, and electromagnetic waves propagating through space and time having electromagnetic radiant energy.

The electromagnetic waves in the electromagnetic spectrum show different frequencies ranging from below one hertz to above 10^{25} hertz. These ranges are divided into discrete bands having different names. The radio waves, microwaves, infrared, visible light and ultraviolet are at the low frequency (long wavelength) end of the spectrum where as portion of the UV radiation, X-rays, and gamma rays at the high-frequency (short wavelength) end. Gamma rays, X-rays, and the higher ultraviolet radiation are the part of electromagnetic spectrum are ionizing, whereas the lower ultraviolet part of the electromagnetic spectrum and all the spectrum below UV, including visible light, infrared, microwaves, and radio waves are considered non-ionizing radiation.

The Ionizing radiation consists of alpha particles, beta particles, neutrons, gamma rays and x rays.

Alpha Radiation: It originates from the decay of heavy atoms like uranium and radon. This radiation is generated in the form of particles when an atom ejects two protons and two neutrons from its nucleus. Alpha radiation cannot pass through the skin, but it can be inhaled, swallowed, or it can enter the body through a cut or from injured area. After entering it can cause the tissue damage leading to cancer.

Beta Radiation: Beta particles have negative charge and smaller than alpha particles with high energy. Beta radiation is emitted by unstable atoms like ^{3}H (tritium), and Carbon-14. Unlike alpha radiation they can penetrate into the human tissue.[1]

Gamma and X- Rays: Gamma and X-ray radiation possess packets of pure energy known as photons. Gamma rays formed inside the atoms of elements like Cobalt-60 and radium-266 with high-energy waves which can penetrate the entire body. They have a potential to alter the tissue and DNA.

X-rays have low energy with less penetrating capacity than gamma rays. They are widely used in medical diagnostic testing. However, one computed tomography (CT) scan emits a much larger amount of radiation at about as much radiation as 200 chest x-rays.

The Health Impacts of Ionizing Radiation: Once the ionizing radiation interacts with any matter, some amount of energy from the radiation transferred to the affected mater.There is two types of energy transfers.1. Linear Energy Transfer (LET) which is “a measure of an average energy loss along the path of radiation”. 2. High-LET radiations (such as alpha particles) ‘deliver’ a dose of radiation much more effectively than Low-LET radiations (such as x-rays or gamma rays). Once it interacts with living tissues the ionizing radiation induce free radicals like the hydroxide ion. Once free radicals formed they can move rapidly within the body and produce chemical changes in molecules at the cellular level and alter the DNA within the cell. Some organs in the body are sensitive to radiation-induced injury than others. Hence it is necessary to consider the targeted organ by calculating the radiation dose by ‘tissue weighting factor’.

For example, lung tissue and bone marrow are considered more radio-sensitive than skin, and have a ‘tissue weighting factor’ 12 times applicable to skin exposures. This is an important medical application and dose estimation when internal exposures like inhalation of radioactive dusts released in mining or

abrasive blasting activities. In some cases repair mechanisms within the body failed to handle the damage caused by the radiation or the free radicals, the cell tissue will be mutated or sometimes die. These mutated cells have a little probability to turn into a cancer and passed on to future generations if the reproductive organs are affected. Accidental exposure to a high dose of radiation for a short period of time is known as an acute exposure, and is able to produce biological effects after exposure.

These effects are:

- Nausea and vomiting
- Malaise and fatigue
- Increased temperature
- Blood changes
- Bone marrow damage
- Damage to cells lining the small intestine
- Damage to blood vessels in the brain

The delayed effects of acute exposure are various forms of cancer like leukemia, bone cancer, thyroid cancer, lung cancer and genetic defects.

Radiation Dose and Dose Limits: The International Commission on Radiological Protection (ICRP, 2007) and other international organizations absorbed dose is defined as a measure of the amount of radiation that a material has received and absorbed per unit mass. Gray (Gy) is the unit of absorbed dose.1Gy= an energy deposition of 1 J/kg.

Individual Dose Limits: The dose limits for ionizing radiation at occupational exposures according to ICRP (2007) are

A) 20 mSv per year (averaged over 5 calendar years)

B) 50 mSv in any one single year.

C) For general public it is 1 mSv in a year.

Risk Assessment for Radiation Exposures: According to the Linear No-Threshold hypothesis, any risk assessment for exposure to radiation is based on the postulate that any amount of radiation exposure can increase the chance of adverse biological effects (e.g. cancer).Control of Radiation protection is categorized into occupational radiation protection (for the protection of workers), medical radiation protection (for the protection of patients and the radiographer), and public radiation protection (for the protection of individual members in the population).

Control of Exposure: The following measures have to be taken to limit the radiation exposure.

1. **Time**: The amount of radiation exposure increases and decreases with the people spending time at or near the source of radiation. Minimize the time of exposure for minimize the damage.

2. **Distance**: The more is the distance from a radiation source, the less is the exposure. If the distance is double, we can reduce the exposure by a factor of four.

3. **Shielding:** Since the ionizing radiation diminishes when it passes through the matter. Shielding is the phenomena where an absorber is placed between the matter and the source of radiation. An absorber can be any material like wooden boards, vehicles, gravel, water, lead etc., Increase in the shielding about the radiation source, decrease the exposure. The shielding required to protect is different for different energy radiations. For example:

Alpha Particles: Very thin material like paper, film, 1.2 inches of air or 0.008inches of water provides enough shielding since alpha particles cannot penetrate.

Beta: Heavy or opaque covering like 10feet of air,2inches of water is required to protect against beta particles since beta particles are able to penetrate and damage the skin.

Gamma: Thick, dense shielding, such as 1.3 feet of lead,6.6feet of concrete or 13.8feet of water is necessary to protect against gamma rays. The higher the energy of the gamma ray, the thicker the lead must be.

Non-ionizing Radiation: Any type of electromagnetic radiation that does not have enough energy per quantum to ionize atoms or molecules. But they are able to produce charged ions when passing through matter. They have sufficient energy for excitation which is the movement of an electron to a higher energy state.

It consists of radio waves, microwaves, infrared, visible and ultraviolet light. All technical devices act as sources of non-ionizing radiation (NIR) in the electromagnetic spectrum of frequencies ranging from 100 nm to static fields. NIR relatively less hazardous to humans than ionizing radiation (ionizing radiation has a wavelength less than 100 nm or a photon energy greater than 12.4 electron Volts). However, depending on the frequency and the irradiance value, some sources of NIR cause a human health hazard.

Dear learner, we have to understand the nature of radiation and their hazards of the Electro Magnetic spectrum under three broad categories:

1. **Optical Radiation (100 nm to 1 mm, ultraviolet/visible light/infrared):** They Possess small wavelengths, large frequencies, and substantial energy (extreme UV approaches the photon energy of ionizing radiation).Depending on wavelength both thermal and photochemical effects may occur on exposures. The energy from the radiation deposited in the human tissues on interaction with surfaces of the body.

Sub bands of UV radiation are as follows

1. Near UV: 400-315 nm (UV-A)
2. Middle UV: 315-280 nm (UV-B)
3. Far UV: 280-100 nm (UV-C)

2. **Microwave Radiation (300 GHz to 300 MHz):** They possess intermediate wavelengths (1 mm to 1 m), frequencies, and moderate energy. Depending

on wavelength both thermal and photochemical effects may occur on exposures. **Radiofrequency and lower frequency radiation (300 MHz to Static Fields):** They possess large wavelengths (>1 m), small frequencies, and very low energy. When compare to other radiations this radiation can easily penetrate, but has less energy deposition in human tissue but adverse thermal and induced current (biological) effects are common.

3. **Extra Low Frequency Radiation:** Extra low frequency (ELF) in electromagnetic spectrum with frequencies of 1 – 3000 Hz. We all well aware that electricity generates both electric and magnetic fields. The strength of the electric field depends on the voltage it possess (for eg: 230 V for households, >400 V or higher for industry) and is present in all electrical live wires whether it is in use or not. Whereas magnetic fields are produced by flowing electric currents hence a magnetic field is created around the electric wire only when it is operating otherwise no magnetic field.

Health Hazards of Ultraviolet Radiation:

The UV radiation has both positive and negative effects on human health. For example, they are used for killing bacteria in medical or dental applications and used in curing resins. Exposure to sunlight, UV-B provides vitamin D which is required for healthy bones. Acute exposure to UV radiation causes 'sunburn' and 'arc-eye', having a sensation of sand in the eyes. Chronic exposure results in skin cancers, damage the eye lens and cataracts. There is a risk of infectious disease and reduced efficacy of vaccinations also. Other adverse health effects of the different UV bands are as follows.

UV-A: Sun tan and pigmentation

UV-B: Skin erythema, keratitis and cataracts

UV-C: Skin cancer

Photosensitize products either natural or synthetic, chemicals, coal tar products and drugs like Ibuprofen increases the sensitivity of skin to UV radiation. Most of the UV-C radiation filtered by the ozone layer where as both UVA and UV-B causes melanoma and non-melanomic skin cancers. Some industries with highest percentage of workers exposed to the sunlight are Agriculture/Forestry/Fishing (75% with cancer) and Construction (60% with cancer).

According to the World Health Organization (WHO) recommendations use of sun protection devices when the UV Index reaches 3 or above to avoid adverse effects like skin damage and skin cancer. The effects of damage for untanned, unprotected skin exposure to sunlight during summer season between 10:00am–2:00pm for approximately 12 min cause mild sunburn, for 30 mins experience the appreciable discomfort, for about 60 minutes exposure can result in peeling and blistering and for 2hrs exposure results in permanent skin damage.

Control Measures:

- Regular checkups of UV radiation emitted devices such as 400W mercury vapour lamps in the working environment
- Switch on to other alternative sources like sodium lamps.

- In case of welding workers installation of non-flammable screens and partitions
- Use signs to warn the welding areas
- Use signs for laser radiation
- Wearing personal protective equipment like filter shades for goggles and face shields to protect the eyes, gloves should be worn to cover exposed skin.

Outdoor Work:

- Arranging shade to protect workers from the sun.
- Alternative actions can take to reduce the workers exposure by assigning morning or later in the afternoon when the solar intensity is less.
- Mandatory for Personal Protective Equipment like sun?protection clothing, hats, sunglasses, and sunscreen.
- Introducing the concept of Ultraviolet Protection Factor (UPF) in engineering controls and protective clothing.

Health Hazards of Infrared Radiation:

According to ISO 20473 the Infra Red (IR) spectrum having the following sub-bands

- Near Infrared (NIR): 780 – 3000 nm
- Middle Infrared (MIR): 3000 – 50 000 nm
- Far Infrared (FIR): 50 000 – 106 nm.

The main source of IR radiation is the sun but other sources which emit IR radiation include combustion process, furnaces, glassmaking, welding, etc. IR is used specifically in heating lamps and 'black' room heaters, food processes like drying and baking, heating and dehydration of food products. Conveyor ovens are used for curing, preheating, drying, soldering, stress relieving and annealing releases IR radiation. Absorption of IR radiation generates heat in the objects, and the human body as well that develops heat stress. Acute IR radiation exposure damages the cornea and aqueous humor and damages the delicate photoreceptors permanently. The effects of chronic exposure to the sub bands of IR are as follows.

MIR and FIR - Erythema

MIR and FIR - Pigmentation

MIR and FIR- Photokeratitis

NIR – Cataracts & Retinal burn

Control Methods: Control of IR radiation can be done at the design stage of devices and to ensure by engineering controls like shielding and failsafe inter-locks. High levels of IR radiation can be controlled by personal protective measures such as reflecting face-shields, glasses, protective clothing like aprons, gloves.

Health Hazards of Visible Radiation:

Visible light can cause photoretinitis which is also known as 'blue-light hazard'. The other effect is glare, which is a gross overloading of the adaptation process of the eye.

Glare can be of two types:

1. **Absolute Glare:** when the source of light is very bright by which the eye cannot adapt to it.
2. **Relative Glare:** when there is excessive brightness contrasts between various parts of the visual area.

This creates visual fatigue that adds to general fatigue Visual fatigue develops double vision, painful irritation of the eye, reduced powers of accommodation, headaches and reduced visual acuity.

Control Measures:

- Design the infrastructure in such a way to use the natural light at maximum
- Wherever possible workers have access to a window at their workplaces.
- Provide 'light breaks' to the workers
- Daylight' fluorescent tubes can be used where artificial lighting is unavoidable.

Health Hazards of Microwave Radiation/Radio frequency:

Frequency	Description	Application
30kHz	Very low frequency	TVs
300 kHz	low frequency	AM radio
3 MHz	Medium frequency	Induction heaters
30 MHz	High frequency	RF heat sealers
300 MHz	Very High frequency	FM radio
3 GHz	Ultra High frequency	Mobile phones, TV broadcasts, microwave ovens
30 GHz	Super High frequency	Radar, satellite links, MW communications
300 GHz	Extra High frequency	Point-to-Point links

At longer wavelengths, RF can generate alternating electric fields in bodies that rotate to align with the field causes the molecule to vibrate. This vibration produces heat in the living tissues and potentially damages it. The magnetic field that was produced simultaneously causes vertigo or nausea.

TERMINAL QUESTIONS

1. Define the term Physical Hazard and explain the health effects when exposed to hot temperature?

2. Explain the effects of noise hazard?
3. Explain the health hazard of UV radiation?
4. Define the following
    a. Absorbed dose
    b. Ionizing radiation
    c. Non-ionizing radiation

1.4 LET US SUM UP

In this unit we have discussed some of the physical hazards. Basically a physical hazard is an agent, factor or circumstance that can cause harm with or without contact. They are categorized as type of occupational hazard or environmental hazard. Physical hazards are a common source of injuries in many industries. Extreme temperature, Noise, Vibration and radiation have discussed in detail. These are considered fairly common workplace hazards. Naturally, noise is considered for occupations like musicians, mine workers, and construction workers where they are exposed to more constant levels of noise for longer duration hence they are at a higher risk of hearing loss.

Overexposure to extreme cold by workers who work outdoors in the winter season like fishermen, hydro and telecommunications linemen, construction workers, transportation workers, military personnel, emergency response workers, and those work in the refrigerated warehouse are prone to illness like frostbite and frostnip, Hyperthermia, Lower work efficiency, Impaired performance of complex mental tasks and Reduced muscular strength and stiffened joint. Whereas workers in laundries, bakeries, restaurant kitchens, steel foundries, glass factories, brick-firing and ceramic plants, electrical utilities, smelters, and outdoor workers such as construction workers, firefighters, farmers, and mining workers are more susceptible to extreme heat and are affected by dehydration, cramps, rashes, burns, dizziness, irritability and heat stroke. The health effects and risk assessment of ionizing and non-ionizing radiation has discussed.

1.5 KEY WORDS

Absorbed Dose : It is the amount of energy deposited by ionizing radiation in a unit mass of tissue. It is expressed in units of joule per kilogram (J/kg) and called “gray” (Gy).

Background Radiation : ionizing radiation from natural sources, such as terrestrial radiation due to radionuclide in the soil or cosmic radiation originating in outer space.

Dose Equivalent : a quantity used in radiation protection to place all radiation on a common scale for calculating tissue damage. Dose equivalent is the absorbed dose in grays times the quality factor. The quality factor account for differences in radiation effects caused

by different types of ionizing radiation.The sievert (Sv) is the unit used to measure dose equivalent.

Effective Dose : a dosimetric quantity useful for comparing the overall health effects of irradiation of the whole body. It takes into account the absorbed doses received by various organs and tissues and weighs them according to present knowledge of the sensitivity of each organ to radiation. The unit of effective dose is the sievert (Sv); 1 Sv = 1 J/kg.

Half-Life : the time any substance takes to decay by half of its original amount.

Ion : an atom that has fewer or more electrons than it has protons causing it to have an electrical charge and, therefore, be chemically reactive.

Ionization : the process of adding one or more electrons to, or removing one or more electrons from, atoms or molecules, thereby creating ions. High temperatures, electrical discharges, or nuclear radiation can cause ionization.

Ionizing Radiation : any radiation capable of displacing electrons from atoms, thereby producing ions. High doses of ionizing radiation may produce severe skin or tissue damage.

Isotope : a nuclide of an element having the same number of protons but a different number of neutrons.

Radiation : energy moving in the form of particles or waves. Familiar non-ionizing radiations are heat, light, radio waves, and microwaves. Ionizing radiation is a very high-energy form of electromagnetic radiation and particles.

Radioactive Material : material that contains unstable (radioactive) atoms that give off radiation as they decay. Radioactivity: the process of spontaneous transformation of the nucleus, generally with the emission of alpha or beta particles often accompanied by gamma rays. This process is referred to as decay or disintegration of an atom.

1.6 REFERENCES AND SUGGESTED FURTHER READINGS

1. NOHSC (National Occupational Health and Safety Commission). (2004). National Code of Practice for Noise Management and Protection of Hearing at Work [NOHSC: 2009(2004)].

2. ISO (International Organization for Standardization). (1997). ISO 2631–1:1997 Mechanical Vibration and Shock – Evaluation of Human Exposure to Whole-body Vibration – Part 1: General Requirements. Geneva: ISO.

3. Griffin, M. J. (1990). Handbook of human vibration. London: Elsevier.

4. EPA (US Environmental Protection Agency). (2011a).Radiation Protection: Health Effects. Retrieved from http://www.epa.gov/radiation/understand/protection_basics.html

1.7 ANSWERS TO CHECK YOUR PROGRESS

Answers to Check Your Progress 1

1. Your answer should include the following points:

   Frostbite means freezing of tissues. It can happen at temperatures above 0°C depend on the situation. It occurs commonly to the body parts like cheeks, nose, fingers, toes and earlobes that are poorly insulated and often left exposed. In frostbite body tissues will damage with the formation of ice crystals in them.

Hypothermia

Hypothermia occurs when the loss of body heat is greater than the heat produced. Insufficient clothing, poor insulation and exhaustion from physical work are the factors for hypothermia.

Answers to Check Your Progress 1

Your answer should include the following points:

i. b ii.e iii.a iv.c v.d

Answers to Terminal Questions

1. Your answer should include the following points:

   Physical hazards are type of hazards that derived from energy, matter and a combination of the two. Physical hazards in the workplace are categorized into worker–material interfaces, the physical work environment, and energy and electromagnetic radiation.

   Health hazards of hot temperature: Many workers working in outdoor environment like construction, hazardous waste, agricultural farming, oil and gas plants are facing severe heat related illness. When a worker exposed to extreme heat the body should eliminate excess heat that absorbed to maintain the normal body temperature without any adverse effect. This will happen by natural body mechanism either through blood circulation to the skin or by sweating. Sometimes the temperature of the air is hotter than normal body temperature the body cooling mechanism is difficult by blood circulation to the skin process and it is done by sweating only. In humid conditions the sweating is also difficult and the excess heat will be stored in the body. As the body accumulates the heat continuously the body temperature will rise up with increase in the heart rate. With this the person become sick and loses concentration, focus on work. The health indications may vary from heat rash, muscle cramps to heat stroke and exhaustion and finally unconscious which leads to death.

2. Your answer should include the following points:

Noise of an explosion causes structural damage known as acoustic trauma with little hearing loss. Roaring noise originally exhaust the fragile hair cells in the inner ear produce a shift in hearing threshold known as temporary threshold shift. This will be recovered overnight. If the regular exposure to extremely loud noise, the effect is cumulative. There is a permanent damage caused to the hair cells causes permanent threshold shift, the damaged hair cells are irreparable and the loss of hearing is permanent.

Noise stress and acoustic shock are also observed.

3. Your answer should include the following points:

   The UV radiation has both positive and negative effects on human health. For example, they are used for killing bacteria in medical or dental applications and used in curing resins. Exposure to sunlight, UV-B provides vitamin D which is required for healthy bones. Acute exposure to UV radiation causes 'sunburn' and 'arc-eye', having a sensation of sand in the eyes. Chronic exposure results in skin cancers, damage the eye lens and cataracts. There is a risk of infectious disease and reduced efficacy of vaccinations also. Other adverse health effects of the different UV bands are as follows.

   UV-A: Sun tan and pigmentation

   UV-B: Skin erythema, keratitis and cataracts

   UV-C: Skin cancer

4. Your answer should include the following points:

   i. **Absorbed dose:** It is the amount of energy deposited by ionizing radiation in a unit mass of tissue. It is expressed in units of joule per kilogram (J/kg) and called "gray" (Gy).

   ii. **Ionizing radiation**: Any radiation capable of displacing electrons from atoms, thereby producing ions. High doses of ionizing radiation may produce severe skin or tissue damage.

   iii. **Non-Ionizing radiation**: Any type of electromagnetic radiation that does not carry enough energy per quantum to ionize atoms or molecules. Instead of producing charged ions when passing through matter, non-ionizing electromagnetic radiation has sufficient energy only for excitation, the movement of an electron to a higher energy state.