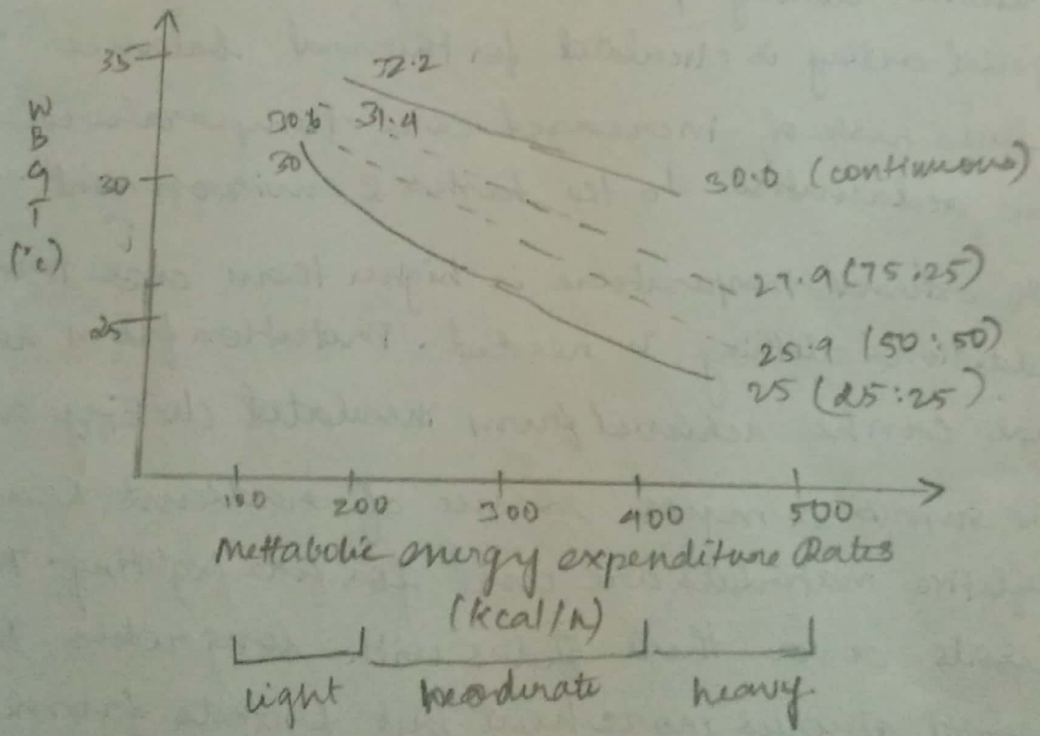
## DESIGN OF PHYSICAL ENVIRONMENT :-

When the work environment can't be improved nor the task can be redesigned, methods of protecting the worker are needed. Some of the ergonomic principles used are the following :-

### a) SPECIFY SAFE WORK - REST CYCLES :-

→ Welch measured pulse rate, skin temperature sweat loss and rectal temperature of workers in hot & humid conditions

→ Rectal temperature indicated the presence of heat exhaustion. Bell measured safe exposure times and rate of heat collapses.




### b) DESIGN COOL SPOTS :-

→ Thermal comfort is provided using thermal refuge for operators. Window coverings and screens provide shade.

→ Sims designed a cool spot for inspectors in glass making factory. Glass and aluminium heat radiant shields and low velocity cooling air reduced thermal discomfort.

→ Ohnaka investigated heat stress under asbestos. protective clothing was used to prevent asbestos inhalation.

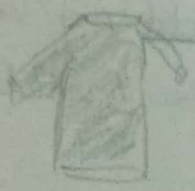
→ some solutions for thermal discomfort include cool room adjacent to work area, usage of ice vests, proper air-conditioning. The hot-cool condition reduced stress and discomfort.

c) ISSUE PROTECTIVE CLOTHING:-

→ Protective clothing provides an acceptable microclimate. Air or a special cooling is circulated for thermal balance. This reduces risk of increased core temperature and helps them acclamatise to the tasks & environment.

→ If external temperature is higher than core temperature additional clothing is needed. Protection from radiation heat can be achieved from insulated clothing assemblages

→ The sun is a major source of radiant heat. Fireproof reflective materials are used for fire fighting. People in deserts cover their bodies with long robes. Black material absorbs more heat but protects from sunburn In humid environments minimal clothing is needed to increase evaporative heat loss.



→ BLACK CLOTHING
→ More absorption of heat
→ Hence sunburn

d) COOL THE EXTREMITIES :-

→ Hyperthermic individuals should immerse hands in cold water. House compared core temperatures of individuals after immersion in cold water. The average was 38.5°c.

→ The immersion technique doesn't prevent hyperthermia The natural response to such immersion is, peripheral vasoconstriction, and it occurs when core temperature rises and in central Nervous system.

→ Peripheral blood vessels remain dilated, and convective heat loss takes place.

e) COLD CLIMATE PROTECTION :-

→ sufficient amount of insulation while allowing moisture from sweating to evaporate is key. Goretex, provides insulation and allows moisture to escape.

→ sweat produced while working, reduced thermal insulation capabilities of the garment, preventing metabolic heat production. At 0°c gloves are ineffective and mittens are needed. The wearer becomes cold very rapidly if this happens.

f) COMFORT AND INDOOR CLIMATE:-

The climate conditions inside a building depend on prevailing conditions. Design of the building is the most important factor.

2. DESIGN OF ACOUSTIC ENVIRONMENT:-

The alerting quality of noise makes it an ideal mode of warning. Noise is also a source of dissatisfaction. Tolerance level for noise varies widely. Woodson studied effects of noise on humans. Noise levels belwow 90dB affect task performance and annoy people.

a) REVERBERATION:-

→ The noise level in a room depends on intensity of sound and reverberation characteristics. The sound from source reaches the listener directly and also bounces of reflective surfaces.

→ Reverberation time is directly proportional to intensity of reflection. With continuous sound, background noise created by interreflection builds up to a steady level, called the reverberant field.

i) Excessive reverberation blurs acoustic signals.

ii) Reverberation time is independant of source position and listener position.

iii) Reverberation intensity depends on sound level, volume and acoustic material in room.

→ Reverberation is a function of room volume and total sound absorption. A point is reached where the intensity of the direct field is equal to that of reverberant field called critical distance.

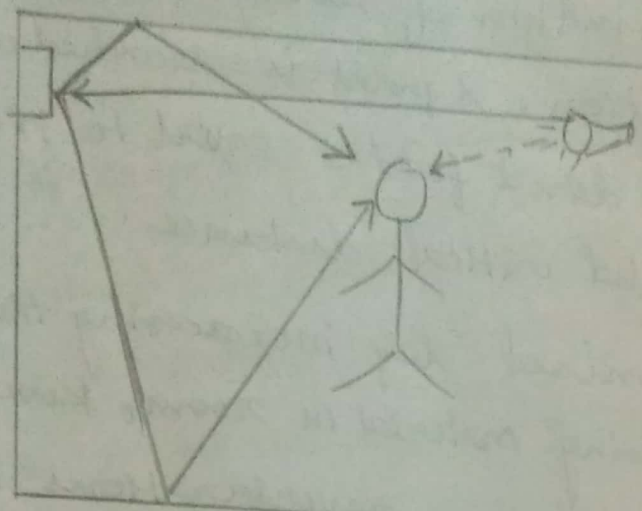
→ It can be minimised by increasing the amount of sound absorbing material in room. Reverberation can mask speech. Longer reverberations are needed for music because it provides more depth. Rooms may not be purpose-independant.

b) THE AUDITORY STARTLE RESPONSE :-

→ The startle reaction generated by unexpected auditory stimuli is common to all mammals and originates from brainstem. Adaptive response results in rapid adoption of a defensive stance with postural stability.

→ Auditory stimuli are powerful producers of the startle response. The ergonomic relevance of the same interferes with task performance. Startle is caused by sounds of 100 dB or higher.

→ For auditory stimuli to be alerting and not startling onset rates of 1 dB/ms. Sudden loud noises can have serious health consequences such as startle epileptis. Posttraumatic stress can also provoke an exaggerated response.



REVERBERATION

3 INDUSTRIAL NOISE CONTROL:-

In the UK, Noise at Work Regulations require that the noisy workplaces are assessed and steps are taken to reduce risks. If noise level is > 85dB, the first action level, where workers are given protective gears. If noise > 90dB, as per 2nd action level, exposure times have to be reduced.

Approaches used are:-

* Eliminate the noise totally.
* Isolate the noisy environment.
* Protect personnel by using protective gear.

Many machines have both primary noise resources and secondary noise resources. The relative contributions depend on the total noise generated. Noise from primary resources are periodic and < 1000Hz, secondary ones have higher frequency. Velocity gradients in compressed air create random vortices which move and are dissipitated in a chaotic manner, giving rise to wide band random noise.

## 2) COMMON PROBLEMS AND CONTROL MEASURES:-

→ Fans or blowers are noisier when running at a higher speed. The sound level varies as the 5th power of speed. A large fan running at lower speed

→ Pneumatic tools such as paving breakers and tools produce noise due exhaustion of compressed air. The air must be piped away using mufflers that reduce the escape velocity of air.

→ Pneumatic ejectors are used to remove parts from presses. Mechanical ejector are quieter. Hydraulic and electric ones are also quieter.

→ Large electric solenoids for tripping clutches can be sources of impact noise. Resilent bumpers fitted to the point of impact can be beneficial.

→ Cavitation and turbulence can increase noise from pumps considerably. Cavitation can be reduced by decreasing fluid flow velocity, by smoothing the system and maintaining pressure.

→ Machine vibration can be exacerbetated by imbalance or eccentricity in rotating members, by inadequate mountings by wear. Resilent couplings can be used to isolate a source from surrounding effects.

A change in process can also reduce noise. Riveting can be replaced with welding and dot matrix printers can be replaced with laser and ink jets. Rubber and wood, don't

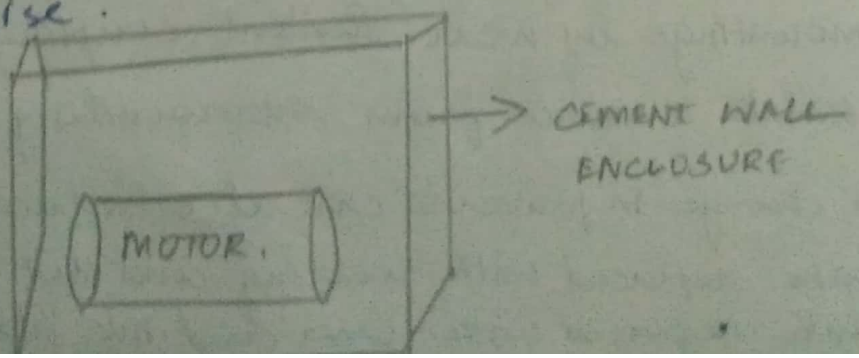
transmit sound to the level of metal. Sound attenuates with distance, attention should be paid to the location of machines or components.

b) NOISE INSULATION :-

* If machine redesign is improbable, an acoustic enclosure can be built. This allows noise to be interreflected and loses energy in the process.
* The interreflection increases noise level in the enclosure by 10 dB. Sound absorbing materials are porous and lightweight. Due to interreflection, their energy is converted to heat by friction. Absorption coefficient is the ratio of energy absorbed to the energy striking of the material.
* Perfect coefficient is 1 and a reflector's is 0. A.C. varies with frequency. sound doesn't pass efficiently across the interface of 2 materials with varying elasticity. The best barrier materials have a high density and are non-porous.

  eg :- Rubber seals windows and Doors.

* Partial enclosure are effective if the ears are in the enclosure. Partial enclosures protect from high frequency noise.

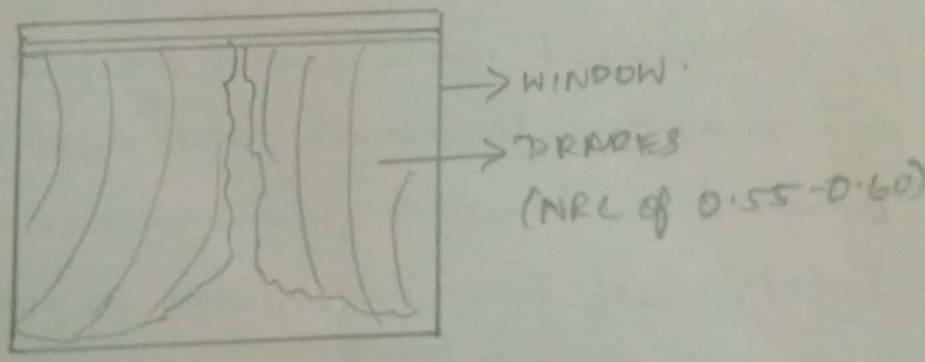


c) SCREENS, CARPETS, CURTAINS, TILES :-

→ In offices, acoustic ceiling is used to absorb noise and block transmission. The materials are rated as per their noise absorption coefficient. An NRC = 0 represents a reflector, NRC = 1 represents absorber.

→ Kleiman found that NRC = 0.85 is needed for offices and must be high with rise in frequency of noise. Thick pile carpets whose NRC - 0.7 absorb vibration.

→ Drapes are used to reduce noise transmission and are effective because the pleating increases the surface area of contact material which aid in absorption of sound. Their NRC is 0.55-0.60.




d) ACTIVE NOISE CONTROL :-

→ Active control is effective at lower frequencies but has many applications because much machine noise is of periodic / cyclic nature. Noise cancellation works well for non-random noise sources.

→ An anti-phase version of the source of equal amplitude is produced. If the propagation of anti noise is

synchronized, noise cancellation is possible. Active vibration cancellation is used, in copters to eliminate vibration transfer from Rotors to cockpit.

4) DESIGN OF LIGHTING:-

For visual comfort and to meet demands the following should be considered.

a) A suitable level of illumination.
b) A balance of surface luminances
c) Avoidance of glare.
d) Temporal uniformity of lighting.

i) ILLUMINATION LEVELS:-

Although early research indicated that improvements in productivity were possible when illumination levels were increased, more does not equally better. High levels of illumination increase glare and hide visual details. Lesser levels degrade performance. Older workers need higher levels of illumination due to loss of refractive power and changes in internal structures of their eyes.

ii) NIGHTING SURVEYS:-

Light meters are used to measure illumination levels on work surfaces. Care should be taken to not stand between the light source and the meter's sensors.

## M) BALANCE OF SURFACE LUMINANCES :-

→ In practice, a balance surface illuminates is achieved by specifying appropriate illuminances and reflectances in a room. Direct lighting is used for modelling effect.

→ the areas of light and dark enhance the 2-D appearance of the works by emphasising differences in depth. Angled direct lighting is good for surface texture of materials.

→ Indirect lighting is prone to reflection. Direct & Indirect lighting is to be combined for balance & min. glare.

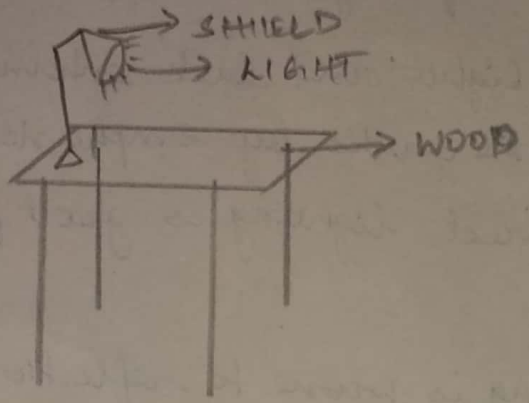
→ A balance can be achieved by using surfaces with different reflectances in a room. As shadow is a depth cue, pattern of shadow on the floor can be misinterpreted as changes in ground level and increase the risk of people slipping etc.

## N) AVOIDANCE OF GLARE :-

→ Glare can bee reduced by choosing a suitable combination of direct & indirect lighting. Direct lighting produces hard shadows and sharp contrasts whereas indirect lighting is prone to reflection and provides smoother transistion among surfaces and reduces shadows.

→ Light sources shouldn't appear in the visual field during work activities. Glare depends on lighting system and

workspace design. Lamps have shields and hos from eye to lamp should be >30°. Overhead lamps should not reflect of workspaces. Wood or matte finishes should be used in workspaces.

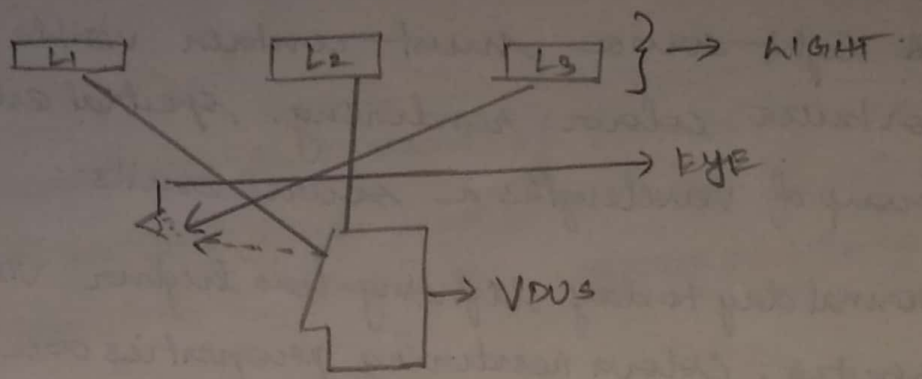



V) GLARE AND VDUS :-

→ Lighting is key in offices where VDUs are used. Pen and paper offices use flourescent lamps for lighting. Multiple workspace lamps should not interfere with the neighbouring cones as it may lead to glare.

→ Because a VDU user looks directly at the screen light from overhead lamps can create a veiling effect - which reduces contrast between characters and background. Positioning lamps and workstationsis key.

→ At the workstation, dark screens and bright docss are a problem. VDU emits own light and hence surrounding illumination can be lower. Low reflectance and task lighting is needed.




VI) TEMPORAL UNIFORMITY IN LIGHTING :-

→ Fluctuating luminances are disturbing compared to high contrasts. This phenomenon is influenced by characteristics of the light source and task requirements. Flouresent lamps work by passing an electric current through glass in glass tube.

→ The gas emits light & UV rays which excites the phosphor to emit light. This is why flouresent lamps flicker more. Phase shifting of flouroscent tubes and regular inspection is needed. flicker creates a stroboscopic effect in industries.

Vii) COLOUR RENDERING & ARTIFICIAL LIGHT :-

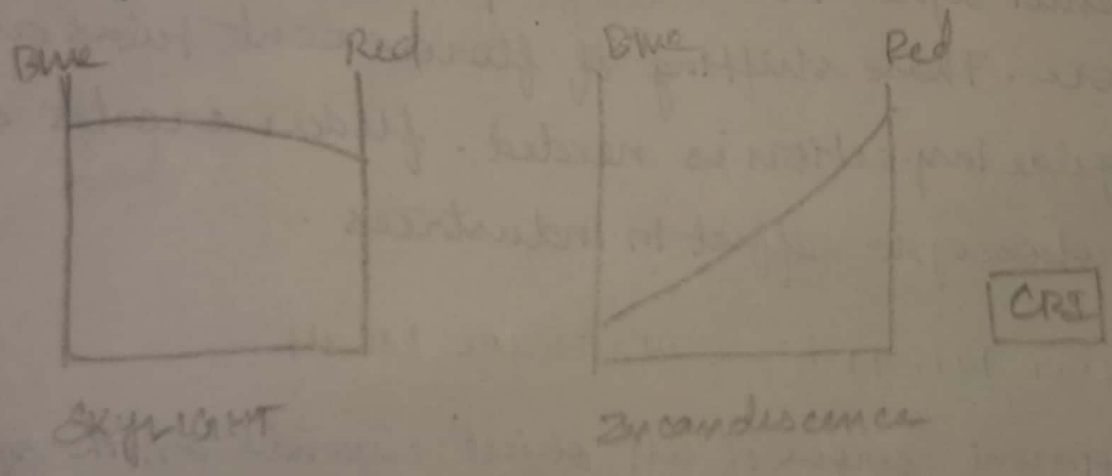
→ The apparent colour of an object depends on the spectral combination of the incident and reflected lights. An object that appeared red in white light would appear black in monochromatic blue light.

→ Light emitted by a source varies in wavelengths. Monochromatic sources have a narrow band. It has poor colour rendering property as it provides no info on how objects reflect light.

→ A light source must contain visible spectrum for better colour rendering. Spectral energy denotes group of wavelengths a source emits.

→ Normal day to day lighting has higher visible spectra. Colour rendering properties are determined by appearance of light itself.

→ Colour Rendering index (CRI) is used to describe colour rendering properties of materials. Daylight has a CRI = 100. A high CRI means better colour rendering. Lamp colour rendering property is needed for evaluating lights sources at work surfaces.




5. COMFORT AND INDOOR CLIMATE :-

The design of building for better indoor climate follows certain ergonomic principles which are the following :-

a) i) BUILDING DESIGN AND INDOOR CLIMATE:-

→ Building design determines the amount of solar penetration into the building and the radiant heat gain. The amount of insulation influences heat exchange in the system.

→ Solar heat gain through uninsulated surfaces leads to overheating. Parts of a structure are exposed to direct sunlight and they can be painted with bright colours for reflectance. Water is poured near or on top a overheated surface to induce cooling.

→ Steel roofs can be shaded with tiles and have increased air space. This minimises degree of heating via sunlight sunlight entering via doors and windows is another source of heating. Special glazing, louvres or shades can prevent solar penetration.

→ The heat transfer property of different materials is different and depends on thermal conduction and surface temperature. The flywheel effect is seen in such situations where heavy weight materials are used to soothen the internal temperature

ii) THERMAL COMFORT IN BUILDINGS:-

The thermal comfort of a factory or office worker depends on being a temperature of 33°C. Draughts, sunlight falling on exposed parts of the body or a cold container can cause.

thermal discomfort. Max. values of humidity are 60-80% at 23°c, 50-70% at 22°c and so on. At T=24°c O2 greater lethargy sets in. At T≤18°c extra clothing is needed.

## iv) THERMAL COMFORT, AIR QUALITY & SICK BUILDINGS:-

→ comfort and well being doesn't depend only on the room but also other factors. If concentration of substances increase beyond the threshold levels, the health of occupants is at Risk.

→ The term Building block Syndrome describes highly undue absenteeism owing to poor quality of air. Modern buildings provide better air circulation. The occupants of a building and the machines are primary contributors of heat.

→ All buildings need a finite volume of air. Scarcity of air leads to suffocation. CO2, CO and ozone are popular contaminants.

→ Indoor air pollution is caused by external air entering indoors. Building sickness occurs due to an imbalance in the interior atmosphere.

→ Photocopiers may degrade the atmosphere due to ozone emission. A ozone hazard is prone to occur in a badly ventilated room.

→ Humidifier fever occurs during mondays at work resumption due to inhalation of spores and cysts in the air.

→ Low humidity increases chances for respiratory infection. Modern buildings may be deficient of negatively charged small air ions. In offices air ions are negated when they come in contact with metalic surfaces.

→ Hawkins pointed out that –ve ions reduced dizziness, nausea and headaches. Increased ventilation is needed for comfort. Kleeman suggested periodic air changes to keep the surrounding healthy and tolerable.

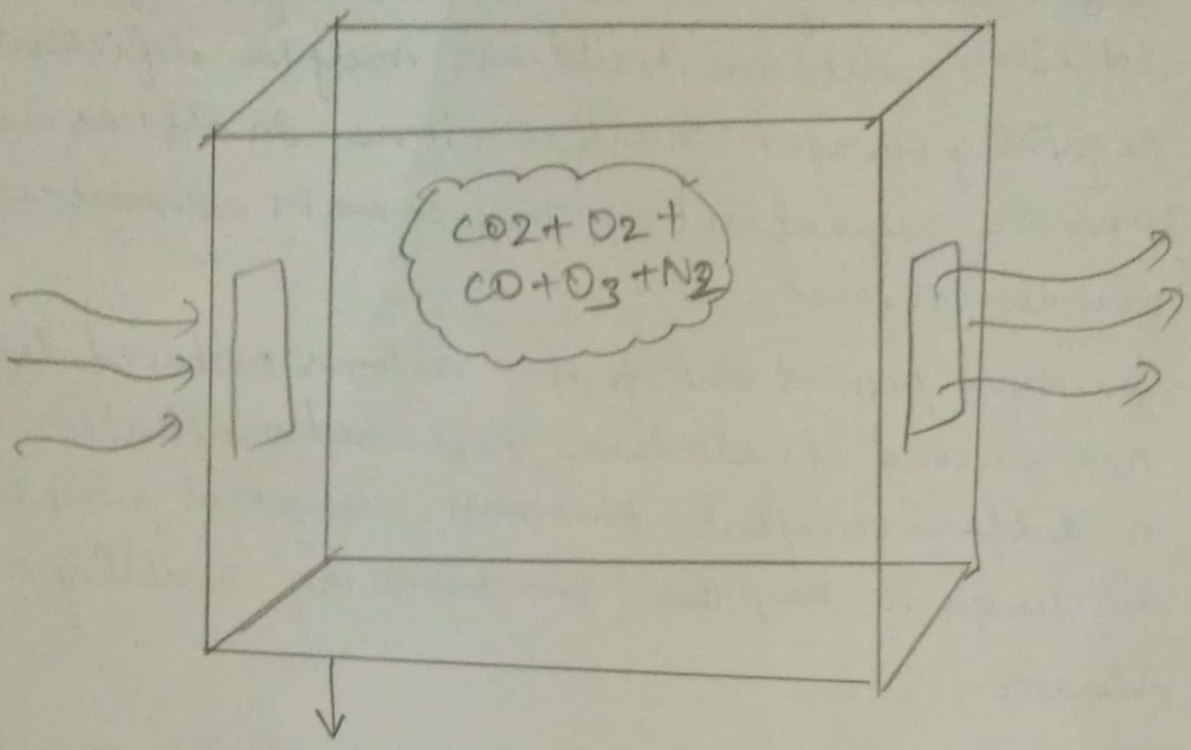
→ Occupational hygienists keep track of the spread of gases in the atmosphere. $CO_2$ test is done to measure indoor air's quality. Elevated $CO_2$ indicates poor ventilation.

V) VENTILATION :-

→ It is property of thermal comfort, and it means to provide fresh air for occupants. Removes heat by convection.

→ It is apparent that whether or not air movement is seen depends on temperature and relative humidity.

→ Low relative humidity causes occupants to have blocked noses. Humidifiers are needed to solve this problem.




ROOM WITH
CROSSBREEZE.