# MODULE 2

PERSONAL PROTECTION IN WORK ENVIRONMENT

# PPPERSONAL PROTECTIVE EQUIPMENTS

- Personal protective equipment (PPE) is protective clothing, helmets, goggles, or other garments or equipment designed to protect the wearer's body from injury or infection.
- PPE is used in a variety of working environments and industries, with the aim
- f protecting the worker from hazards while carrying out work.

# PERSONAL PROTECTIVE EQUIPMENTS

PPE is equipment that will protect the user against the risk of accidents or of adverse effects on health.

It can include items such as;

- **Safety helmets**
- **Gloves**
- **Eye protection goggles**
- **High-visibility clothing**
- **Safety footwear**
- **Safety harnesses**
- **Respiratory protective equipment (RPE).**

# Why is PPE important?

- Even where engineering controls and safe systems of work have been applied, some hazards might remain. These include injuries to:
  - **The lungs, e.g. From breathing in contaminated air;**
  - **The head and feet, e.g. From falling materials;**
  - **The eyes, e.g. From flying particles or splashes of corrosive liquids;**
  - **The skin, e.g. From contact with corrosive materials;**
  - **The body, e.g. From extremes of heat or cold.**
- PPE is needed in these cases to reduce the risk.

# Types of PPE

- There are two types of PPE

- **Simple personal protective equipment** – this refers to equipment that has a basic design model, it protects against lower risk hazards.

- **Complex personal protective equipment** – this refers to equipment that it more of a technical design and provides protection against fatal or serious risk.

- Personal protection equipment's may be divided into following two broad groups:
  - **Respiratory Protective equipment.**
  - ·**Non-respiratory Protective equipment.**

# Types of PPE that can be used

## Eyes Protection

- **Hazards**
- Chemical or metal splash, dust, projectiles, gas, welding light, vapour, radiation, sparks
- **Options**
- Safety spectacles, goggles, face screens, face shields, and visors
- Make sure the eye protection chosen has the right combination of impact/dust/ splash/molten metal eye protection for the task and fits the user properly.

# Types of PPE that can be used

## Head and neck Protection

- **Hazards**

- Impact from falling or flying objects, risk of head bumping, hair getting tangled in machinery, chemical drips or splash, climate or temperature

- **Options**

- Industrial safety helmets, bump caps, hairnets and firefighters' helmets

- Some safety helmets incorporate or can be fitted with specially-designed eye or hearing protection.

- Don't forget neck protection, e.g. scarves for use during welding.

# Types of PPE that can be used

## Ears Protection

- **Hazards**
- Noise – a combination of sound level and duration of exposure, very high-level sounds are a hazard even with short duration

- **Options**
- Earplugs, earmuffs, semi-insert/canal caps
- Provide the right hearing protectors for the type of work, and make sure workers know how to fit them.
- Choose protectors that reduce noise to an acceptable level, while allowing for safety and communication.

# Types of PPE that can be used

## Hands and Arms Protection

- **Hazards**
- Abrasion, temperature extremes, cuts and punctures, impact, chemicals, electric shock, radiation, biological agents and prolonged immersion in water
- **Options**
- Gloves, gloves with a cuff, gauntlets and sleeving that covers part or all of the arm
- Some materials are quickly penetrated by chemicals – take care in selection
- Wearing gloves for long periods can make the skin hot and sweaty, leading t skin problems.
- Using separate cotton inner gloves can help prevent this

# Types of PPE that can be used

## Feet and Legs Protection

- **Hazards**

- Wet, hot and cold conditions, electrostatic build-up, slipping, cuts and punctures, falling objects, heavy loads, metal and chemical splash, vehicles

- **Options**

- Safety boots and shoes with protective toecaps and penetration-resistant, mid-sole wellington boots and specific footwear, e.g. foundry boots and chainsaw boots

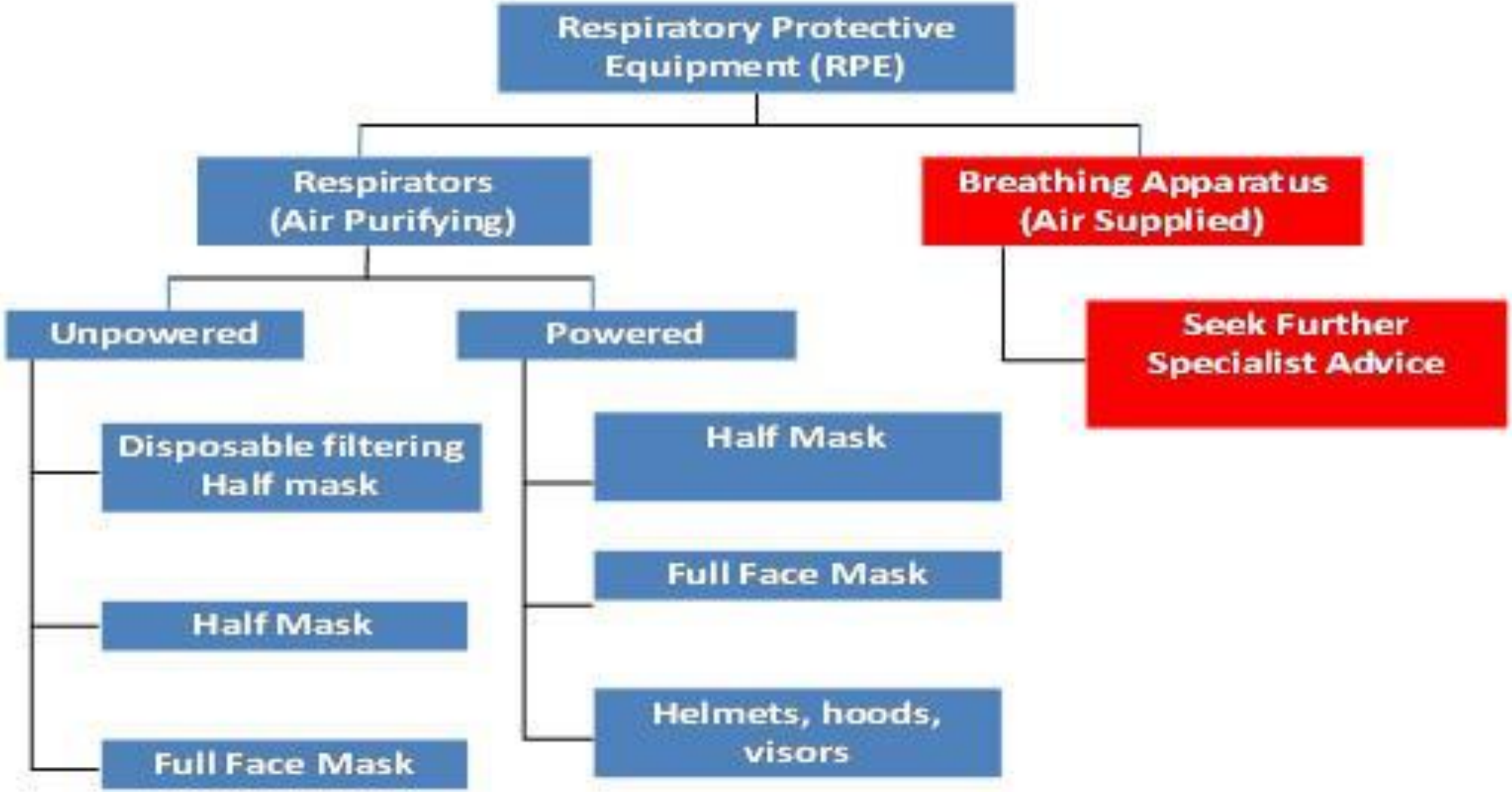
- Footwear can have a variety of sole patterns and materials to help prevent slips in different conditions, including oil- or chemical-resistant soles.

- It can also be anti-static, electrically or thermally non-conductive.

# Types of PPE that can be used

**Lungs Protection**

- **Hazards**
- Oxygen-deficient atmospheres, dusts, gases and vapours
- **Options**
- Respiratory protective equipment (RPE)
- Some **respirators** rely on filtering contaminants from workplace air.
- These include simple filtering facepieces and respirators
- Wearers must ensure the RPE fits properly, e.g. for tight-fitting respirators
- There are also types of **breathing apparatus** which give an independent supply of breathable air, e.g. fresh-air hose, compressed airline and self-contained breathing apparatus.



Respiratory Protective Equipment (RPE)
Respirators (Air Purifying)
Breathing Apparatus (Air Supplied)
Unpowered
Powered
Seek Further Specialist Advice
Disposable filtering Half mask
Half Mask
Full Face Mask
Half Mask
Full Face Mask
Helmets, hoods, visors

# TYPES OF RESPIRATORY PROTECTION

**Elastomeric Half Facepiece Respirators** are reusable and have replaceable cartridges or filters. They cover the nose and mouth and provide protection against gases, vapors, or particles when equipped with the appropriate cartridge or filter.

**Elastomeric Full Facepiece Respirators** are reusable and have replaceable canisters, cartridges, or filters. The facepiece covers the face and eyes, which offers eye protection.


**Filtering Facepiece Respirators** are disposable half facepiece respirators that filter out particles such as dusts, mists, and fumes. They do NOT provide protection against gases and vapors.

**Powered Air-Purifying Respirators (PAPRs)** have a battery-powered blower that pulls air through attached filters, canisters, or cartridges. They provide protection against gases, vapors, or particles, when equipped with the appropriate cartridge, canister, or filter. Loose-fitting PAPRs do not require fit testing and can be used with facial hair.

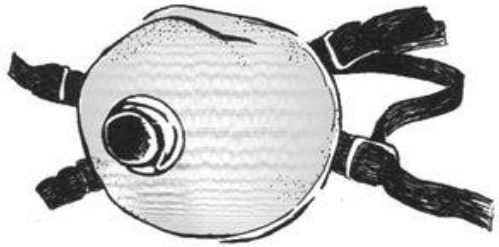
**Supplied-Air Respirators** are connected to a separate source that supplies clean compressed air through a hose. They can be lightweight and used while working for long hours in environments not immediately dangerous to life and health (IDLH).

Example of an open-circuit SCBA

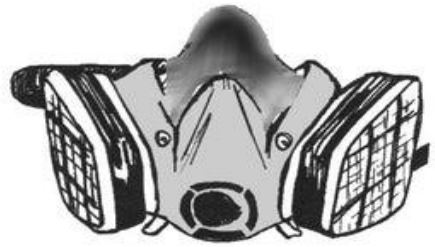
**Self-Contained Breathing Apparatus (SCBAs)** are used for entry into or escape from environments considered to be IDLH. They contain their own breathing air supply and can be either open circuit or closed circuit.

Example of an SAR/SCBA

**Combination Respirators** can be either a supplied-air/SCBA respirator or supplied-air/air-purifying respirator. The SCBA type has a self-contained air supply if primary airline fails and can be used in IDLH environments. The air-purifying type offers protection using both a supplied-air hose & an air-purifying component and cannot be used for entry into IDLH environments.



Half Mask,
Particulate



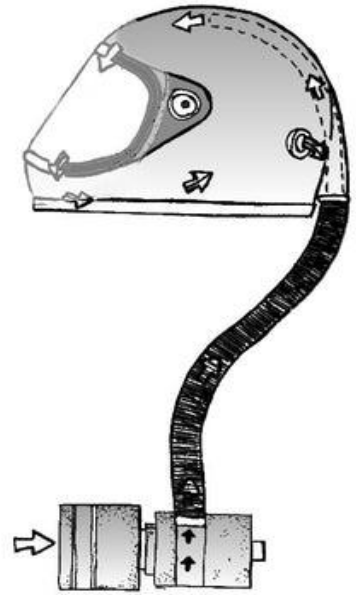
Half Mask,
Dual Cartridge
Disposable

Half Mask,
Dual Cartridge
Reusable

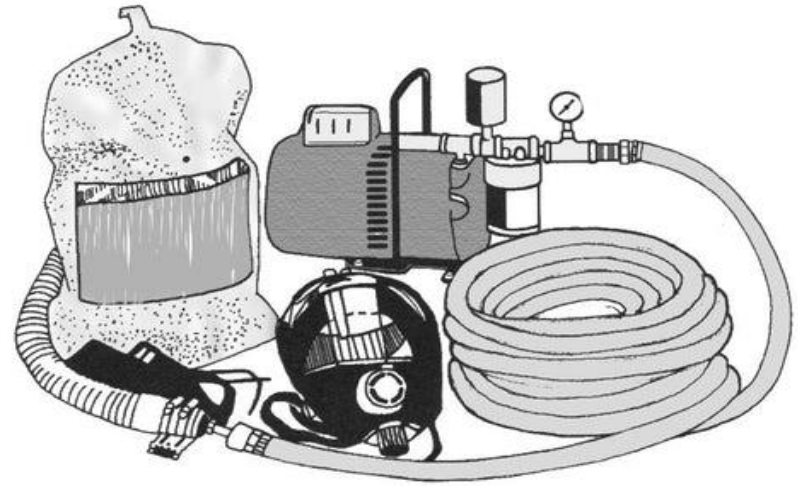
Self Contained Breathing Apparatus (SCBA)

Full-Face
Dual Cartridge
Reusable

Canister Type
Gas Mask



Powered air Purifying
Respirator (PAPR)



Continuous Flow Supplied Air Respirator

# Types of PPE that can be used

## Whole body Protection

- **Hazards**

- Heat, chemical or metal splash, spray from pressure leaks or spray guns, contaminated dust, impact or penetration, excessive wear or entanglement of own clothing

- **Options**

- Conventional or disposable overalls, boiler suits, aprons, chemical suits

- The choice of materials includes flame-retardant, anti-static, chain mail, chemically impermeable, and high-visibility.

- Don’t forget other protection, like safety harnesses or life jackets.

# PPE Standards

1. **29 CFR 1910.133 Eye and Face Protection:**
   - "The employer shall ensure that each employee uses appropriate eye or face protection when exposed to eye or face hazards from flying particles, molten metal, liquid chemicals, acids or caustic liquids, chemical gases or vapours, or potentially injurious light radiation."
2. **29 CFR 1910.134 Respiratory protection:**
   - "The employer shall provide a respirator to each employee when such equipment is necessary to protect the health of such employee.
   - The employer shall provide the respirators which are applicable and suitable for the purpose intended.
   - The employer shall be responsible for the establishment and maintenance of a respiratory protection program

# PPE Standards

3. **29 CFR 1910.135 Head protection**
   - “The employer shall ensure that each affected employee wears a protective helmet when working in areas where there is a potential for injury to the head from falling objects.
   - The employer shall ensure that a protective helmet designed to reduce electrical shock hazard is worn by each such affected employee when near exposed electrical conductors which could contact the head.

4. **29 CFR 1910.136 Occupational foot protection:**
   - “The employer shall ensure that each affected employee uses protective footwear when working in areas where there is a danger of foot injuries due to falling or rolling objects, or objects piercing the sole, and where such employee's feet are exposed to electrical hazards.”

# PPE Standards

5. **29 CFR 1910.137 Electrical protective equipment:**
   - Details the design requirements for specific types of electrical protective equipment—rubber insulating blankets, rubber insulating matting, rubber insulating covers, rubber insulating line hose, rubber insulating gloves, and rubber insulating sleeves used for the primary insulation of employees from energized circuit parts.

6. **29 CFR 1910.138 Hand protection:**
   - “Employers shall select and require employees to use appropriate hand protection when employees' hands are exposed to hazards such as those from skin absorption of harmful substances; severe cuts or lacerations; severe abrasions; punctures; chemical burns; thermal burns; and harmful temperature extremes.”

# PPE Standards

7. **29 CFR 1910.140 Personal Fall Protection Systems:**
   - "Employers shall ensure that each personal fall protection system used to comply with this part must meet all applicable requirements of this section.
   - This section establishes performance, care, and use criteria for all personal fall protection systems such as personal fall arrest systems and positioning systems."

# PPE Standards

**29 CFR 1910.132 General requirements:**

- says that all PPE has to meet these minimum requirements:
    1. Provide adequate protection against the particular hazards for which they are designed
    2. Be of safe design and construction for the work to be performed
    3. Be reasonably comfortable when worn under the designated conditions
    4. Fit snugly and not unduly interfere with the movements of the wearer
    5. Be durable
    6. Be capable of being disinfected
    7. Be easily cleanable
    8. Be distinctly marked to facilitate identification only of the manufacturer

# IS Standards related to PPEs

**HEAD PROTECTION**

**IS CODE 2745 : 1983** – Specification for non-metal helmet for firemen and civil defence personnel.

**IS CODE 2925 : 1984** – Specification Industrial safety helmet.

**IS CODE 4151 : 1993** – Specification for protective helmets for scooter and motorcycle riders.

# IS Standards related to PPEs

**BODY PROTECTION**

**IS CODE 3521 : 1999** – Industrial safety belt and harness.

**IS CODE 4501 : 1981** – Specification for aprons.

**IS CODE 6153 : 1971** – Protective leather clothing.

**IS CODE 7352 : 1974** – X-ray lead protective aprons.

**IS CODE 8519 : 1977** – Guide for selection industrial safety equipment for the body.

**IS CODE 8990 : 1978** – Code of practice for care and maintenance of industrial safety clothing.

# IS Standards related to PPEs

**EAR PROTECTION**

**IS CODE 6229 : 1980** – Methods for measurement of real-ear protection of hearing protectors and physical attenuation of ear muffs.

**IS CODE 8520 : 1977** – Guide for selection of industrial safety equipment for eye, face and ear protection.

**IS CODE 9167 : 1779** – Specification for ear protectors

# IS Standards related to PPEs

**EYE AND FACE PROTECTION**

**IS CODE 1179 : 1967** – Equipment for eye and face protection during welding.

**IS CODE 5983 : 1980** – Eye Protector.

**IS CODE 7524 : 1980** – Method of test for eye protectors: -non optical tests. (part -1)

**IS CODE 2521 : 1977** – Industrial safety face shield with plastic visor (part – 1)

**IS CODE 2521 : 1994** – Industrial safety face shield with wire mesh visor (part – 2)

# IS Standards related to PPEs

## EYE AND FACE PROTECTION (Contd…)

**IS CODE 8940 : 1978** – Code of practice for maintenance and care of industrial safety equipment for eyes and face protection.

**IS CODE 9973 : 1981** – Specification for the visor for scooter helmets.

**IS CODE 9995 : 1981** – Specification for the visor for non-metal police and firemen helmets.

**IS CODE 14352 : 1996** – Miner's safety goggles – Specification.

# IS Standards related to PPEs

**FEET AND LEG PROTECTION**

**IS CODE 1989 : 1986** – Specification for leather safety boots and shoes – for miners (part – 1).

**IS CODE 1989 : 1986** – Specification for leather safety boots and shoes -for heavy metal industries (part – 2)

**IS CODE 3737 : 1966** – Leather safety boots for workers in heavy metal industries.

**IS CODE 3738 : 1998** – Rubber boots – Specification.

**IS CODE 3976 : 2003** – Protective rubber canvas boots for miners – Specification.

# IS Standards related to PPEs

**FEET AND LEG PROTECTION (Contd…)**

**IS CODE 4128 : 1980** – Specification for fireman leather boots.

**IS CODE 5557 : 1999** – Safety rubber boots.

**IS CODE 5852 : 2004** – Steel toe safety shoes.

**IS CODE 6519 : 1971** – Code of practice for selection, care, and repair of safety footwear.

# IS Standards related to PPEs

**HANDS PROTECTION**

**IS CODE 2573 : 1986** – Specification for leather, gauntlets and mittens.

**IS CODE 4770 : 1991** – Rubber Gloves – electrical purposes – specification.

**IS CODE 6994 : 1973** – Specification for safety gloves –leather and cotton gloves (part – 1).

**IS CODE 8807 : 1978** – Guide for selection of industrial safety equipment for the protection of arms and hands.

# IS Standards related to PPEs

**RESPIRATORY PROTECTION**

**IS CODE 8318 : 1977** – Colour identification markings for air purifying canisters and cartridges.

**IS CODE 8347 : 1977** – Glossary of terms relating to respiratory protective devices.

**IS CODE 8522 : 1977** – Respirators chemical cartridge.

**IS CODE 8523 : 1977** – Respirators canister type gas masks.

**IS CODE 9473 : 2002** – Respiratory protective devices -filtering half masks to protect against particles – specification

**IS CODE 9563 : 1980** – Carbon monoxide filter self rescuers.

# IS Standards related to PPEs

**RESPIRATORY PROTECTION (Contd…)**

**IS CODE 9623 : 1980** – Recommendations for selection use and maintenance of respiratory protective devices.

**IS CODE 10245 : Part 1 to 46** – Breathing apparatus.

**IS CODE 15322 : 2003** – Particle filters used in respiratory protective equipment – Specification.

**IS CODE 15323 : 2003** – Gas filters and combined filters used in respiratory protective equipment -Specification.

# Specification for Industrial Safety Helmets(IS:2925-1984)

(i) Material:

Shell: non-metallic.

(ii) Size:

Circumference inside headband:

Small - 500 - 540 mm.

Medium - 540 - 590 mm.

Large - 590 - 640 mm.

# Specification for Industrial Safety Helmets(IS:2925-1984)

(iii) Essential Parts:

- Shell, peak, ventilation holes.
- Harness consisting of headband.
- Anti-concussion tapes.
- Chin strap.

(iv) Marking:

The following should be marked on the helmet:

- trade mark of manufacturer,
- size,
- ISI marking, and
- year of manufacture.

(v) Mass:

400 g (maximum)

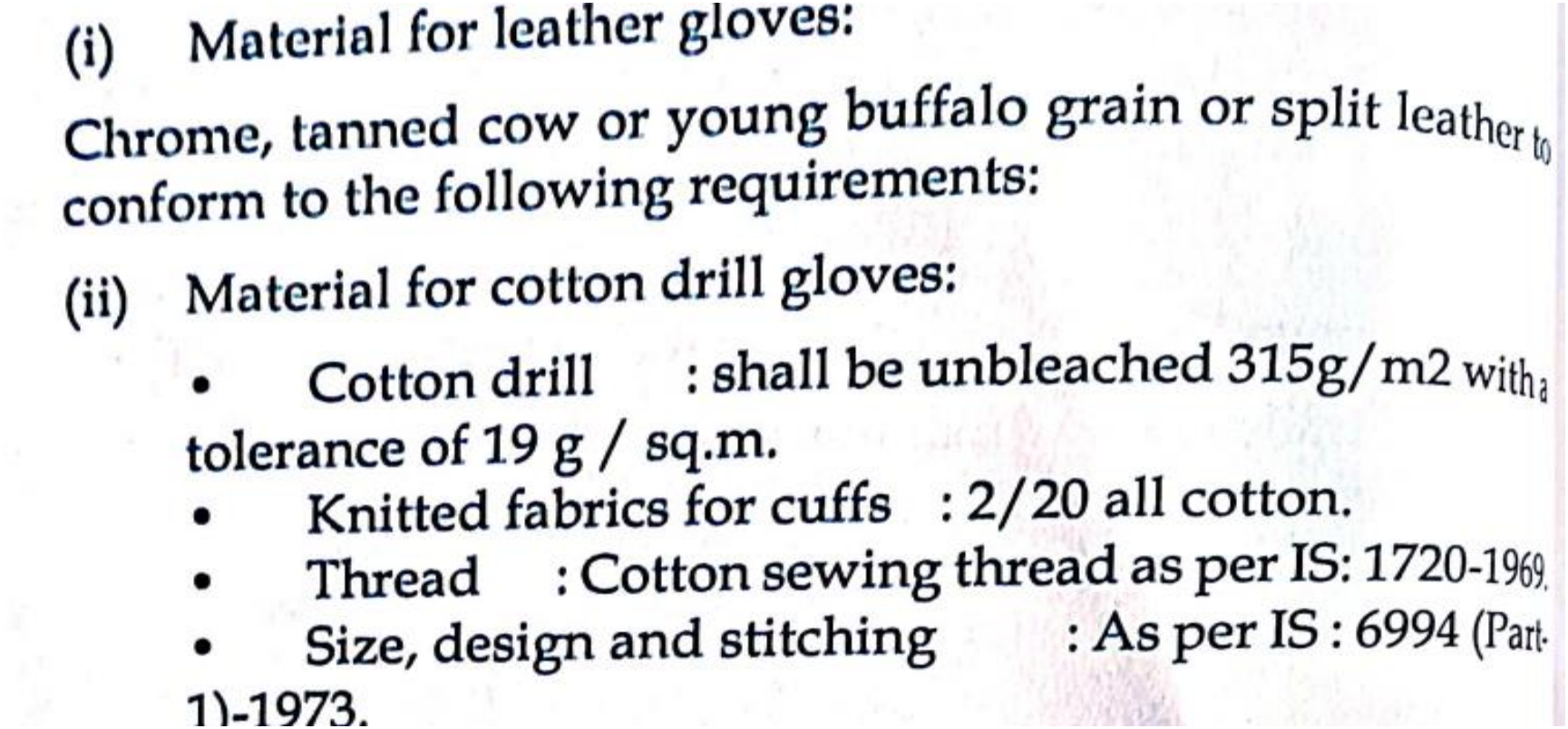
# Specification for Industrial Safety Helmets(IS:2925-1984)

(vi) Test and Performance Requirements:

- Shock absorption resistance against a wooden block of 3 kg dropped from a height of 1.5 m.,
- Penetration resistance against a plumb of 500 g with conical steel point falling from a height of 3 m.,
- Electrical resistance against 2000 V, 50 Hz for one minute.,
- < 5% water absorption when immersed in water for 24 hours at a temperature of 25°C.
- Heat resistance in an oven at 93° ± 50°C for 15 min.,
- No visible damage when a flame from a barthel burner (IS: 4355- 1977) is applied on the shell for 10 seconds,
- Sterilisation and corrosion resistance tests.

# Specification for Leather and Cotton Gloves [IS:6994(Part 1)-1973]

- It covers eleven types of industrial gloves made of leather and cotton



(i) Material for leather gloves:

Chrome, tanned cow or young buffalo grain or split leather to conform to the following requirements:

(ii) Material for cotton drill gloves:

- Cotton drill : shall be unbleached 315g/m2 with a tolerance of 19 g / sq.m.
- Knitted fabrics for cuffs : 2/20 all cotton.
- Thread : Cotton sewing thread as per IS: 1720-1969.
- Size, design and stitching : As per IS : 6994 (Part-1)-1973.

# Specification for Leather and Cotton Gloves [IS:6994(Part 1)-1973]

(iii) Markings:

The gloves shall be legibly stamped on the inside of the cuffs with the following information:

- type and nominal size of the gloves,
- where applicable, the words 'light mass', 'medium mass' or 'heavy mass',
- manufacturer's name or recognised trademark, and
- year of manufacture.

# Specification for Leather Safety Boots and Shoes [IS:1989(Part 1&2)-1986]

- Should be ankle high.
- Should have six eyelets (four eyelets or less in each of safety shoes.)
- Toe should be reinforced with steel toe cap.
- Tongue should be padded.
- Bottom be made of vegetable-tanned sole leather or moulded rubber sole and heel.
- Eyelets be made of aluminum or brass coated steel of size 10 mm.

# Specification for Leather Safety Boots and Shoes [IS:1989(Part 1&2)-1986]

- Mass - 1750 g/pair of size 8 (maximum) with hob nails, toe tips and heel tips. 1650 g/pair of size 8 (maximum) without hob nails, toe-tips and heel tips. The mass shall increase or decrease by 75 g per pair for each bigger or smaller size respectively.
- Steel - toe cap should be as per IS: 5852- 1996 and should withstand blows of 14.2 kgf.m.

# Monitoring Safety Performance:

- The primary goal of a safety system is to reduce operational risks and improve the overall process safety of a plant over its entire lifecycle.
- In the event of a deviation or failure of the safety system, Safety Instrumented Systems (SIS) are there to ensure that a plant is taken into a safe state, limiting the negative consequences to people, equipment and the environment.
- It is important that organizations in the process industry are able to react quickly under variable conditions and have the capabilities to continuously monitor and evaluate safety system performance.
- Few factors which are useful for the statistical analysis of safety are :

# Safety Performance Indicators

- Frequency Rate
- Severity Rate
- Incidence Rate
- Injury Index
- Frequency Severity Indexes
- Safe-T-Score
- Safety Activity Rate

# 1. Frequency rate

- The frequency rate is the number of disabling/lost time injuries per one million man-hours worked.
- The frequency rate shall be calculated both for lost time injury and reportable lost time injury.

$$F_A = \frac{\textbf{Number of lost time injury} \times 1000000}{\textbf{Man hour worked}}$$

$$F_B = \frac{\textbf{Number of reportable lost time injury} \times 1000000}{\textbf{Man hour worked}}$$

Purpose – To know how often disabling accidents occur.

# 1. Frequency rate

- Since frequency rate $F_B$ is based on the lost time injuries reportable to the statutory authorities, it may be used for official purposes only.
- In all other cases, frequency rate $F_A$ should be used for comparison purposes.
- **Disabling Injury ( Lost Time Injury )**
  - An injury causing disablement extending beyond the day of shift on which the accident occurred.
- **Reportable Disabling Injury ( Reportable Lost Time Injury )**
  - An injury causing death or disablement to an extent as prescribed by the relevant statute.

# What does 1000000 mean ?

No of workers in a year = **500**

Daily Hour Worked = **8 hrs**

No. of days worked in a week = **5 days**

Total hours worked in a week = 8 x 5 = **40 hrs**

Total week in a year = **50 week**

So, In a year = 50 week x 40 hrs/week x 500 workers = **10 00 000 man hours**

# Man-Hours Worked

- The total number of employee-hours worked by all employees in the industrial premises
- It includes managerial, supervisory, professional, technical, clerical and other workers including contractors, labors etc.
- It shall be calculated from the pay roll or time clock recorded including overtime.
- When this is not feasible, the same shall be estimated by multiplying the total man-days worked for the period covered by the number of hours worked per day
- Total number of man-days is the sum of the number of men at work on each day of the period

# Question 1

Using the following data calculate the frequency rate of accident in an industrial plant.

- Number of workers= **500**
- Number of disabling injuries per year= **5**.
- Average number of hours worked by worker per year= **2000**.
- Sol:

Frequency rate=number of disabling injuries/number of man-hours worked x 1000,000

$$=\frac{5*1000000}{500*2000} =5$$

# 2.Severity Rate

- Number of man-days lost per million man hours worked.
- The severity rate is the total number of days lost or charged due to accidents per one million man-hours worked
- Purpose
  - To know how serious the injuries are

# 2.Severity Rate

**6.2 Severity Rate** — The severity rate shall be calculated from man-days lost both of lost time injury and reportable lost time injury as follows:

$$S_A = \frac{\text{Man-days lost due to lost time injury} \times 1\,000\,000}{\text{Man-hours worked}}$$

$$S_B = \frac{\text{Man-days lost due to reportable lost time injury} \times 1\,000\,000}{\text{Man-hours worked}}$$

NOTE — Since severity rate $S_B$ is based on the lost time injuries reportable to the statutory authorities, it should be used for official purposes only. In all other cases severity rate $S_A$ should be used for comparison purposes.

# Days lost

- **Days lost=** actual days lost due to accidents + standard number of days considered to be lost depending on nature of disabling injury.

- Standard number of days lost is correlated to the nature of injury

Eg: of Standard number of days lost

35days - the nature of injury being cutting of the tip of a finger

6000 days - total disability case or multiple injuries.

**Question 2.** Using the following date calculate the severity rate of accident in an industrial plant where only one accident occurred during the year, the type of injury being cutting of the tip of a finger.

Number of workers=2000.

Number of days lost in a year due to accidents=100

Average number of hours worked by worker per year=2000.

**Sol.** Severity rate=days lost in year due to accidents/number of man-hours worked x 1000,000

Number of man-hours worked =2000 X 2000.

Days lost in year due to accidents=100+35=135.

$$\text{Severity rate} = \frac{135 * 1000{,}000}{2000 * 2000}$$

$$= 135/4 = 33.75$$

Q: Using the following data calculate the severity rate of accident in an industrial plant where only one accident occurred during the year involving total disability of a worker.

Number of workers=2000.
Number of days lost in a year due to accident=100.
Average number of hours worked by worker per year=2000.

**Sol.** Severity rate= days lost in year due to accidents/number of man hours worked x 1000000.

Number of hours worked in this case=2000×2000.

Total disability; days lost=100+6000=6100 days.

Severity rate $=\frac{6100*1000000}{2000*2000}$ = 6100/4=1525

# 3.Incident Rate

General incidence rate is the ratio of the number of injuries to the number of persons during the period under review. It is expressed as the number of injuries per 1 000 persons employed.

The incidence rate may be calculated both for lost-time injuries and reportable lost-time injuries as follows:

$$\text{Lost-time injury incidence rate} = \frac{\text{Number of lost-time injuries} \times 1\,000}{\text{Average number of persons employed}}$$

$$\text{Reportable lost-time injury incidence rate} = \frac{\text{Number of reportable lost-time injuries} \times 1\,000}{\text{Average number of persons employed}}$$

**Purpose – To know the simple ratio of number of accidents to number of employees**

## 4.Injury Index

- It is the product of Frequency Rate and severity rate divided by 1000

- 5.Frequency Severity Index(FSI)

$$FSI=\sqrt{\frac{FRXSR}{1000}}$$

# 6. Safe-T- Score(STS)

- For comparison of performance between two variables, Safe T Score is used which is a statistical control technique.
- It is a dimensionless number
- Positive (+) STS indicates a downgrading condition while negative (-) STS indicates improvement from the past
- The value of STS between +2 & -2 indicates random fluctuation in variation which is not significant

$$\text{Safe-T-Score} = \frac{\text{Frequency rate new} - \text{Frequency rate past}}{\sqrt{\left(\frac{\text{Frequency rate past} \times 10^6}{\text{Man-hours worked new}}\right)}}$$

# 7.Safety Activity Rate

- It is the overall safety promotional and awareness activity including safety training and safety inspection conducted in a year wrt to total employees present and man hours worked in a year.
- This emphasizes the cost of accident prevention activities against the cost of accident occurrences incidents
- Safety activity number is the sum of safety activities in a year, with respect to man hours worked and average number of employees.
- Safety Activity Numbers = $\sum N = N1+N2+N3+ N4+\ldots\ldots\ldots$

# Safety Activity Rate

* **Formula: -**

$$\text{Safety Activity Rate} = \frac{\text{Safety Activity Number} \times 5 \times 10^6}{\text{Man-Hours Worked} \times \text{Avg. No. of Employees}}$$

The parameters for safety activity as follows.

- No. of safety recommendations mentioned in safety audit report, are complied with ($N_1$).
- No. of unsafe practice detected ($N_2$).
- No. of unsafe condition detected ($N_3$).
- No. of statutory compliances carried out ($N_4$).
- No. of safety committee meeting held ($N_5$).
- No. of training session of health & safety arranged internally ($N_6$).
- No. of training session of health & safety done trainer being external agency ($N_7$).
- No. of mock drill of on-site emergency planning conducted ($N_8$).
- No. of safety motivation programmers like safety arranged ($N_9$).
- No. of suggestions for safety received from employees ($N_{10}$).

How will you compare the safety performance of two industries?

- Safety performance can be measured in a number of ways, usually through a combination of lag (output) and lead (input)indicators.
- Lag indicators
  - measure outcomes after an incident (e.g. incident rate, lost time work injury),and is effectively a measure of past results
- Lead indicators
  - measure activities to prevent or reduce the severity of an incident in the present or future (e.g. safety training, safety audits).

# Housekeeping

- Housekeeping is most important aspect in ensuring safe condition at workplace in factories/plants.
- It is the process of keeping premises clean, neat and in a pleasing order
- A lot of care, alertness and time consciousness are required in carrying out industrial housekeeping

# Responsibility of Management

1. Plan and protect the housekeeping programme carefully and completely. Associate the employees in the venture.

2. Divide the plant and offices into cleaning zones and assign a person to each zone who will be responsible for good housekeeping and orderliness of his zone.

3. Keep an eye on performed housekeeping schedule and conduct periodic housekeeping inspections. The following checklist may help in carrying out inspection properly.

# Responsibility of Employees

1. Machinery and Equipment
   - General cleanliness
   - Containers for waste materials
   - Machine guards on and operating
   - Avoiding Oil, air, water, steam leakage
   - Check – Portable equipment. Do they hamper personnel and material movement?
2. Materials and Storage:
   - Check - Piling and stacking - Can material slip easily?
   - Check – Materials protruding out of racks, bins, benches and machines etc

# Responsibility of Employees

3. Building
   - Windows clean and unbroken
   - Painting and upkeep
   - Door joints clean
   - Fire extinguishers and sprinklers clear

4. Floors
   - Take care Slippery, wet and oily floors
   - Take care Badly worn floor
   - Avoid Garbage, dirt or debris from floors
   - Carefully Loose materials

5. Stairways and Aisles:
   - Ensure Clear and unblocked
   - Ensure Well lighted

# Responsibility of Employees

6.Employee Facilities:

- Ensure Drinking taps clean
- Ensure Toilets and locker rooms clean
- Ensure Soap and towels available

7. Other Aspects:

- Ensure Lamps and lamp reflector clean
- Ensure Bulletin boards and safety signs clean.
- Ensure Protective equipment and clothing clean and in good condition
- Ensure Electric motors clean
- Ensure Ventilation unobstructed

# Advantages

Good housekeeping and cleanliness normally results into

1. a workplace which is cleaner, safer, well organized and more pleasant for work,
2. improved utilization of floor space,
3. smoother and systematic workflow with substantial reduction in non-value added activities,
4. better inventory control of tools and materials,
5. reduced handling to ease the flow of materials,
6. reduction in wastages of materials,
7. more efficient equipment clean-up and maintenance leading to lower break-downs,
8. minimization of errors leading to better products,
9. safe environment for work and lower exposures of employees to hazardous substances (such as dusts, and vapours etc.),
10. more hygienic workplace conditions which lead to improved health of the employees,
11. improved overall look and feel of the work environment, and
12. improved morale of the employees.

# Disadvantages

Poor housekeeping and cleanliness, creates workplace hazards which lead to various accident such as

1. slips, trips and falls,
2. caught in-between objects,
3. struck by falling objects,
4. struck by moving objects,
5. cut/stabbed by objects, and
6. struck against objects.
7. poor housekeeping and cleanliness also create fire hazards which inevitably lead to increased fire risk.

# Elements of housekeeping and cleanliness at workplace

- **Dust and dirt removal**
  - Working in a dusty and dirty area is unhygienic and unhealthy for the employees since there can be respiratory type irritations.
  - If dust and dirt are allowed to accumulate on surfaces, there is a potential for a slip hazard.
  - Regular sweeping the workplace for the removal of dust and dirt is an essential housekeeping and cleanliness practice.
  - Compressed air is not to be used for removing dust or dirt off employees or equipment as it can cause dirt and dust particles to be embedded under the skin or in the eye.
- **Employee facilities**
  - Adequate employees' facilities such as drinking water, wash rooms, toilet blocks, rest rooms etc. are to be provided at the workplace

# Elements of housekeeping and cleanliness at workplace

- **Flooring**
  - Floors are to be cleaned regularly and immediately if liquids or other materials are spilled.
  - Poor floor conditions are a leading cause of accidents in the workplace.
  - Areas which cannot be cleaned continuously are to have mats or anti-slip flooring.
  - It is also important to replace worn, ripped or damaged flooring that poses a trip hazard.
- **Lighting**
  - Adequate lighting reduces the potential for accidents.
  - Inoperative light fixtures are repaired and dirty light fixtures are cleaned regularly so that the light intensity levels are maintained at the workplace.

# Elements of housekeeping and cleanliness at workplace

- **Aisles and stairways**
  - Aisles and stairways are to be kept clear and not to be used for storage.
  - Warning signs and mirrors can improve sight lines in blind corners and help prevent accidents.
  - It is also important to maintain adequate lighting in stairways.
- **Spill control**
  - The best method to control spills is to prevent them from happening.
  - Regular cleaning and maintenance on machines and equipment is an essential practice.
  - Use of drip pans where spills might occur is a good preventative measure.
  - When spills do occur, it is important to clean them up immediately.
  - When cleaning a spill, it is required to use the proper cleaning agents or absorbent materials.
  - It is also to be ensured that the waste products are disposed of properly.

# Elements of housekeeping and cleanliness at workplace

- **Maintenance**

  It is important to have a replacement program for replacing or fixing broken and damaged items as quickly as possible.

- **Waste disposal**
  - The regular collection of the waste materials contribute to good housekeeping and cleanliness practices.
  - It also makes it possible to separate materials that can be recycled from those going to waste disposal facilities.
  - Allowing material to build up on the floor wastes time and energy since additional time is required for cleaning it up.
  - Placing containers for wastes near the place where the waste is produced encourages orderly waste disposal and makes collection easier.
  - All recyclable wastes after their collection are to be transferred to their designated places so that the waste materials can be dispatched to the point of use or sold.

# Elements of housekeeping and cleanliness at workplace

- **Tools and equipment**
  - Tools and equipment are required to be inspected prior to their use.
  - Damaged or worn tools are to be taken out of service immediately.
  - Tools are to be cleaned and returned to their storage place after use.

- **Storage**
  - Proper storage of materials is essential in a good housekeeping and cleanliness practice.
  - All storage areas need to be clearly marked.
  - Flammable, combustible, toxic and other hazardous materials are to be stored in approved containers in designated areas
  - The stored materials are not to obstruct aisles, stairs, exits, fire equipment, emergency eyewash fountains, emergency showers, or first aid stations.
  - All containers be labeled properly.
  - If materials are being stored correctly, then the incidents of strain injuries, chemical exposures and fires get reduced drastically.

# Elements of housekeeping and cleanliness at workplace

- **Clutter control**
  - Cluttered workplaces happen because of poor housekeeping practices.
  - This type of workplace can lead to a number of issues which include ergonomic as well as injuries.
  - It is important to develop practices where items like tools, chemicals, cords, and containers are returned to their appropriate storage location when not in use.
  - Clutter is also a serious threat to safety.
  - Danger to the employees increases if the established exit routes and doors are blocked.
  - For this reason, as well as to prevent slips and trips, assorted waste materials need to be disposed of promptly in the appropriate waste containers.
  - Aisles are to be kept clear of obstructions for obvious reasons.
  - **Individual workspace**
    - Individual workspace need to be kept neat, cleared of everything not needed for work.
    - Many workplace injuries occur right in the employee's workspace.
    - This space is often overlooked when conducting general housekeeping and cleanliness inspections.
    - It is necessary to make a checklist which is to be used by the employees to evaluate their workspace.

# 5 S in Housekeeping

- 5S is a system for organizing spaces so work can be performed efficiently, effectively, and safely.
- This system focuses on putting everything where it belongs and keeping the workplace clean, which makes it easier for people to do their jobs without wasting time or risking injury.

# 5 S in Housekeeping

- Sort
- Set in Order
- Shine
- Standardize
- Sustain


Each S represents one part of a five-step process that can improve the overall function of a business.

# Sort

- The first step of 5S, Sort, involves going through all the tools, furniture, materials, equipment, etc. in a work area to determine what needs to be present and what can be removed.

- Some questions to ask during this phase include:

  - What is the purpose of this item?
  - When was this item last used?
  - How frequently is it used?
  - Who uses it?
  - Does it need to be here?

- When a group has determined that some items aren't necessary, consider the following options:
  - Give the items to a different department
  - Recycle/throw away/sell the items
  - Put items into storage

# Set in Order

- Once the extra clutter is gone, it's easier to see what's what.
- Take the items you need in that area on a daily or weekly basis and find the best homes for them
- label, mark locations, colour code – make it clear to anyone entering the area what should be where
- Work groups can come up with their strategies for sorting through the remaining items. Things to consider:
  - Which people (or workstations) use which items?
  - When are items used?
  - Which items are used most frequently?
  - Should items be grouped by type?
  - Where would it be most logical to place items?
    - Would some placements be more ergonomic for workers than others?
    - Would some placements cut down on unnecessary motion?
  - Are more storage containers necessary to keep things organized?

# Shine

- The Shine stage of 5S focuses on cleaning up the work area, which means sweeping, mopping, dusting, wiping down surfaces, putting tools and materials away, etc.
- Shine also involves performing regular maintenance on equipment and machinery.
  - Planning for maintenance ahead of time means businesses can catch problems and prevent breakdowns.
  - Less wasted time and no loss of profits related to work stoppages.
- In 5S, everyone takes responsibility for cleaning up their workspace, ideally daily.
- Doing so makes people take ownership of the space, which in the long run means people will be more invested in their work and the company.

# Standardize

- The new arrangement and level of cleanliness is our new standard for each area.
- Take photos and display in the area
- Talk about the 5S activities in your toolbox talks and daily meetings
- Share ideas across the factory
- This helps to create your new 5S standards and brings consistency across the factory.

# Sustain

- Once standard procedures for 5S are in place, businesses must perform the ongoing work of maintaining those procedures and updating them as necessary.
- Sustain refers to the process of keeping 5S running smoothly, but also of keeping everyone in the organization involved.
- Managers need to participate, as do employees out on the manufacturing floor, in the warehouse, or in the office.
- Sustain is about making 5S a long-term program, not just an event or short-term project. Ideally, 5S becomes a part of an organization's culture.
- When 5S is sustained over time, that's when businesses will start to notice continuous positive results.

# Work Permit System

- The work permit authorize one to carry out a specific job in a specific location during a given time interval.
- Work permit is a document that, categorically spells out the
  - tasks
  - equipment involved
  - its location
  - personnel involved
  - time limitations
  - precautionary measure to be taken together with likely hazards to be encountered if any.

# Work Permit System

- Formal recorded process used to control work which is identified as potentially hazardous.
- A means of communication between different departments, plant supervisors, operators,agencies etc.
- Before starting any job in an area, it must be ensured that it is safe to work in the environment as well as with the machinery involved.
- In order to ensure that no work has to start before ascertaining the safe conditions, work permit system is being followed.
- Specifies the conditions and procedures for safe execution of the work and allows the work to be carried out under controlled risk conditions.

# Objectives of Work Permit System

- Give written permission to carry out a task
- Ensure every aspect of the work is planned
- Make sure every aspect of the work is checked
- Put risk assessments and method statements into action
- Communicate health and safety information
- Provide a procedure to ensure essential controls remain in place
- Provide a procedure to return the area to a safe state on completion of the work
- Give a means of communication

# Work not requiring permit

- Routine work in established workshop and adjacent yard with boundaries.
- Routine material handling work in ware houses and lay down area.
- Routine office work.
- Visual inspection or checking without using any tools in operation area of verbal permission from assist custodians.
- Work carried out by operation employees as their daily start up and shout down of plant.
- Work carried out in designated area which has declared as work permit free by Client.
- Any work approved by Client on special request by contractor.

# General Principles

Following aspects should be considered w.r.t. permit to work systems:

- Human factors
- Management of WPS
- Poor skilled manpower
- Lack of Knowledge
- Incompetence
- Objectives of WPS
- Types of Work permit required
- Contents of work permit

# Contributory Factors to consider in WPS

- Whether staff have been sufficiently informed, instructed, trained and supervised to minimise a human failing operation of WPS
- Whether the work permit contains sufficient information about the type of work
- Whether there is sufficient provision available to fulfill the requirements of WPS
- Whether the employees responsible for control of maintenance work are identified within the WPS and that the work is properly authorised by responsible person
- Whether the WPS is managed, regularly inspected and received and reviewed

# Contributory Factors to consider in WPS

- Whether all the permits are kept in file for future analysis
- Whether sufficient precautions are taken prior to initiating a work permit (draining, flushing, environmental monitoring, risk assessments)
- Whether staff are aware of the environment they are working induring the operation of work permit (flammable, corrosive, explosive)
- Whether the person responsible for operating the plant is aware of the type of maintenance involved and how long it is likely to take

# Major Hazards

- Wrong type of work permit used
- Wrong information about the work required on the work permit
- Failure to recognise the hazards where work is carried out
- Introduction of ignition source is controlled flame proof area (e.g. welding, non-spark proof tools)
- Instruction of work permit not adhered ( e.g. failure to isolate plant, drain lines of hazardous substances)

# Major Hazards

- Failure to have over plant in safe condition on completion of work/ cancelling of work permit
- Unauthorised staff performing work permit functions
- Poor management of permit to work system
- Insufficient monitoring of WPS

# Types of Work Permit

There are Seven main types of Work Permit.

1) Hot Work Permits,

2) Cold Work Permits,

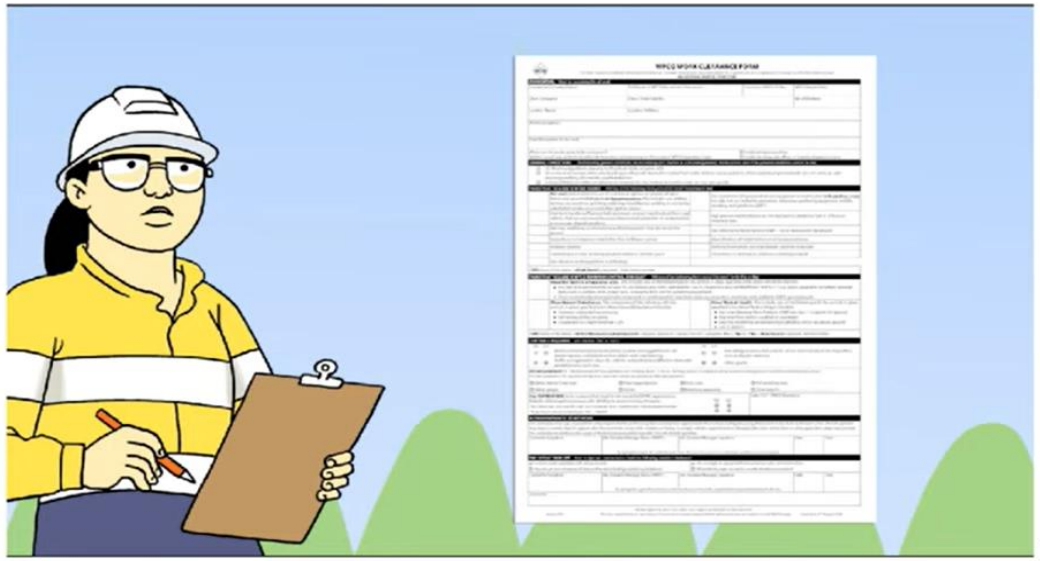
3) Height Work Permit,

4) Confined Spaces Work Permits,

5) Excavation Permit,

6) Electrical Isolation Permit,

7) Chemical Work Permits,



# Hot work permit (Red color)

- Hot work permit is required for any job which involves or use of source of ignition, spark, and fire.
- Hot work permits are red-colored permits used to authorize work that will generate heat or sparks, such as:
  - Welding
  - Drilling
  - Grinding
  - Riveting
  - Cutting
  - Use of internal combustion engines

# Hot Work Permit-Precautions

- Equipment of the area should be tested to determine the explosive range.
  - Cleaning or ventilating can clear explosive content.
- Cover all pits , slums, opening etc with fireproof material to prevent spark entering and causing exposure or fire.
  - Surrounding area are sufficiently wetted to facilitate extinguishments of sparks, hot slag etc
- Adequate fire fighting equipment should be kept ready along with the person who know the operation of the equipment
- Examine the workplace completely and eliminate any visual hazards
- Comply with the applicable regulatory requirements and legislation in the sector/location

# Risks triggered by Hot Work

- **Electrical Hazards**
  - risk of equipment short-circuiting, faulty wiring and the risk of shocks or even fatal electrocution.
- **Exposure to Harmful UV or Infrared Light**
  - cause damage to their skin or eyes.
- **Exposure to Dangerous Fumes**
  - Fumes can cause respiratory health conditions, burns, flu-like symptoms and damage to the eyes.
- **Flying Sparks Can Cause Fires or Combustion**
  - sparks can cause fires or combustion if they come into contact with flammable materials, debris or hazardous materials.
- **Conducting Heat through Pipes**
  - Heat can come into contact with flammable, combustible or hazardous materials.
- **Skin Injuries through Contact with Hot Materials or Equipment**
  - skin injuries like heat burns, friction burns or cuts.

# Cold work permit (Green color)

- Cold work permits is required for any job which does not involve or use of any source of ignitions, spark, and fire.
- Cold work permits are green colored permits issued for hazardous maintenance work that does not involve the ignition hazards found in hot work.
- Cold work situations are determined by conducing a risk assessment for the task and the working environment.
- If no flammable or explosive risks are identified, a cold work permit is sufficient for carrying out the the work.

# Cold Work Permit

Authorization to operate machinery or other functions that do not generate any form of heat in the manufacturing process.

Example :- Mechanically induced bending, shearing, squeezing and drawing etc.


# Examples of cold work permits

- Chemical cleaning or the use of solvents,
- Handling of hazardous substances (e.g., toxic/corrosive chemicals, asbestos, etc.)
- The use of resins typically used during blade repairs,
- Any painting activity,
- Heavy lifts ,
- Erecting or dismantling scaffolds,
- Any non-routine and potentially hazardous activity,

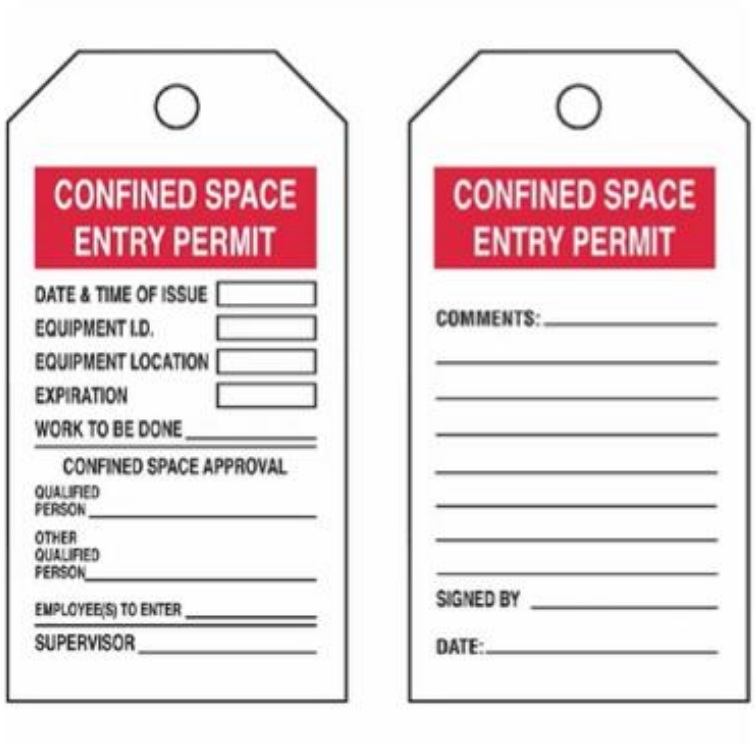
# Height Work Permit

Authorization to work on elevated spaces (2m from the ground) be it ladders, scaffolds, Mobile Elevated Work Platforms (MEWP) and other spaces that are off the ground.


# Confined Spaces Work Permit

Authorization to perform tasks in a narrow space which is prone to hazards like asphyxiation, a substance that has the ability to engulf, toxic atmosphere, etc.

Confined spaces refer to Vents, Shafts, Sewages, Tanks and much more.




# Excavation Permit

Authorization for personnel to mine or dig land in order to build infrastructure, extract resources or unearth hidden artifacts. The risk involved in excavation includes falling, being trapped, explosions, airborne contaminants, etc.


# Electrical Permit

Authorization to work in high voltage zones that are prone to uncontrolled dispersion of electricity. Common electrical isolation work is to manage and maintain Lock-out systems and site maintenance by electrical engineers.


# Chemical Work Permit

Authorization to work with harmful chemical substances or in a chemically induced atmosphere that is either toxic or corrosive by nature. Chemical engineers that mostly work in chemical plants and labs.

# Entry into Confined Spaces

- A confined space is a fully or partially enclosed space that:
- is not primarily designed or intended for continuous human occupancy
- has limited or restricted entrance or exit, or a configuration that can complicate first aid, rescue, evacuation, or other emergency response activities
- Can represent a risk for the for the health and safety of anyone who enters, due to one or more of the following factors:
  - its design, construction, location or atmosphere
  - the materials or substances in it
  - work activities being carried out in it, or the mechanical, process and safety hazards present

# Entry into Confined Spaces

- Confined spaces can be below or above ground.
- Confined spaces can be found in almost any workplace.
- A confined space is not necessarily small.
- eg :of confined spaces
  - silos, vats, hoppers, utility vaults, tanks, water supply towers, sewers, pipes, access shafts, truck or rail tank cars, aircraft wings, boilers, manholes, pump stations, digesters, manure pits and storage bins.
  - Ditches, wells, and trenches may also be a confined space when access or egress is
  - Barges, shipping containers and fish holds are also considered as possible confined spaces.

# CLASSES OF CONFINED SPACE

**Class A – *IDLH* (Immediately Dangerous To Life or Health )**

- Atmosphere may have oxygen deficiency, explosive or flammable atmospheres, and /or concentrations of toxic substances.

**Class B**

- space has potential for causing injury if proper safety steps are not followed

**Class C**

- space has potential hazards, but would not require any special modification of the work procedures.

# Confined Space entry procedure

1. Conduct an assessment
2. Post signage; Barricade
3. Write the ***Permit***
4. Perform pre-entry tests
5. Follow all other safety procedures
   - PPE
   - LO/TO(Lockout/Tag out)
   - Ventilation
6. Pre-entry briefing
7. Perform entry & work
8. Perform continuous atmospheric tests
9. Exit the confined space
10. Debrief employees/contractors
11. Verify completion

# 1.Confined Space Assessment

Assessments must include:

1. Pre-entry testing and monitoring of/for:
   - Atmospheric conditions
   - Potential hazards in and around the area
     - Deficient or enriched oxygen -Safe level: 19.5% - 23.5%
     - Combustible, flammable, and explosive atmospheres
     - Toxic gases and vapors
     - Corrosive chemicals or biological agents
     - Physical hazards– Falling,tripping,moving parts,engulfment,heat extremes,etc…
     - Electrical hazards—Shock hazard, static electricity, sparks, etc…
     - Rodents,snakes, and insects
2. Written procedures to remove or control hazards including ventilation, LOTO, PPE and communication
3. Written emergency response

# 2.Post Signage and Barricade

- Post Signage
  - MUST be in the immediate area
  - MUST identify the Confined Space
  - Restricts **unauthorized** personnel
    - E.G.: ***"DANGER—PERMIT REQUIRED CONFINED SPACE, DO NOT ENTER"***
- Barricade
  - MUST prevent unwanted access to the work area
  - MUST ensure clear workspace for attendant and emergency rescue (if needed)

# 3.Write the permit

- Permits
  - are written authorization and approval specifying the location and type of work
  - certify that all existing hazards have been assessed
  - ensure the safety of each worker
  - specify the date & length of time it applies

# Confined Space Permit


NOTE:
PERMITS ARE ALWAYS POSTED IN THE WORKPLACE DURING ENTRY

# 4.Perform pre entry tests

- Testing standards
  - Duration—recommend continuous
  - Sample priority—oxygen; flammable/combustible chemicals; toxic chemicals
- Testing Methods
  - Sample in layers
    - Every four feet in direction of travel
    - Different chemicals stratify
    - Do not get equipment wet

Chemical Stratification

- Chemicals will stratify according to their vapor density
- Strata changes with environmental conditions (Temperature and pressure)

- Remember to document all atmospheric testing results!!

# 5.Take other safety precautions

- PPE
- Lockout/Tag out
- Verify emergency response
- Remove sources of hazardous materials outside of confined space
- Ventilation
- Exhaust
  - Negative pressure
    - Local - for specific sources
    - General - for non-specific sources
- Purging
  - Positive pressure
    - Using inert gases in flammable/combustible environment
    - Causes need for additional PPE

# 6.Pre-entry briefing

- Conduct meeting
- Include all affected persons
- Document topics discussed at the briefing.

# 7.Perform entry and work

- Entry documentation
- Each entrant should sign an entry log
  - Posted in immediate area

- 8.Perform continuous monitoring
  - Remember the mentioned sampling methods
- 9. Exiting the confined space
  - When work is complete, when replacement arrives, or if an alarm sounds
  - In the event of an emergency, utilize emergency rescue
  - Remember to update the entry log

# 10.Conduct Debriefing

- Discuss the success of the work
- Identify concerns that occurred
- Verify completion of all documentation
- Document meeting, if possible

# 11. Verify completion

- The entry supervisor should remain for at least 30 minutes after the entry to ensure the security of the site and that no hazards remain (ex. Fires)

# Module 1 Important Questions

1. Explain the responsibilities of safety officer in a plant

2. Which are the various accident causation theories? Explain.

3. Define terms: Accident, Reportable accident, Dangerous occurrence.

4. Differentiate Unsafe act and Unsafe conditions with suitable examples

5. Discuss the significance of a safety committee in improving the safety performance of an Industry

6. List the various accident causation theories and explain any one in detail.

7. Discuss the significance of safety policy in reducing the accidents.

8. Safety and productivity are the two sides of a coin. Are you agreeing with this statement?Explain with your arguments.

# Module 2 Important Questions

1. Which are the different types of permit? Highlight its suitability.
2. Which are five 'S' used in housekeeping?
3. Classify the personal protective equipment. List the suitability of at least fifteen types of PPEs.
4. How will you calculate the frequency rate? Explain with an example.
5. How will you compare the safety performance of two industries? Explain with suitable example.
6. Which are the steps to be followed in confined space entry to protect the life a worker.
7. Discuss different types of personal protective equipment
8. Discuss the significance of work permit system in accident prevention.