INDUSTRIAL SAFETY, SECURITY MEASURES & POLLUTION CONTROL

Chapter: INDUSTRIAL SAFETY

Complete Study Notes with 50 MCQs and Answer Key

For technical government job examinations in West Bengal and other competitive examinations

How to use these notes

- Read each topic once for understanding, then revise only the **EXAM FOCUS** box at the end of the topic.
- Learn the tables carefully: examinations often ask for names, numbers, colours, section numbers and full forms.
- Study the figures; they help in recalling signs, the fire triangle, the hierarchy of controls and the PPE list.
- Finish with the Quick Revision page and attempt the 50 MCQs without looking at the answers. Check them with the Answer Key.

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TOPIC 1: Meaning and Importance of Industrial Safety

Industries use machines, electricity, chemicals, heat and heavy materials. Every one of these can injure a worker or damage property if it is not controlled. **Industrial safety** is the discipline that keeps people, plant and environment free from harm. Questions from this topic are asked regularly in technical government job examinations, so the definitions, numbers and laws below must be remembered exactly.

1.1 Meaning of Safety and Industrial Safety

Safety means freedom from danger, injury or loss. **Industrial safety** is the set of rules, practices, procedures, devices and attitudes that are used in an industry to prevent accidents, occupational diseases and damage to property and the environment. It is not the job of the safety officer alone; it is the shared duty of the owner (occupier), managers, supervisors and every worker.

In simple words: **Industrial Safety = Protection of Man + Machine + Material + Environment.**

1.2 Important Terms

Term	Meaning
Hazard	Any source or situation with the potential to cause harm (e.g. an unguarded rotating shaft, a leaking gas pipe).
Risk	The chance (likelihood) that a hazard will actually cause harm, together with how severe that harm would be.
Danger	Exposure to a hazard; the condition in which harm is likely to occur.
Accident	An unplanned, unexpected event that results in injury, illness or damage to property.
Incident	Any unplanned event that has caused or could have caused injury or damage (includes accidents and near misses).
Near miss	An unplanned event that did NOT cause injury or damage but had the potential to do so.
Unsafe act	A human error or wrong behaviour, e.g. removing a guard, not wearing PPE, horseplay, working at unsafe speed.
Unsafe condition	A faulty physical situation, e.g. defective machine, slippery floor, poor lighting, missing guard.
Dangerous occurrence	A specified event such as bursting of a vessel, collapse of a crane or explosion, reportable even if nobody is hurt.
Occupational disease	A disease caused by long exposure to a work-related agent, e.g. silicosis, lead poisoning.
First aid	Immediate help given to an injured person before medical aid arrives.

1.3 Objectives of Industrial Safety

- To prevent injuries, deaths and occupational diseases among workers.
- To protect machines, plant, buildings and materials from damage or loss.
- To maintain continuous production without accident-related stoppages.
- To comply with laws such as the Factories Act, 1948 and avoid penalties.
- To create a safety culture and raise safety awareness among all employees.
- To protect the public and the surrounding environment from industrial hazards.

1.4 Importance of Industrial Safety

Aspect	Why safety is important
Humanitarian	A worker's life, health and limbs cannot be replaced by money. Accidents bring pain and hardship to families.

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Aspect	Why safety is important
Economic	Accidents cause medical expenses, compensation, damaged machines, lost production and higher insurance premiums.
Legal	Employers must provide a safe workplace by law. Violations lead to fines, imprisonment and closure of the factory.
Productivity	A safe and tidy plant improves morale, reduces absenteeism and increases output and quality.
Social / reputation	Companies with a good safety record attract skilled workers, customers and investors.
Environmental	Prevents leaks, fires and explosions that pollute air, water and land and affect the neighbouring community.

1.5 Causes of Accidents

According to **H. W. Heinrich**, who studied thousands of accident reports, about **88%** of accidents are caused by **unsafe acts** of persons, about **10%** by **unsafe conditions**, and only about **2%** are unavoidable (acts of God). Therefore, nearly 98% of accidents can be prevented.

Cause	Share (Heinrich)	Examples
Unsafe acts	88%	Not using PPE, removing safety guards, operating without authority, distraction, fatigue, using wrong tools, horseplay.
Unsafe conditions	10%	Unguarded machinery, defective tools, poor housekeeping, inadequate lighting or ventilation, noise, wrong layout.
Unavoidable causes	2%	Natural calamities such as earthquake, lightning, flood.

Heinrich's Domino Theory (five dominoes)

- Social environment and ancestry
- Fault of the person
- **Unsafe act or unsafe condition** (the key domino)
- Accident
- Injury

If the third domino (unsafe act/condition) is removed, the chain breaks and the accident does not happen.

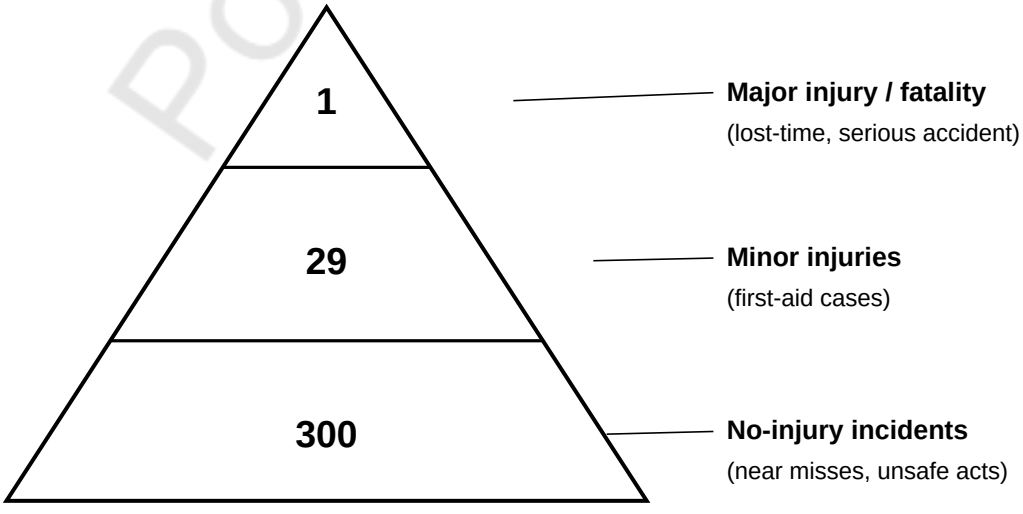


Fig. 1.1: Heinrich's Accident Triangle (Safety Pyramid), ratio 1 : 29 : 300

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Meaning: Out of every 330 accidents of the same type, 1 causes a major injury, 29 cause minor injuries and 300 cause no injury. So reporting and fixing near misses prevents major accidents.

1.6 Cost of Accidents

Direct (insured) costs	Indirect (hidden / uninsured) costs
Medical treatment, compensation to worker, insurance claims.	Lost working time of the injured and co-workers, damaged equipment, production delay, investigation time, training of replacement, loss of morale, loss of reputation.

Heinrich estimated that indirect costs are about **four times** the direct costs (ratio 4 : 1), like the hidden part of an iceberg.

1.7 Measurement of Safety Performance

Measure	Formula	Meaning
Frequency Rate (FR)	FR = (Number of disabling injuries x 1,000,000) / Man-hours worked	How often injuries occur
Severity Rate (SR)	SR = (Man-days lost x 1,000,000) / Man-hours worked	How serious injuries are
Incidence Rate	IR = (Number of injuries x 1000) / Average number of workers	Injuries per 1000 workers

1.8 Legal Framework and Organisations in India

Law / Body	Key point
Factories Act, 1948	Main law for safety, health and welfare of factory workers. Applies to premises with 10 or more workers using power, or 20 or more without power.
Occupational Safety, Health and Working Conditions (OSH) Code, 2020	Labour code that combines and replaces 13 older labour laws, including the Factories Act, 1948 and the Mines Act, 1952. Learn both names for exams.
Employees' Compensation Act, 1923	Compensation to workers (or family) for injury or death due to accident at work. Earlier named Workmen's Compensation Act.
Employees' State Insurance (ESI) Act, 1948	Medical care and cash benefits for insured employees.
Indian Boilers Act, 1923	Regulates safety of boilers and steam pipes.
Explosives Act, 1884; Petroleum Act, 1934	Control manufacture, storage and transport of explosives and petroleum.
Environment (Protection) Act, 1986	Passed after the Bhopal gas tragedy; empowers Central Government to protect the environment.
Public Liability Insurance Act, 1991	Immediate relief to victims of accidents involving hazardous substances.
National Safety Council (NSC), 1966	Non-profit body promoting safety; National Safety Day is observed on **4 March**.
DGFASLI	Directorate General, Factory Advice Service and Labour Institutes, Mumbai. Technical advisory body under the Ministry of Labour.
Directorate of Factories, West Bengal	State body that inspects factories and enforces the Factories Act in West Bengal.
ILO / BIS	ILO: international labour standards. BIS: Indian Standards (IS codes) for safety equipment.

Important provisions of the Factories Act, 1948

Section	Subject
7A	General duties of the occupier (owner or person in control of the factory)

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Section	Subject
21	Fencing (guarding) of machinery
31	Pressure plant
36	Precautions against dangerous fumes, gases (confined spaces)
38	Precautions in case of fire
40B	Safety Officers: compulsory where 1000 or more workers are employed
41G	Workers' participation in safety management (safety committee)
45	First-aid boxes: one for every 150 workers; ambulance room if 500 or more workers
46	Canteen: where more than 250 workers are employed
48	Creche: where more than 30 women workers are employed
49	Welfare Officer: where 500 or more workers are employed

EXAM FOCUS: Topic 1

- Safety = Man + Machine + Material + Environment.
- Heinrich: 88% unsafe acts, 10% unsafe conditions, 2% unavoidable. Accident triangle 1 : 29 : 300.
- Indirect cost of accident is about 4 times the direct cost.
- Frequency rate and severity rate are calculated per 10 lakh (1,000,000) man-hours.
- Factories Act 1948: Section 21 = fencing of machinery; 40B = Safety Officer (1000+ workers).
- National Safety Day = 4 March. World Day for Safety and Health at Work = 28 April.

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TOPIC 2: Workplace Safety Rules

Workplace safety rules are written instructions that tell every worker what must be done and what must not be done to stay safe. They are based on past accidents and legal requirements. Rules work only when they are explained, displayed, followed and enforced.

2.1 General Safety Rules

Area	Rules to follow
Personal conduct	Report for duty fit and alert. No alcohol or drugs. No running, horseplay or practical jokes. Do not operate any machine without training and authority.
Dress and PPE	Wear prescribed PPE. No loose clothing, ties, rings, chains or open footwear near machines. Tie up long hair.
Housekeeping	Keep floors clean and dry. Keep walkways, exits and fire equipment free of obstruction. Store materials neatly.
Machinery	Use only with guards in place. Never clean, oil or repair a moving machine. Stop the machine and isolate power before maintenance.
Tools	Use the right tool for the job. Inspect before use. Return to proper place. Report damaged tools.
Material handling	Use correct lifting method or mechanical aids. Do not overload racks or lifting equipment. Do not stand under suspended loads.
Electrical	Only authorised persons handle electrical work. Treat every wire as live until proved dead.
Emergency	Know the location of fire extinguishers, first-aid box, exits and assembly point. Follow the alarm and evacuation plan.
Reporting	Report every injury, near miss and unsafe condition immediately to the supervisor.

2.2 Housekeeping and the 5S System

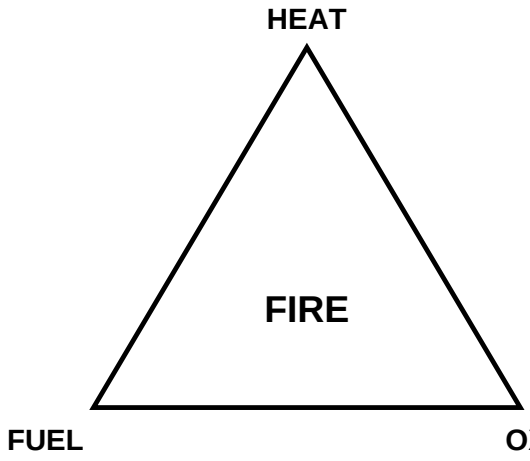
Good housekeeping is the cheapest form of accident prevention. Poor housekeeping causes slips, trips, falls, fires and wasted time. The Japanese **5S** method is a standard tool for good housekeeping.

Japanese term	English term	Meaning
Seiri	Sort	Remove all unnecessary items from the workplace.
Seiton	Set in order (Straighten)	A place for everything and everything in its place.
Seiso	Shine (Sweep)	Clean the workplace and inspect equipment while cleaning.
Seiketsu	Standardise	Make the first three S a routine, with standard procedures.
Shitsuke	Sustain (Self-discipline)	Maintain the habit through training and discipline.

2.3 Fire Safety

Fire needs three things together: **heat (ignition source), fuel and oxygen**. This is called the **fire triangle**. If the chain reaction is also considered, it becomes the **fire tetrahedron**.

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To put out a fire, remove any ONE side:

1. Starving - remove the fuel
2. Smothering - cut off oxygen
3. Cooling - remove heat (e.g. water)
4. Breaking chain reaction - dry chemical powder / halon (fire tetrahedron)

Fig. 2.1: Fire Triangle and the methods of extinguishing fire

Classes of Fire

Class	Fuel	Examples	Suitable extinguisher
A	Ordinary combustible solids	Wood, paper, cloth, rubber, plastic	Water, foam, dry powder (ABC)
B	Flammable liquids	Petrol, diesel, oil, paint, solvents	Foam, CO_2, dry powder. NOT water jet.
C	Flammable gases	LPG, methane, acetylene	Dry powder, CO_2. Stop the gas supply first.
D	Combustible metals	Magnesium, sodium, aluminium powder	Special dry powder or dry sand. NEVER water.
Electrical	Live electrical equipment	Switchboards, motors, cables	CO_2 or dry powder. NEVER water or foam.

Note: Classification of gas and electrical fires differs a little between Indian (IS), British and US (NFPA) standards. In an examination, follow the wording of the question.

Types of Fire Extinguishers

Type	Body colour band (IS)	Used on	Remarks
Water type	Red	Class A	Cools the fuel. Not for oil or electrical fires.
Foam type	Cream	Class A and B	Forms a blanket that smothers the fire.
Carbon dioxide (CO_2)	Black	Class B and electrical	Leaves no residue; suitable for computers and electrical panels.
Dry chemical powder (DCP)	Blue	Class A, B, C and electrical	Interrupts chain reaction. Multi-purpose.
Clean agent (halon substitute)	Green	Sensitive electronic equipment	Leaves no residue.

How to use an extinguisher: PASS

P	A	S	S
Pull the safety pin	**Aim** the nozzle at the base of the fire	**Squeeze** the lever / handle	**Sweep** from side to side

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- Fire prevention: no smoking in restricted areas, proper storage of flammable material, good housekeeping, regular electrical inspection, hot-work permits.
- Fire detection: smoke detectors, heat detectors, manual call points, fire alarm. Fire fighting: hydrants, hose reels, sprinklers, extinguishers.
- Emergency exits must be clearly marked, unlocked, and open outward. Conduct regular fire drills.
- Remember **RACE**: Rescue people, Alarm, Contain (close doors), Extinguish or Evacuate.

2.4 Safe Manual Lifting

- Check the weight and path first; get help or use a trolley or crane for heavy loads.
- Keep feet apart, bend the **knees**, keep the **back straight**, get a firm grip.
- Lift smoothly using leg muscles, keep the load close to the body, avoid twisting.
- Never lift above shoulder height without aids. Section 34 of the Factories Act prohibits employment on loads likely to cause injury.

2.5 Safety Management Tools and Procedures

Tool	Purpose
Safety induction training	Every new worker is told about hazards, rules and emergency actions before starting work.
Toolbox talk	Short (5-10 minute) safety talk by the supervisor at the start of a shift or job.
Job Safety Analysis (JSA)	Break a job into steps, find the hazard in each step and decide controls.
Permit-to-Work (PTW)	Written authorisation for dangerous jobs such as hot work, confined space entry, work at height, electrical isolation.
Lock-Out Tag-Out (LOTO)	Energy source is isolated, locked with a personal lock and tagged so that nobody can start the machine during repair.
Safety inspection and audit	Regular checks of the workplace and the safety system to find defects and non-compliance.
Safety committee	Joint committee of management and workers that reviews safety (Section 41G of the Factories Act).
Accident investigation	Finding the root cause of an accident so that it never happens again; not to blame an individual.
Mock drill	Practice of emergency response such as fire or gas leak evacuation.

2.6 First Aid Basics

- **Check safety** of the scene first, then call for help (ambulance or emergency number 112).
- **Bleeding:** apply firm direct pressure with a clean cloth and raise the injured part.
- **Burns:** cool with running clean water for at least 10 minutes. Do not apply ointment, ice or burst blisters.
- **Not breathing:** start CPR, 30 chest compressions followed by 2 rescue breaths.
- Keep the casualty calm and warm; never give food or drink to an unconscious person.

EXAM FOCUS: Topic 2

- Fire triangle = heat + fuel + oxygen. Class A = solids, B = liquids, C = gases, D = metals.
- Never use water on oil, electrical or metal fires. CO_2 is best for electrical and flammable-liquid fires.
- PASS = Pull, Aim, Squeeze, Sweep. 5S = Seiri, Seiton, Seiso, Seiketsu, Shitsuke.
- LOTO prevents accidental start-up during maintenance. PTW is needed for hot work and confined space entry.
- First-aid box: 1 per 150 workers (Sec. 45). CPR ratio = 30 compressions : 2 breaths.

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TOPIC 3: Industrial Hazards

A **hazard** is anything that can cause harm. Industrial hazards exist in every plant and must be identified, assessed and controlled before they turn into accidents. This topic covers types of hazards, occupational diseases, risk assessment, the hierarchy of controls and some well-known industrial disasters.

3.1 Hazard and Risk

Hazard	Risk
A potential source of harm (e.g. oil on the floor).	The chance that harm will occur and how severe it will be (e.g. chance of someone slipping and the injury it causes).

Risk = Likelihood (Probability) x Severity (Consequence)

3.2 Classification of Industrial Hazards

Type	Examples	Possible effects
Physical	Noise, vibration, extreme heat or cold, radiation, poor lighting, abnormal pressure	Deafness, heat stroke, burns, eye strain, cancer (radiation)
Chemical	Acids, alkalis, solvents, toxic gases, dust, fumes	Poisoning, burns, lung disease, cancer
Biological	Bacteria, viruses, fungi, animal or plant matter	Infections such as anthrax, tetanus, hepatitis
Mechanical	Rotating parts, moving belts, sharp edges, falling objects, pressure vessels	Cuts, crushing, amputation, fractures
Electrical	Live wires, faulty insulation, static electricity, arc flash	Shock, burns, fire, death
Ergonomic	Bad posture, repetitive movement, heavy lifting, poorly designed tools or workstations	Back pain, muscle and joint disorders, fatigue
Psychosocial	Work stress, long shifts, harassment, monotony, violence	Depression, anxiety, errors, accidents
Fire and explosion	Flammable liquids, gases, dust clouds, hot work	Burns, structural damage, death

3.3 Occupational Diseases

Disease	Cause / agent	Industry affected
Silicosis	Silica (quartz) dust	Mining, stone cutting, sand blasting, pottery
Asbestosis	Asbestos fibres	Insulation, brake lining, asbestos cement
Coal workers' pneumoconiosis (black lung)	Coal dust	Coal mining
Byssinosis	Cotton dust	Cotton textile mills
Bagassosis	Sugarcane bagasse dust	Sugar mills
Siderosis	Iron oxide dust	Iron ore mining, welding, grinding
Anthrax	Bacteria on animal hair, hides, wool	Leather, wool, hide handling
Plumbism (lead poisoning)	Lead	Battery making, paints, printing
Noise-induced hearing loss	Prolonged loud noise	Foundry, forging, weaving, boiler plants
Dermatitis	Oils, solvents, cement, chemicals	Machine shops, construction, chemical plants

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Disease	Cause / agent	Industry affected
Caisson disease (decompression sickness)	Sudden decrease in air pressure	Divers, tunnel workers
Welder's flash	Ultraviolet radiation from the arc	Welding

The general term for lung diseases caused by inhaling dust is **pneumoconiosis**.

3.4 Hazard Identification and Risk Assessment

Technique	Description
Safety checklist	List of items inspected against a standard.
Job Safety Analysis (JSA)	Step-by-step study of a job to find hazards and controls.
What-If analysis	Brainstorming questions beginning "What if ...?"
HAZOP (Hazard and Operability Study)	Systematic study of a process using guide words (no, more, less, reverse) to find deviations. Widely used in chemical industry.
FMEA (Failure Mode and Effects Analysis)	Lists possible failures of each component and their effects.
FTA (Fault Tree Analysis)	Top-down logic diagram tracing an undesired event back to its causes.
Safety audit	Independent, periodic review of the whole safety management system.

Steps of Risk Assessment

- **Step 1:** Identify the hazards.
- **Step 2:** Decide who might be harmed and how.
- **Step 3:** Evaluate the risk and decide control measures.
- **Step 4:** Record the findings and implement controls.
- **Step 5:** Review and update regularly.

Simple Risk Matrix (Likelihood x Severity)

Likelihood \ Severity	Minor (1)	Serious (2)	Fatal (3)
Unlikely (1)	1 - Low	2 - Low	3 - Medium
Possible (2)	2 - Low	4 - Medium	6 - High
Likely (3)	3 - Medium	6 - High	9 - Very high

3.5 Hierarchy of Controls

Hazards are controlled in order of effectiveness. The best method is to remove the hazard itself; PPE is the **last** line of defence because it depends on the worker and does not remove the hazard.

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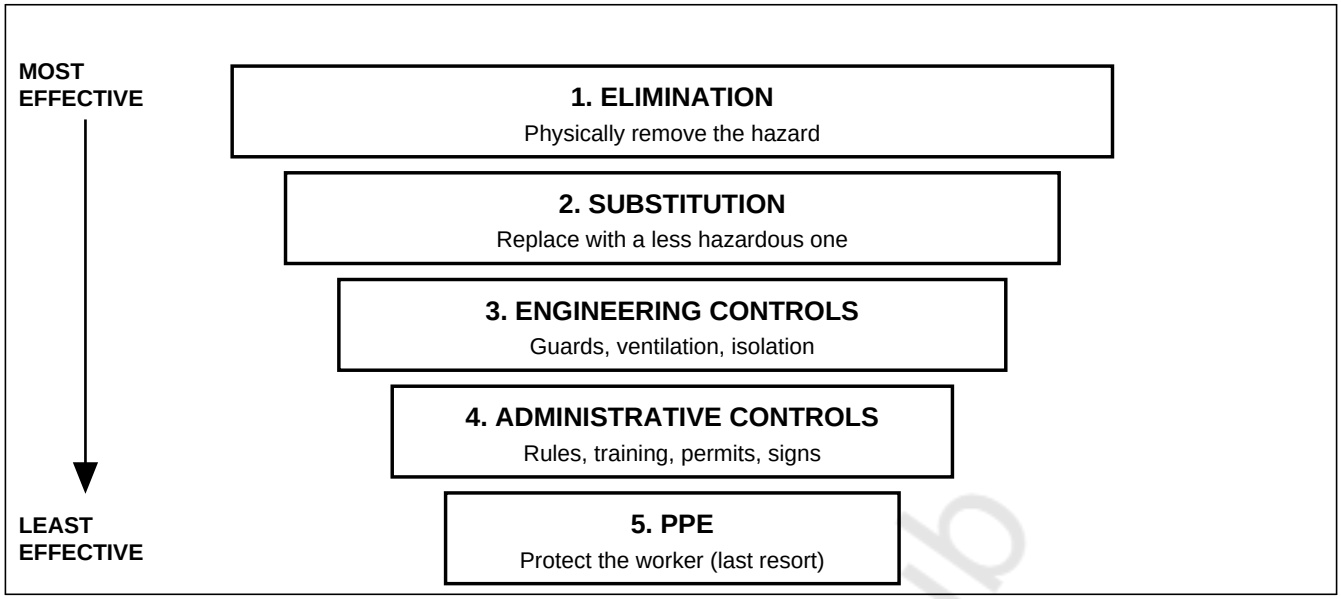


Fig. 3.1: Hierarchy of Hazard Controls

3.6 Major Industrial Disasters

Year	Event	Cause and impact
1974	Flixborough, UK	Cyclohexane vapour explosion at a chemical plant; 28 deaths.
1975	Chasnala, Dhanbad (India)	Coal mine flooding after an explosion; about 375 miners died.
1976	Seveso, Italy	Release of dioxin from a chemical plant; led to the European Seveso Directive.
1984	**Bhopal Gas Tragedy**, India	Leak of **methyl isocyanate (MIC)** from Union Carbide pesticide plant on the night of 2-3 December; the world's worst industrial disaster. Led to the Environment (Protection) Act, 1986 and the 1987 amendment of the Factories Act (Chapter IVA, hazardous processes).
1986	Chernobyl, USSR	Nuclear reactor explosion and radiation release.
1988	Piper Alpha, North Sea	Gas explosion on an oil platform; 167 deaths.
2020	Visakhapatnam (LG Polymers), India	Styrene vapour leak from a polymer plant on 7 May; 12 deaths and many hospitalised.

3.7 Noise as a Hazard

- Noise is measured in **decibels (dB)**; the A-weighted scale dB(A) is used for hearing hazard.
- Continued exposure above about 85-90 dB(A) for 8 hours damages hearing permanently.
- Control: reduce noise at source (silencers, enclosures), isolate the source, reduce exposure time, and use ear plugs or ear muffs.

EXAM FOCUS: Topic 3

- Risk = Likelihood x Severity. Hazard is the source of harm; risk is the chance of harm.
- Hierarchy of controls: Elimination, Substitution, Engineering, Administrative, PPE (last).
- Silicosis = silica dust; Byssinosis = cotton dust; Bagassosis = sugarcane; Anthrax = hides and wool; Plumbism = lead.
- HAZOP is used in process (chemical) industries. FTA is a top-down logic method.
- Bhopal 1984 = MIC gas, Union Carbide. Chasnala 1975 = mine flooding, Dhanbad.

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TOPIC 4: Electrical Safety

Electricity is used in every industry, but it is invisible, silent and can kill in a fraction of a second. Electrical hazards include **shock, burns, arc flash, fire and explosion**. A large number of fatal accidents are caused by electric shock, so this topic is very important for exams.

4.1 Effects of Electric Current on the Human Body

The seriousness of a shock depends on the **magnitude of current** (not the voltage alone), the path through the body, the duration of contact, body resistance and the type of supply (AC at 50 Hz is generally more dangerous than DC of the same value). By Ohm's law, **I = V / R**: wet skin has a very low resistance (about 1000 ohm) compared with dry skin (up to 100,000 ohm), so a wet person is at far higher risk.

Current (50 Hz AC, approx.)	Effect on the body
About 1 mA	Threshold of perception: slight tingling.
5 - 10 mA	Painful shock; person can usually still let go.
10 - 30 mA	Muscular contraction; "let-go" ability lost, person cannot release the conductor.
30 - 50 mA	Severe pain, breathing difficulty.
50 - 100 mA (and above)	Ventricular fibrillation of the heart; usually fatal if not treated quickly.
Above 200 mA	Severe burns, heart may stop (clamping), respiratory arrest.

Values are approximate and are used for comparison; exact limits vary between sources.

4.2 Voltage Levels in India

As per the Indian Electricity Rules, 1956:

Category	Voltage range
Low Voltage (LV)	Not exceeding 250 V
Medium Voltage (MV)	Above 250 V up to 650 V
High Voltage (HV)	Above 650 V up to 33 kV
Extra High Voltage (EHV)	Above 33 kV

4.3 Causes of Electrical Accidents

- Faulty, damaged or poor insulation; exposed live parts.
- Absence of or defective **earthing**.
- Overloading of circuits and short circuits leading to overheating and fire.
- Use of damaged plugs, extension boards or wrong rating of fuse.
- Working on live equipment, wet hands or wet floors.
- Contact of cranes or ladders with overhead lines.
- Lack of training, carelessness and not following lock-out procedures.

4.4 Electrical Protective Devices

Device	Function
Fuse	Protects the circuit from overcurrent. The fuse wire melts (heating effect of current) and opens the circuit. Must be of correct rating.

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Device	Function
MCB (Miniature Circuit Breaker)	Automatically trips on overload and short circuit; can be reset. Replaces rewirable fuses in homes and small installations.
MCCB (Moulded Case Circuit Breaker)	Similar to MCB for higher current ratings in industrial panels.
ELCB / RCCB (Earth Leakage / Residual Current Circuit Breaker)	Trips when current leaks to earth or through a person. Sensitivity of **30 mA** is used for protection against electric shock.
Isolator	Manually operated switch used to disconnect a circuit for maintenance (to be operated off-load).
Earthing (grounding)	Connects metal body of equipment to the earth, giving fault current a low-resistance path so that the protective device trips and the body does not remain live.
Insulation	Non-conducting covering (PVC, rubber) on wires and equipment.
Lightning arrester	Protects buildings and equipment from lightning and surge voltage.

4.5 Earthing

- **Purpose:** to protect persons from shock, to protect equipment, and to allow protective devices to operate.
- **Common methods:** plate earthing and pipe earthing (GI pipe or copper plate buried in the ground with salt and charcoal layers).
- Earth resistance must be as low as possible; it is checked regularly with an earth tester (megger).
- **Double-insulated** appliances (Class II) do not need an earth connection.
- **Standard wire colours (India):** Phase = Red (R, Y, B for three-phase), Neutral = Black, Earth = Green.

4.6 Safe Working Practices

- Treat every wire as live until it is tested dead and isolated.
- Use **Lock-Out Tag-Out (LOTO)**: isolate, lock, tag, test for dead, then work.
- Use insulated tools, **rubber gloves**, dielectric safety boots, rubber mats and insulated ladders (fibreglass, not metal).
- Do not work on electrical equipment with wet hands, wet floor or standing on wet ground.
- Keep a safe distance from overhead lines; do not operate cranes or carry long pipes near them.
- Use correct plugs and sockets; do not overload sockets; never use damaged cable.
- Only qualified and licensed electricians should repair electrical equipment.
- Electrical fire: switch off power first; use CO_2 or dry powder extinguisher, **never water**.

4.7 Rescue and First Aid for Electric Shock

Step	Action
1	**Switch off** the supply or pull out the plug immediately.
2	If the supply cannot be switched off, push the victim away using a dry non-conductor (dry wood, rubber, dry rope). **Do not touch the victim directly.**
3	Call for medical help. Check breathing and pulse.
4	If not breathing, begin CPR (30 compressions : 2 breaths).
5	Treat burns with cool running water and cover with clean dressing. Take the victim to hospital even if he seems fine, because heart effects can be delayed.

4.8 Static Electricity

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Static charge builds up during flow of liquids, powders and conveyor belts. A spark can ignite flammable vapour or dust. **Control:** bonding and earthing of tanks, tankers and pipelines; anti-static footwear; humidity control; limiting flow velocity.

EXAM FOCUS: Topic 4

- Current, not voltage, kills. Ventricular fibrillation occurs at about 50-100 mA and above. Body resistance falls sharply when skin is wet.
- Low voltage in India = up to 250 V. Medium = 250-650 V. High = 650 V-33 kV. EHV = above 33 kV.
- RCCB / ELCB (30 mA) gives protection from shock. Fuse = heating effect.
- Earth wire = Green; Neutral = Black; Phase = Red (R, Y, B).
- First step in rescue: switch off the supply. Never use water on electrical fire.

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TOPIC 5: Mechanical Safety

Mechanical safety deals with hazards arising from machines, moving parts, tools, lifting equipment and pressure systems. Many serious injuries such as amputation and crushing occur because moving parts were not guarded.

5.1 Mechanical Hazards

Hazard	Description	Example
Entanglement / winding	Hair, clothing or gloves wrapped around a rotating part	Rotating shaft, drill spindle, lathe chuck
Drawing-in (nip point)	Hand or clothing pulled between two parts moving together	Gears, belt and pulley, rollers
Crushing	Body part squeezed between two moving or one moving and one fixed object	Power press, lifts, closing doors of machines
Shearing	Cutting action between two parts moving past each other	Shearing machine, guillotine
Cutting / severing	Contact with a sharp edge or moving blade	Saws, milling cutters, grinding wheels
Stabbing / puncture	Sharp pointed object enters the body	Drills, nails, protruding wire
Impact	Hit by moving or falling object	Swinging crane load, falling tools
Ejection	Parts or chips thrown out at high speed	Broken grinding wheel, flying chips, bursting vessel
Friction / abrasion	Skin rubbed off by rough or fast-moving surface	Conveyors, rotating brushes
High-pressure injection	Fluid at high pressure penetrates skin	Hydraulic hose leak, air gun

5.2 Machine Guarding

A **guard** is a physical barrier that prevents contact with dangerous moving parts. Under **Section 21 of the Factories Act, 1948**, every dangerous part of machinery must be securely fenced (guarded). Guards must never be removed or bypassed while the machine is running.

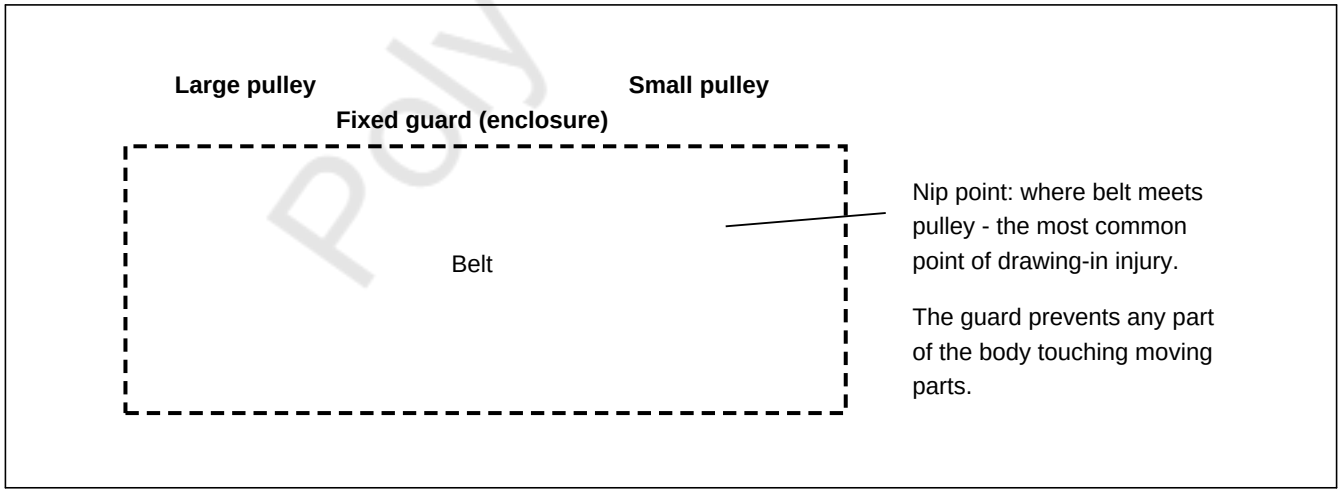


Fig. 5.1: Fixed guard enclosing a belt-and-pulley drive

Requirements of a Good Guard

- It must prevent contact with the hazard and be strong enough to withstand impact and vibration.
- It must not create a new hazard (no sharp edges, no pinch points).
- It must not interfere with the operator's work or visibility.
- It should be durable, easy to inspect and fix, made of steel, mesh, or transparent polycarbonate.

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Types of Guards

Type	Working / use
Fixed guard	Permanent part of the machine; can be removed only with tools. Preferred type. Example: gear cover, belt guard.
Interlocked guard	Machine cannot start (or stops) when guard is opened. Used where frequent access is needed.
Adjustable guard	Can be adjusted to suit the size of the work; used on drilling, band saw, milling.
Self-adjusting guard	Opening moves automatically according to the size of the stock; used on circular saws.
Distance guard	Keeps the operator away from the danger zone by distance (fence or barrier).
Automatic guard	Pushes or pulls the operator's hand out of the danger zone during the cycle (used on presses).
Trip device	Pressure-sensitive bar or wire that stops the machine when touched.

Safety Devices

- **Two-hand control:** machine operates only when both hands are on the buttons, so hands stay away from the die.
- **Presence-sensing devices:** light curtains and pressure mats stop the machine when a person enters the danger area.
- **Emergency stop (red mushroom push button)** within easy reach.
- **Overload protection and limit switches** to prevent overtravel.

5.3 Safe Practices on Common Machines

Machine	Key safety rules
Lathe	Remove chuck key before starting. No loose clothing, long hair tied. Do not measure or touch the job while rotating. Use a brush or hook, not hands, to remove swarf (chips). Keep guards in place.
Drilling machine	Clamp the work in a vice; never hold it by hand. No gloves. Remove drill chuck key. Remove chips with a brush after stopping.
Grinding machine	Check the wheel for cracks (ring test) and never exceed rated speed. Wheel guard essential. Keep the work rest within about 3 mm of the wheel. Wear goggles. Stand to the side when starting.
Power press	Two-hand control or interlocked guard. Never put hands in the die area; use tongs to feed or remove parts.
Welding	Welding helmet with correct filter shade, leather gloves and apron, good ventilation, remove flammables, keep gas cylinders upright and chained.
Compressed air	Never point an air jet at a person or use it to clean clothes.

5.4 Material Handling and Lifting Equipment

- Cranes, hoists, chains, ropes, slings and hooks must be tested and examined by a competent person at regular intervals and records kept (Factories Act, Sections 28 and 29).
- The **Safe Working Load (SWL)** must be marked on every lifting machine and must never be exceeded.
- Never walk or stand under a suspended load. Use tag lines to control swinging loads.
- Use correct slinging angles; a larger angle between sling legs increases tension in each leg.
- Only trained and authorised persons should operate cranes; use standard hand signals.
- Keep the load low when travelling with forklifts; wear seat belt; do not carry passengers.

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5.5 Boilers, Pressure Vessels and Gas Cylinders

A boiler or pressure vessel can explode violently if pressure exceeds its design limit. Important boiler fittings called **mountings** are:

Mounting	Function
Safety valve	Releases steam automatically when pressure exceeds the safe limit.
Pressure gauge	Shows steam pressure in the boiler.
Water level gauge	Shows water level; low water causes overheating and explosion.
Fusible plug	Melts when water level is dangerously low, releasing steam and warning the operator.
Stop valve	Controls the flow of steam to the main steam pipe.
Feed check valve	Allows water into the boiler and prevents back flow.
Blow-off cock	Removes sediment and drains the boiler.

Compressed gas cylinders: store upright and chained, keep valve caps on, keep away from heat and from each other (oxygen away from fuel gases), transport on trolleys, never use oil or grease on oxygen cylinder fittings, and check for leaks with soap solution.

5.6 Hand Tools and Maintenance Safety

- Use tools only for the purpose they are designed for; replace tools with mushroomed heads, cracked handles or damaged insulation.
- Carry sharp tools in a tool bag or holster, never in pockets.
- Before maintenance: stop machine, isolate power (LOTO), release stored energy (pressure, springs), then work.
- **Confined space** (tank, pit, silo): entry only with permit, gas testing for oxygen and toxic gases, ventilation, a standby person outside, and rescue arrangements (Section 36 of the Factories Act).

EXAM FOCUS: Topic 5

- Section 21 of the Factories Act = fencing of machinery. Fixed guard is the preferred guard.
- Interlocked guard stops the machine when opened. Two-hand control keeps hands out of the danger zone.
- Nip point = point where belt, chain or gear meets the pulley/wheel; common drawing-in hazard.
- SWL = Safe Working Load. Never stand under a suspended load.
- Boiler mountings: safety valve, pressure gauge, water level gauge, fusible plug, stop valve, feed check valve, blow-off cock.

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TOPIC 6: Chemical Safety

Chemicals are used in manufacturing, laboratories, fertilizer and pharmaceutical plants and many other places. Chemical hazards can cause poisoning, burns, fire, explosion and long-term diseases. The Bhopal disaster of 1984 showed how a single chemical leak can harm thousands of people.

6.1 Classification of Chemical Hazards

Class	Meaning	Examples
Flammable	Catches fire easily	Petrol, acetone, alcohol, LPG, hydrogen
Explosive	Releases energy suddenly with heat and pressure	TNT, nitroglycerine, ammonium nitrate (in some conditions)
Oxidising	Gives oxygen and helps other materials burn	Oxygen, hydrogen peroxide, nitric acid, chlorates
Toxic (poisonous)	Harmful or fatal on inhalation, skin contact or swallowing	Hydrogen sulphide, cyanides, mercury, pesticides
Corrosive	Destroys living tissue and metals on contact	Sulphuric acid, hydrochloric acid, caustic soda
Irritant	Causes redness, itching or inflammation	Ammonia (dilute), dust, some solvents
Reactive	Reacts violently with water or air	Sodium, potassium, phosphorus
Carcinogenic	Can cause cancer	Asbestos, benzene, vinyl chloride
Asphyxiant	Displaces oxygen from the air	Nitrogen, CO_2, argon; (chemical asphyxiant: carbon monoxide)

6.2 Routes of Entry and Forms of Contaminants

Chemicals enter the body by **inhalation** (the most common route), **skin contact/absorption**, **ingestion** and, rarely, injection.

Form	Description
Dust	Solid particles produced by crushing, grinding or drilling (e.g. silica dust).
Fume	Very fine solid particles formed by condensation of vapour from hot metal (e.g. welding fume).
Mist	Fine liquid droplets in air (e.g. paint spray, acid mist).
Vapour	Gaseous form of a substance that is liquid or solid at normal temperature (e.g. petrol vapour).
Gas	Substance that is in gaseous state at normal temperature and pressure (e.g. chlorine, CO).
Smoke	Particles and gases from incomplete combustion.

6.3 Exposure Limits and Toxicity Terms

Term	Meaning
TLV (Threshold Limit Value)	Concentration of a substance to which nearly all workers can be repeatedly exposed without harmful effect.
TLV-TWA	Time-Weighted Average concentration for a normal 8-hour day and 40-hour week.
TLV-STEL	Short-Term Exposure Limit: maximum average exposure for 15 minutes.
TLV-C (Ceiling)	Concentration that must never be exceeded, even instantaneously.
IDLH	Immediately Dangerous to Life or Health: concentration that can cause death or permanent harm within 30 minutes.

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Term	Meaning
LD_{50} / LC_{50}	Dose (or concentration) that kills 50% of test animals. Lower value means more toxic.
PPM	Parts per million, unit for gas and vapour concentration.

6.4 Fire-Related Properties of Chemicals

Property	Meaning
Flash point	Lowest temperature at which a liquid gives enough vapour to flash (ignite briefly) with a flame. Lower flash point means more dangerous.
Fire point	Temperature at which the vapour keeps burning (slightly above flash point).
Auto-ignition temperature	Temperature at which a substance ignites on its own without any flame or spark.
LEL / LFL	Lower Explosive (Flammable) Limit: minimum concentration of vapour in air that can burn. Below this the mixture is too lean.
UEL / UFL	Upper Explosive Limit: maximum concentration that can burn. Above this the mixture is too rich.
Flammable range	The range between LEL and UEL. Wider range means greater hazard.
Vapour density	Weight of vapour compared with air (air = 1). Heavy vapours (LPG, petrol) collect in low places like pits and drains.

Under the Petroleum Rules, petroleum products are classed by flash point: **Class A** below 23°C, **Class B** 23°C to 65°C, **Class C** 65°C to 93°C.

6.5 Hazard Communication: GHS, Labels and SDS

The **Globally Harmonised System (GHS)** provides a uniform way of classifying and labelling chemicals. A GHS label has: product identifier, hazard **pictogram**, **signal word**, **hazard statements (H-codes)**, **precautionary statements (P-codes)** and supplier details. Signal words are **"Danger"** (more severe hazards) and **"Warning"** (less severe). Each pictogram is a **diamond (square on its point) with a red border**.

GHS pictogram	Hazard
Exploding bomb	Explosives, self-reactive substances
Flame	Flammable gases, liquids, solids
Flame over circle	Oxidisers
Gas cylinder	Gases under pressure
Corrosion	Corrosive to metals and skin; serious eye damage
Skull and crossbones	Acute toxicity (fatal or toxic)
Exclamation mark	Irritant, skin sensitiser, harmful (less serious)
Health hazard	Carcinogen, mutagen, respiratory sensitiser, organ toxicity
Environment	Hazardous to the aquatic environment

Safety Data Sheet (SDS): 16 Sections

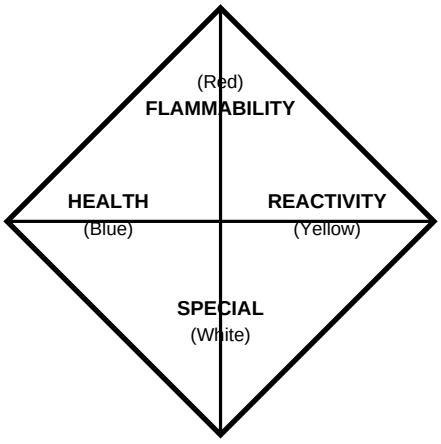
An SDS (formerly MSDS) gives complete information about a chemical. It has **16 sections**:

No.	Section	No.	Section
1	Identification	9	Physical and chemical properties
2	Hazard identification	10	Stability and reactivity

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No.	Section	No.	Section
3	Composition / ingredients	11	Toxicological information
4	First-aid measures	12	Ecological information
5	Fire-fighting measures	13	Disposal considerations
6	Accidental release measures	14	Transport information
7	Handling and storage	15	Regulatory information
8	Exposure controls / PPE	16	Other information

6.6 NFPA 704 Fire Diamond



NFPA 704 "Fire Diamond"

Rating scale for Health, Flammability, Reactivity:
0 = no hazard 1 = slight 2 = moderate
3 = serious 4 = severe / extreme

White quadrant (special) symbols:
OX = oxidiser W (with bar) = reacts with water
SA = simple asphyxiant gas

Fig. 6.1: NFPA 704 hazard diamond used on storage tanks and chemical containers

6.7 Safe Storage and Handling

- Read the label and SDS before using any chemical. Keep chemicals in original, labelled containers.
- Store flammable liquids in approved metal cabinets or tanks away from heat, sparks and direct sunlight.
- **Segregate incompatible chemicals.** Never store them together (see table below).
- Use fume hood or local exhaust ventilation. Do not eat, drink or smoke in chemical areas.
- **Always add acid to water, never water to acid**, slowly and with stirring (to avoid violent spattering).
- Use proper PPE: chemical goggles, gloves of correct material, apron, respirator if required.
- Provide eyewash fountains and safety showers within easy reach; test them regularly.

Do not store together	Hazard if mixed
Acids and bases (alkalis)	Violent heat-releasing reaction
Oxidisers and flammables / organics	Fire or explosion
Cyanides and acids	Release of toxic hydrogen cyanide gas
Bleach (hypochlorite) and acids or ammonia	Release of toxic chlorine / chloramine gas
Water-reactive metals (sodium, potassium) and water	Fire and hydrogen explosion

6.8 Common Toxic and Hazardous Gases

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Gas	Properties	Effect
Carbon monoxide (CO)	Colourless, odourless; from incomplete combustion	Combines with haemoglobin, blocks oxygen transport; "silent killer"
Hydrogen sulphide (H_2S)	Smell of rotten eggs at low level; deadens sense of smell at high level	Respiratory paralysis, sudden collapse; found in sewers and refineries
Chlorine (Cl_2)	Greenish-yellow, pungent, heavier than air	Severe lung and eye irritation
Ammonia (NH_3)	Colourless, sharp smell, lighter than air	Irritates eyes, throat and lungs; used in refrigeration
Methyl isocyanate (MIC)	Colourless, highly toxic volatile liquid	Cause of Bhopal tragedy; eye, lung damage, death
Carbon dioxide (CO_2)	Colourless, heavier than air	Asphyxiant in confined spaces at high concentration
LPG	Highly flammable, heavier than air; stench added to detect leaks	Fire and explosion; collects in low-lying areas

6.9 Chemical Spill and Emergency Response

- Alert people, evacuate the area, and call the emergency team.
- Remove ignition sources if the spill is flammable. Ventilate the area.
- Only trained persons with proper PPE should clean up. Contain the spill with absorbent material or sand; neutralise only if trained.
- **Skin or eye contact:** flush with plenty of clean water for at least **15 minutes**, remove contaminated clothing, get medical help.
- **Swallowing:** do not induce vomiting after corrosive or petroleum products; give medical help urgently.
- **Inhalation:** move the person to fresh air; give oxygen or CPR if trained.

6.10 Legal Provisions in India

Law / Rule	Main purpose
Factories Act, 1948: Chapter IVA (Sections 41A to 41H)	Provisions for hazardous processes; added after Bhopal in 1987. Site appraisal committee, safety and health policy, workers' participation, emergency plan.
Manufacture, Storage and Import of Hazardous Chemicals (MSIHC) Rules, 1989	Safety measures for industries handling hazardous chemicals; safety reports, on-site emergency plans.
Chemical Accidents (Emergency Planning, Preparedness and Response) Rules, 1996	Crisis groups at central, state and district levels.
Environment (Protection) Act, 1986	Overall protection of environment and control of hazardous substances.
Public Liability Insurance Act, 1991	Compulsory insurance of owners handling hazardous substances to provide relief to victims.

EXAM FOCUS: Topic 6

- Most common route of chemical entry = inhalation. SDS has 16 sections. GHS signal words: Danger / Warning.
- GHS pictogram = diamond with red border. NFPA 704: Blue = Health, Red = Flammability, Yellow = Reactivity, White = Special.
- Always add acid to water. Flush eyes and skin with water for 15 minutes.
- TLV-TWA = 8 hours / day, 40 hours / week. STEL = 15 minutes. Lower flash point = more dangerous.
- CO = colourless, odourless silent killer. H_2S = rotten-egg smell. Bhopal gas = MIC.

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TOPIC 7: Personal Protective Equipment (PPE)

7.1 Meaning and Need

Personal Protective Equipment (PPE) is any equipment or clothing worn by a worker to protect the body from hazards at work. PPE is used when hazards cannot be fully removed by elimination, substitution or engineering controls. It is the **last line of defence** in the hierarchy of controls: it only reduces the effect of the hazard on the person; it does not remove the hazard.

Requirements of Good PPE

- Gives adequate protection against the specific hazard.
- Comfortable, light in weight and does not hinder movement or vision.
- Properly fitting; available in correct sizes.
- Durable, easy to clean and maintain; conforms to BIS (IS) or equivalent standard.
- Does not create an additional hazard.

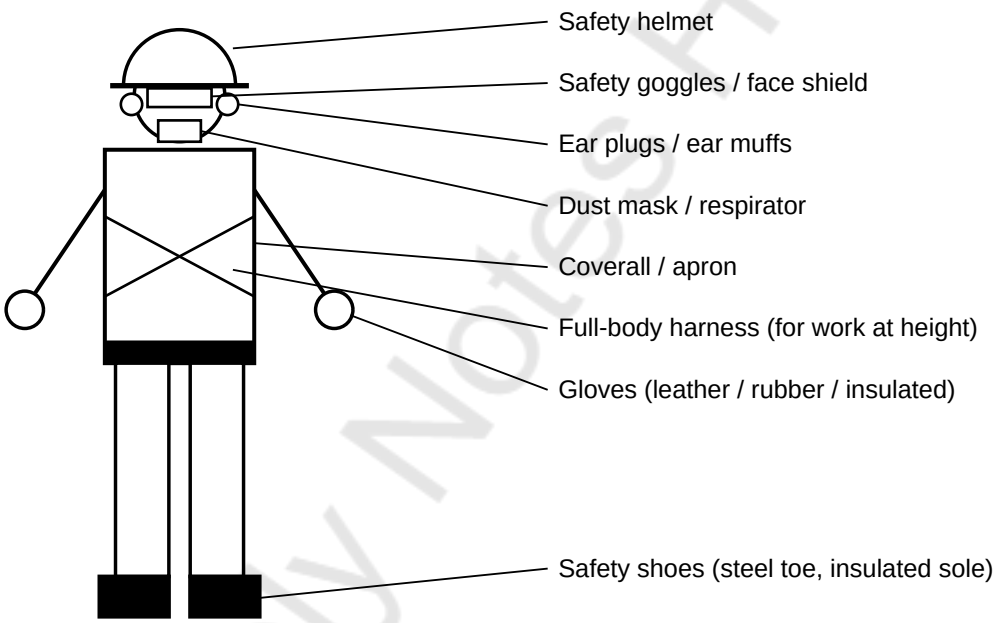


Fig. 7.1: PPE for different parts of the body

7.2 Types of PPE

Body part	PPE	Protects against	Notes
Head	Safety helmet (hard hat), bump cap	Falling objects, impact, electric shock (non-conductive type)	IS 2925 is the Indian standard for industrial safety helmets. Replace after a heavy blow.
Eyes and face	Safety glasses, chemical goggles, face shield, welding helmet	Flying particles, chemical splash, radiation, welding arc	Welding helmets use filter lenses; goggles seal around the eyes (IS 5983 for eye protectors).
Ears	Ear plugs, ear muffs	Noise (hearing loss)	Reduce noise by about 20-30 dB; muffs are easier to see and fit.

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Body part	PPE	Protects against	Notes
Respiratory system	Dust mask, half- or full-face respirator, SCBA, air-line respirator	Dust, fumes, vapours, gases, oxygen-deficient air	Filters/cartridges must match the contaminant.
Hands	Leather, rubber, chemical-resistant, insulating, cut-resistant, heat-resistant gloves	Cuts, burns, chemicals, electric shock, abrasion	Do not wear gloves near rotating machines like lathe and drill.
Feet	Safety shoes with steel toe cap, gum boots, insulating shoes, anti-slip soles	Falling objects, sharp objects, wet floor, chemicals, electric shock	IS 15298 covers safety footwear.
Body	Coverall, apron (leather / PVC), flame-retardant suit, chemical suit, high-visibility jacket	Heat, sparks, chemical splash, being unseen	Choose material according to hazard.
Fall protection	Full-body harness, lanyard with shock absorber, lifeline, anchor point	Falls from height (work above about 1.8 to 2 m)	Anchor point must be strong and above the worker.

7.3 Respiratory Protective Equipment

Type	Working	Use
Air-purifying respirator (APR)	Filters or cartridges remove contaminants from the surrounding air.	Only when oxygen is normal and contaminant type and concentration are known and low.
Atmosphere-supplying respirator	Supplies clean air from outside source (air line) or from a cylinder (SCBA - Self-Contained Breathing Apparatus).	Oxygen-deficient atmospheres, confined spaces, IDLH conditions, firefighting, rescue.

Normal air contains about 20.9% oxygen. An atmosphere with less than 19.5% oxygen is considered oxygen-deficient; an air-purifying respirator must NEVER be used there.

7.4 Selection, Use and Care of PPE

- Select PPE after hazard assessment; the type should match the hazard.
- Train workers on how to wear, adjust, use, clean and store it.
- Inspect PPE before each use; replace damaged or expired items.
- Clean and store in a dry, clean place. Never share personal items like respirators and ear plugs.
- Enforce use through supervision and display of mandatory signs.
- **Limitations:** PPE does not remove the hazard, can be uncomfortable, may fail if worn wrongly, and needs continuous supervision.

EXAM FOCUS: Topic 7

- PPE = last line of defence (lowest in hierarchy of controls).
- Safety helmet: IS 2925. Eye protectors: IS 5983. Safety footwear: IS 15298.
- SCBA / air-line respirator is required in oxygen-deficient or IDLH atmospheres. Normal air has 20.9% oxygen.
- Rubber insulating gloves for electrical work; leather gloves for welding; chemical-resistant gloves for acids and solvents.
- Full-body harness for work at height; ear plug / ear muff for noise.

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TOPIC 8: Safety Signs and Symbols

Safety signs give quick, clear warning or instruction through colour, shape and a symbol, so that they are understood even by a worker who cannot read the language. In India, safety colours and signs follow **IS 9457** (based on international ISO standards).

8.1 Safety Colours and Their Meaning

Colour	Meaning	Examples
Red	Prohibition, danger, stop, fire-fighting equipment	No smoking, stop button, fire extinguisher, fire alarm
Yellow (Amber)	Caution, warning, risk of danger	Slippery floor, hot surface, overhead crane, floor marking of hazards
Blue	Mandatory action; information	Wear helmet, wear gloves, use ear protection
Green	Safe condition, first aid, emergency exit, safety equipment	First-aid box, emergency exit, assembly point, eyewash
White / Black	Contrast colours used as background and for symbols and text	White background for prohibition; black symbol on yellow

8.2 Categories of Safety Signs



Fig. 8.1: The five basic categories of safety signs

Category	Shape	Colour scheme	Meaning	Examples
Prohibition sign	Circle with diagonal bar	Red border and bar, black symbol, white background	Something must NOT be done	No smoking, no entry, do not touch, no mobile phones
Mandatory sign	Circle	Blue background, white symbol	Something MUST be done	Wear safety helmet, goggles, gloves, ear protection
Warning sign	Equilateral triangle	Yellow background, black border and symbol	Beware of a hazard	Danger high voltage, flammable material, slippery floor, toxic
Safe condition (emergency) sign	Square or rectangle	Green background, white symbol	Indicates safe route or help	Emergency exit, first aid, assembly point, eyewash
Fire-fighting equipment sign	Square or rectangle	Red background, white symbol	Location of fire equipment	Fire extinguisher, hose reel, fire alarm call point

8.3 Other Warning and Identification Methods

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Method	Details
GHS pictograms	Black symbol inside a red-bordered white diamond, used on chemical containers (see Topic 6).
NFPA 704 diamond	Four coloured diamonds (Blue health, Red flammability, Yellow reactivity, White special) rated 0 to 4.
Danger / Caution tags	Red "DANGER" tag on a switch or valve means do not operate. Yellow "CAUTION" tag means take care. Used with LOTO.
Barricade tape	Red and white tape = danger area, do not enter. Yellow and black tape = caution, physical hazard.
Signal words (ANSI)	DANGER (red) = will cause death or serious injury. WARNING (orange) = could cause death or serious injury. CAUTION (yellow) = minor injury possible.
Floor markings	Yellow lines for walkways and machine danger zones; green for safety equipment; red for fire-fighting equipment.
Audible and visual alarms	Sirens, flashing lights and bells for fire, gas leak or evacuation.

8.4 Rules for Effective Use of Safety Signs

- Place signs at eye level, close to the hazard, clearly visible and well lit.
- Use simple symbols with short text in English and local language (Bengali or Hindi) so every worker understands.
- Do not overcrowd; too many signs reduce attention.
- Keep signs clean, replace damaged ones, and make signs for emergency exits glow-in-the-dark or illuminated.
- Train all employees on the meaning of signs; signs alone do not control a hazard.

EXAM FOCUS: Topic 8

- Red = prohibition / stop / fire equipment; Yellow = warning; Blue = mandatory; Green = safe condition.
- Prohibition = circle with slash. Mandatory = blue circle. Warning = triangle. Safe condition = green square.
- GHS pictogram = red-bordered diamond. NFPA 704 = four-colour diamond.
- Red-and-white barricade tape = danger; yellow-and-black = caution.
- Indian standard for safety colours and signs = IS 9457.

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QUICK REVISION: Numbers, Names and Facts

Revise this one-page table just before the examination.

Fact	Remember
Heinrich accident ratio	1 major : 29 minor : 300 no-injury; 88% unsafe acts, 10% unsafe conditions, 2% unavoidable
Indirect cost : Direct cost	4 : 1
Frequency / Severity rate	Per 1,000,000 man-hours
National Safety Day	4 March (NSC established 1966)
Factories Act	1948; Sec. 21 fencing; 40B Safety Officer (1000+); 45 first-aid (1 per 150); 46 canteen (250+); 49 welfare officer (500+)
Bhopal gas tragedy	2-3 December 1984, MIC gas, Union Carbide
Fire triangle	Heat + Fuel + Oxygen; classes A, B, C, D and electrical
Extinguisher on electrical fire	CO_2 or dry powder, never water
PASS	Pull, Aim, Squeeze, Sweep
5S	Seiri, Seiton, Seiso, Seiketsu, Shitsuke
Low voltage (India)	Up to 250 V; medium 250-650 V; high 650 V-33 kV; EHV above 33 kV
RCCB / ELCB	30 mA, protects against electric shock
Wire colours	Phase red, neutral black, earth green
First action in electric shock	Switch off the supply
Hierarchy of controls	Elimination, Substitution, Engineering, Administrative, PPE
SDS sections	16
NFPA 704	Blue health, Red flammability, Yellow reactivity, White special; rating 0-4
Chemical on skin or eye	Flush with water at least 15 minutes
Oxygen in normal air	20.9%; below 19.5% = oxygen deficient
IS codes	IS 2925 helmet; IS 5983 eye protectors; IS 15298 safety footwear; IS 9457 safety signs
Safety sign colours	Red prohibition / fire; yellow warning; blue mandatory; green safe condition

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PRACTICE TEST: 50 Multiple Choice Questions

Instructions: Choose the single best answer. Each question carries 1 mark. Time suggested: 40 minutes. Answers are given in the Answer Key on the next page.

Q1. Industrial safety mainly aims at:
(A) Reducing wages of workers
(B) Increasing production at any cost
(C) Protecting workers, machines, materials and the environment from accidents
(D) Increasing working hours

Q2. An unplanned event that causes no injury or damage but had the potential to do so is called a:
(A) Near miss
(B) Fatality
(C) Occupational disease
(D) Major accident

Q3. According to Heinrich's accident triangle, for every 1 major injury there are ____ minor injuries and ____ no-injury incidents.
(A) 10 and 100
(B) 29 and 300
(C) 5 and 50
(D) 30 and 600

Q4. National Safety Day in India is observed on:
(A) 4 March
(B) 5 June
(C) 28 April
(D) 2 December

Q5. The Factories Act in India was enacted in the year:
(A) 1948
(B) 1956
(C) 1986
(D) 1936

Q6. As per Heinrich, approximately what percentage of accidents are caused by unsafe acts of persons?
(A) 10%
(B) 2%
(C) 50%
(D) 88%

Q7. In the 5S system, 'Seiri' means:
(A) Set in order
(B) Sort (remove unnecessary items)
(C) Shine (clean)
(D) Standardise

Q8. The three components of the fire triangle are:
(A) Fuel, smoke and spark
(B) Heat, fuel and oxygen
(C) Oxygen, nitrogen and heat
(D) Heat, water and air

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Q9. Class B fire involves:
(A) Flammable liquids
(B) Ordinary combustible solids
(C) Live electrical equipment only
(D) Combustible metals

Q10. Which extinguisher is most suitable for a fire on live electrical equipment?
(A) Water
(B) Foam
(C) Carbon dioxide (CO_2)
(D) Soda-acid

Q11. In the extinguisher technique PASS, the letter 'S' (first one) stands for:
(A) Squeeze
(B) Stop
(C) Spray
(D) Switch

Q12. Under the Factories Act, one first-aid box must be provided for every:
(A) 250 workers
(B) 50 workers
(C) 150 workers
(D) 100 workers

Q13. Risk is expressed as:
(A) Likelihood x Severity
(B) Severity / Likelihood
(C) Likelihood + Severity
(D) Hazard / Exposure time

Q14. Which control measure is at the top (most effective) of the hierarchy of controls?
(A) Administrative control
(B) Elimination
(C) Warning signs
(D) Personal protective equipment

Q15. HAZOP stands for:
(A) Health and Occupational Protection
(B) Hazardous Operation Procedure
(C) Hazard and Operability Study
(D) Hazard and Operation Plan

Q16. Lung disease caused by inhalation of silica dust is called:
(A) Anthrax
(B) Bagassosis
(C) Byssinosis
(D) Silicosis

Q17. The Bhopal gas tragedy of 1984 was caused by the leakage of:
(A) Chlorine
(B) Methyl isocyanate (MIC)
(C) Ammonia
(D) LPG

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Q18. A potential source of harm is called a:
(A) Risk
(B) Hazard
(C) Exposure
(D) Accident

Q19. Which device protects a person from electric shock due to earth leakage?
(A) RCCB / ELCB
(B) Isolator
(C) Lightning arrester
(D) Rewirable fuse

Q20. The main purpose of earthing is to:
(A) Reduce the cost of wiring
(B) Increase the current in the circuit
(C) Provide a low-resistance path for fault current to the ground
(D) Increase the voltage of the supply

Q21. As per the Indian Electricity Rules, low voltage means voltage not exceeding:
(A) 125 V
(B) 250 V
(C) 440 V
(D) 650 V

Q22. In standard wiring in India, the colour of the earth wire is:
(A) Green
(B) Blue
(C) Red
(D) Black

Q23. The first action to rescue a person sticking to a live electrical conductor is to:
(A) Switch off the electric supply
(B) Pull the person by hand
(C) Wait for the doctor
(D) Pour water on the person

Q24. A fuse works on the principle of:
(A) Hall effect
(B) Heating effect of electric current
(C) Chemical effect of current
(D) Magnetic effect of current

Q25. A current of about ____ passing through the body can cause ventricular fibrillation.
(A) 1 mA
(B) 15 mA
(C) 100 mA
(D) 5 mA

Q26. A guard that can be removed only with the help of tools is called a:
(A) Interlocked guard
(B) Adjustable guard
(C) Automatic guard
(D) Fixed guard

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Q27. An interlocked guard:
(A) Adjusts itself to the size of work
(B) Prevents the machine from operating unless the guard is closed
(C) Works only when the machine is switched off
(D) Is always welded to the machine

Q28. A worker's loose clothing being pulled in by a rotating shaft is an example of:
(A) Ejection hazard
(B) Thermal hazard
(C) Entanglement hazard
(D) Chemical hazard

Q29. Which boiler mounting releases steam automatically when pressure exceeds the safe limit?
(A) Feed check valve
(B) Safety valve
(C) Blow-off cock
(D) Stop valve

Q30. Fencing of machinery is covered under which Section of the Factories Act, 1948?
(A) Section 21
(B) Section 7A
(C) Section 36
(D) Section 45

Q31. SWL marked on a crane or sling stands for:
(A) Safe Working Load
(B) Standard Weight Limit
(C) Special Working Level
(D) Safe Weight of Lifting

Q32. A Safety Data Sheet (SDS) contains how many sections?
(A) 8
(B) 12
(C) 16
(D) 20

Q33. In the NFPA 704 diamond, the red quadrant indicates:
(A) Flammability
(B) Special hazard
(C) Health hazard
(D) Reactivity

Q34. While diluting a concentrated acid, one should:
(A) Always add acid to water slowly
(B) Heat the water first
(C) Mix both at once
(D) Add water to acid quickly

Q35. Under GHS, the signal word used for the more severe hazards is:
(A) Caution
(B) Alert
(C) Warning
(D) Danger

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Q36. Which gas is colourless, odourless and called the 'silent killer'?
(A) Hydrogen sulphide
(B) Carbon monoxide
(C) Ammonia
(D) Chlorine

Q37. TLV-TWA refers to the average concentration of a chemical for:
(A) An 8-hour working day and 40-hour week
(B) A 24-hour day
(C) A single breath
(D) A 15-minute period

Q38. If a corrosive chemical splashes into the eye, the first aid is to:
(A) Close the eye and wait
(B) Rub the eye with a cloth
(C) Apply ointment
(D) Flush with plenty of clean water for at least 15 minutes

Q39. In the hierarchy of controls, PPE is considered:
(A) The most effective control
(B) A replacement for engineering controls
(C) Not required in industry
(D) The last line of defence

Q40. The Indian Standard for industrial safety helmets is:
(A) IS 9457
(B) IS 15298
(C) IS 5983
(D) IS 2925

Q41. Which respiratory equipment must be used in an oxygen-deficient atmosphere?
(A) Cloth mask
(B) Self-Contained Breathing Apparatus (SCBA)
(C) Cartridge respirator
(D) Simple dust mask

Q42. Ear plugs and ear muffs are used to protect against:
(A) Radiation
(B) Falling objects
(C) Noise
(D) Dust

Q43. Which gloves are suitable for electrical work?
(A) Metal mesh gloves
(B) Cotton gloves
(C) Rubber insulating gloves
(D) Leather gloves

Q44. A full-body safety harness protects a worker against:
(A) Electric shock only
(B) Falls from height
(C) Chemical splash
(D) Noise

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Q45. A circle with a red border and a diagonal red bar indicates a:
(A) Mandatory sign
(B) Safe condition sign
(C) Warning sign
(D) Prohibition sign

Q46. A blue circular sign with a white symbol indicates a:
(A) Mandatory sign
(B) Warning sign
(C) Fire-fighting sign
(D) Prohibition sign

Q47. A yellow triangular sign with a black border indicates a:
(A) Prohibition sign
(B) Mandatory sign
(C) Emergency exit sign
(D) Warning sign

Q48. Green colour in safety signs indicates:
(A) Danger
(B) Mandatory action
(C) Fire-fighting equipment
(D) Safe condition, first aid or emergency exit

Q49. The safety colour used for fire-fighting equipment is:
(A) Yellow
(B) Green
(C) Blue
(D) Red

Q50. A GHS hazard pictogram is shaped as a:
(A) Green square
(B) Diamond with a red border
(C) Yellow triangle
(D) Blue circle

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ANSWER KEY

Q.	Ans	Q.	Ans	Q.	Ans	Q.	Ans	Q.	Ans
1	**C**	11	**A**	21	**B**	31	**A**	41	**B**
2	**A**	12	**C**	22	**A**	32	**C**	42	**C**
3	**B**	13	**A**	23	**A**	33	**A**	43	**C**
4	**A**	14	**B**	24	**B**	34	**A**	44	**B**
5	**A**	15	**C**	25	**C**	35	**D**	45	**D**
6	**D**	16	**D**	26	**D**	36	**B**	46	**A**
7	**B**	17	**B**	27	**B**	37	**A**	47	**D**
8	**B**	18	**B**	28	**C**	38	**D**	48	**D**
9	**A**	19	**A**	29	**B**	39	**D**	49	**D**
10	**C**	20	**C**	30	**A**	40	**D**	50	**B**

Scoring guide: 45-50 Excellent | 38-44 Good | 30-37 Average, revise the tables | Below 30: re-read the topics.

Best wishes for your preparation. For more notes visit www.polynoteshub.co.in

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