Subject Name & Code:

INDUSTRIAL SAFETY AND STANDARDS- BE02000061

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Unit-I: Industrial Safety – Concepts and Standards

1. Explain the need for safety in modern-day industries.

Need	Explanation
Humanitarian	Preventing loss of life, injury, and suffering of workers.
Legal	Compliance with Factories Act, 1948, and other statutory regulations.
Economic	Reducing costs from accidents, medical aid, compensation, and damage to equipment.
Productivity	Safe environment improves morale, reduces absenteeism, and increases output.
Reputation	Good safety record enhances company image and stakeholder trust.

2. Explain the relationship between safety and productivity.

Safety and productivity are directly proportional. A safe workplace reduces downtime due to accidents, lowers employee turnover, and boosts morale. When workers feel secure, they focus better, work faster with fewer errors, and take fewer sick days. Conversely, accidents cause production halts, rework, and legal interruptions. Thus, investment in safety is investment in sustainable productivity.

3. Explain the types of accidents and ways to control them.

Types of accidents:

- **Mechanical:** Cuts, fractures, crushing – due to machine guarding failures.
- **Electrical:** Shocks, burns, electrocution – from exposed wires or faulty insulation.
- **Chemical:** Burns, poisoning, inhalation – from spills or toxic fumes.

- **Thermal:** Burns, scalds – from hot surfaces, steam, or fire.
- **Ergonomic:** Repetitive strain, back injury – poor workstation design.

Control measures:

- Engineering controls (guards, ventilation, insulation)
- Administrative controls (safety training, job rotation)
- PPE (helmets, gloves, goggles, earplugs)
- Regular inspections and safety audits

4. Define industrial safety. Explain its significance.

Definition: Industrial safety is the management of all operations and processes within an industry to prevent accidents, injuries, and occupational diseases by identifying, controlling, and eliminating hazards.

Significance:

- Protects human life and health
- Ensures legal compliance (Factories Act, 1948)
- Reduces financial losses from accidents
- Improves worker morale and efficiency
- Enhances quality and productivity

5. Write theories of accident causation.

Theory	Description
Domino Theory (Heinrich)	Accidents result from a sequence of 5 factors: ancestry/social environment, fault of person, unsafe act/condition, accident, injury. Removing the middle domino (unsafe act) prevents injury.
Human Factors Theory	Accidents due to human errors: overload, inappropriate response, or poor working conditions.
Accident/Incident Theory	Extension of human factors – includes ergonomic traps, system failures, and decision errors.

Theory	Description
Epidemiological Theory	Accidents similar to diseases – involves host (worker), agent (energy/hazard), and environment.
Systems Theory	Accidents arise from interactions among human, machine, environment – failure in one component propagates.

6. Describe salient points of Factories Act, 1948.

- **Health (Sections 11–20):** Cleanliness, ventilation, dust/fume control, lighting, drinking water, sanitation.
- **Safety (Sections 21–40):** Fencing of machinery, work on near moving parts, hoists, pressure vessels, fire safety.
- **Welfare (Sections 42–50):** Washing facilities, first-aid boxes, canteens, shelters, rest rooms.
- **Working hours (Sections 51–66):** Weekly hours (48 max), daily hours (9 max), overtime, intervals, prohibitions on young persons.
- **Hazardous processes (Section 87–106):** Special provisions for chemical, dangerous operations.

7. Explain safety colour codes.

Colour	Meaning	Application
Red	Danger / Fire protection	Fire extinguishers, emergency stop buttons
Yellow	Caution / Warning	Trip hazards, low beams, mobile equipment
Green	Safety / First aid	First aid boxes, emergency exits
Blue	Mandatory information	Signage for PPE requirements
White/Black	Housekeeping / Information	Floor markings, directional signs

8. Explain: Frequency rate, severity rate, incidence rate, activity rate.

Term	Formula	Meaning
Frequency Rate	(No. of lost-time injuries × 1,000,000) / Total person-hours worked	Accidents per million man-hours
Severity Rate	(Total days lost × 1,000,000) / Total person-hours worked	Seriousness of accidents
Incidence Rate	(No. of injuries × 1,000) / Average number of employees	Injuries per 1000 workers per year
Activity Rate	(No. of events/activities × 100) / Total opportunities	Percentage of safety activities completed

9. Write a note on safety policy and safety standards for industry/organisation.

A **safety policy** is a written commitment by top management to provide safe working conditions. It includes:

- Statement of intent (safety priority)
- Organization structure for safety
- Arrangements for training, inspections, audits

Safety standards (e.g., ISO 45001, OHSAS 18001, IS 14489) provide frameworks for hazard identification, risk assessment, legal compliance, and continual improvement. Standards ensure uniformity, legal defense, and best practices across industries.

Unit-II: Hazard Identification and Analysis

1. Define hazard and list different types of hazards.

Hazard: A source or situation with potential to cause harm to people, property, or environment.

Type	Example
Physical	Noise, radiation, vibration
Chemical	Toxic gases, corrosive liquids
Biological	Bacteria, viruses, fungi
Ergonomic	Repetitive motion, poor posture
Electrical	Live wires, short circuits
Mechanical	Unguarded moving parts
Psychosocial	Stress, harassment, shift fatigue

2. Classify fire (as per IS 15683).

Class	Fuel	Example
A	Solid combustibles	Wood, paper, cloth
B	Flammable liquids	Petrol, oil, paint
C	Flammable gases	LPG, methane
D	Combustible metals	Magnesium, sodium
E	Electrical equipment	Motors, panels, wires

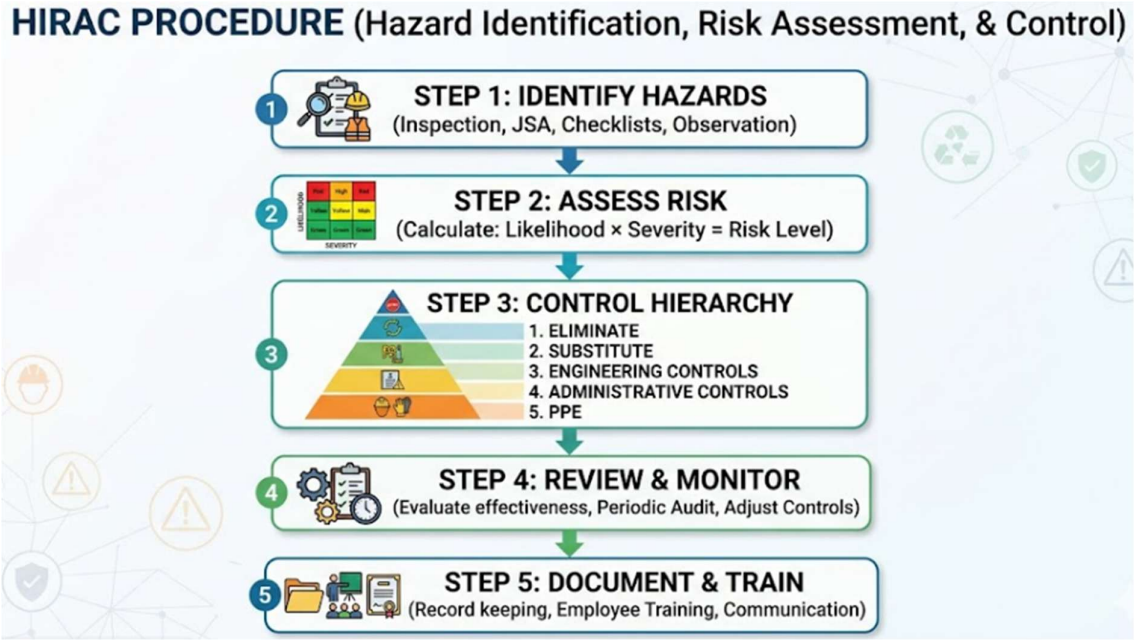
Class	Fuel	Example
F	Cooking oils/fats	Kitchen oil, grease

3. Explain types of fire extinguishers and their specific applications.

Type	Agent	Classes	Application
Water	Water	A	Wood, paper, textiles
Foam	AFFF	A, B	Flammable liquids
CO_2	CO_2 gas	B, E	Electrical, liquids
Dry powder	ABC powder	A, B, C, E	General purpose
Wet chemical	Potassium	F	Kitchen fires

4. Hazard identification, risk assessment, and control procedure (HIRAC).

Diagram:



5. Fire and explosion risk assessment (FERA).

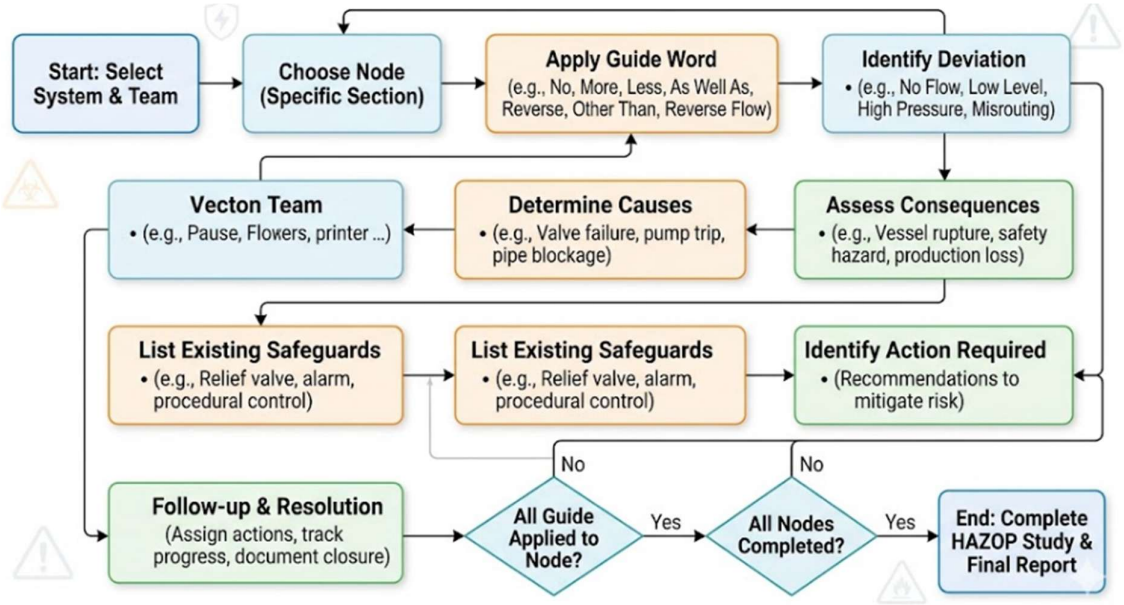
FERA is a structured study to identify potential fire/explosion events, their likelihood, and consequences. Steps:

1. Identify flammable inventories
2. Ignition sources (electrical, static, hot work)
3. Consequence modeling (heat flux, overpressure)
4. Risk ranking (risk matrix)
5. Recommendations (fireproofing, blast walls, drainage)

6. HAZOP – methodology, criticality analysis, corrective actions.

HAZOP (Hazard and Operability Study) – Systematic team-based method using guide words (No, More, Less, Reverse, As well as, Other than) applied to process parameters (flow, temperature, pressure).

Diagram:



Criticality Analysis: Risk ranking based on severity and likelihood.
Corrective Actions: Redesign, interlocks, alarms, training.
Follow-up: Action tracker, reassessment, sign-off.

7. Control chemical hazards in workplace.

Diagram:



8. Key information in Material Safety Data Sheet (MSDS).

1. Product identifier & supplier info
2. Hazard identification
3. Composition/ingredients
4. First-aid measures
5. Fire-fighting measures
6. Accidental release measures
7. Handling & storage
8. Exposure controls/PPE
9. Physical & chemical properties
10. Stability & reactivity
11. Toxicological info

Unit-III: Fundamentals of Maintenance Engineering

1. Define maintenance.
Maintenance is the combination of technical and administrative actions to retain or restore an equipment/item to a state where it can perform its required function.

2. Aims of maintenance.

- Maximize equipment availability
- Minimize breakdowns and downtime
- Extend asset life
- Ensure safety and compliance
- Optimize life-cycle cost

3. Primary & secondary functions of maintenance department.

Primary	Secondary
Preventive & breakdown maintenance	Spare parts management
Inspection & lubrication	Condition monitoring
Repairs & overhauls	Safety checks
Installation & relocation	Documentation & reporting

4. Function & responsibility of maintenance department.

- Plan & schedule maintenance work
- Diagnose faults & repair equipment
- Maintain inventory of spares
- Liaise with production and safety
- Train operators in basic upkeep

5. Types of maintenance & tools used.

Type	Application	Tools (example)
Breakdown (reactive)	After failure	Wrenches, multimeter
Preventive (time-based)	Regular intervals	Grease gun, calibration kit
Predictive (condition-based)	Vibration, thermography	Vibration meter, thermal imager
Corrective	Improvement after fault	Diagnostic software
Shutdown maintenance	Planned plant halt	Heavy tools, cranes

6. Maintenance cost & relation with replacement economy.
Maintenance cost = Direct (labor, spares) + Indirect (lost production). As equipment ages, maintenance cost rises. **Replacement economy** finds the optimal time when total annual cost (maintenance + depreciation + operating) is minimum – usually when marginal maintenance cost exceeds average total cost.

7. Service life of equipment.
Service life = period equipment can operate economically and safely before replacement. Determined by wear, corrosion, obsolescence, maintenance history, and safety standards.

Unit-IV: Wear, Lubrication, Corrosion

1. Wear and its types.

Wear = progressive loss of material from contacting surfaces due to relative motion.

Type	Description
Abrasive	Hard particles cut/scratch surface
Adhesive	Surface welding & tearing
Fatigue	Surface cracks due to cyclic stress
Erosive	Fluid/solid impact
Corrosive	Chemical attack + motion

2. Causes & effects of wear.

Causes: Hard particles, poor lubrication, high load/speed, misalignment, corrosion.
Effects: Loss of precision, increased vibration, reduced efficiency, overheating, eventual failure.

3. Wear reduction methods.

- Proper lubrication
- Surface hardening (case hardening, coating)
- Filtering contaminants
- Material selection (hard/soft couples)
- Reducing sliding distance/load

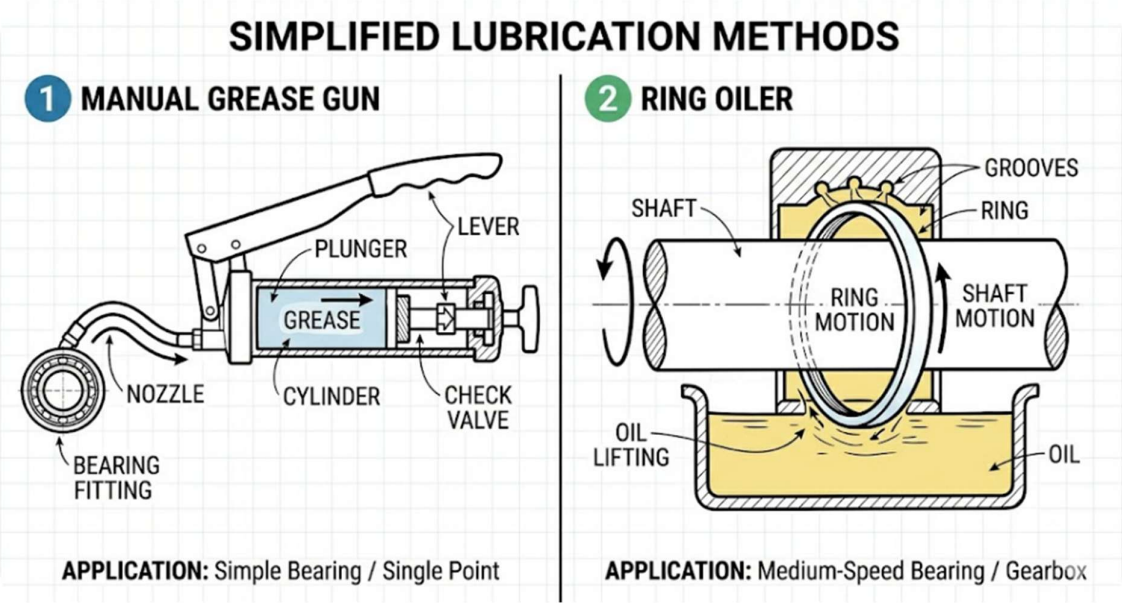
4. Lubricant types & applications.

Type	Form	Application
Oil	Liquid	Engines, gears, hydraulics

Type	Form	Application
Grease	Semi-solid	Bearings, joints, slow-moving parts
Solid (graphite, MoS_2)	Dry	High temp, vacuum
Synthetic	Chemical	Extreme temp, long life

5. Lubrication methods with sketches.

Diagram:



6. Corrosion – principle and factors.
Principle: Electrochemical reaction – metal + oxygen + moisture → metal oxide.
Factors: Humidity, temperature, pollutants (SO_2, NaCl), dissimilar metals, pH, surface finish.

7. Types of corrosion & prevention methods.

Type	Prevention
Uniform	Paint, coating, cathodic protection

Type	Prevention
Galvanic	Avoid dissimilar metals, insulation
Pitting	Use inhibitors, smooth surface
Crevice	Sealing, proper joint design
Stress corrosion	Stress relief, material selection

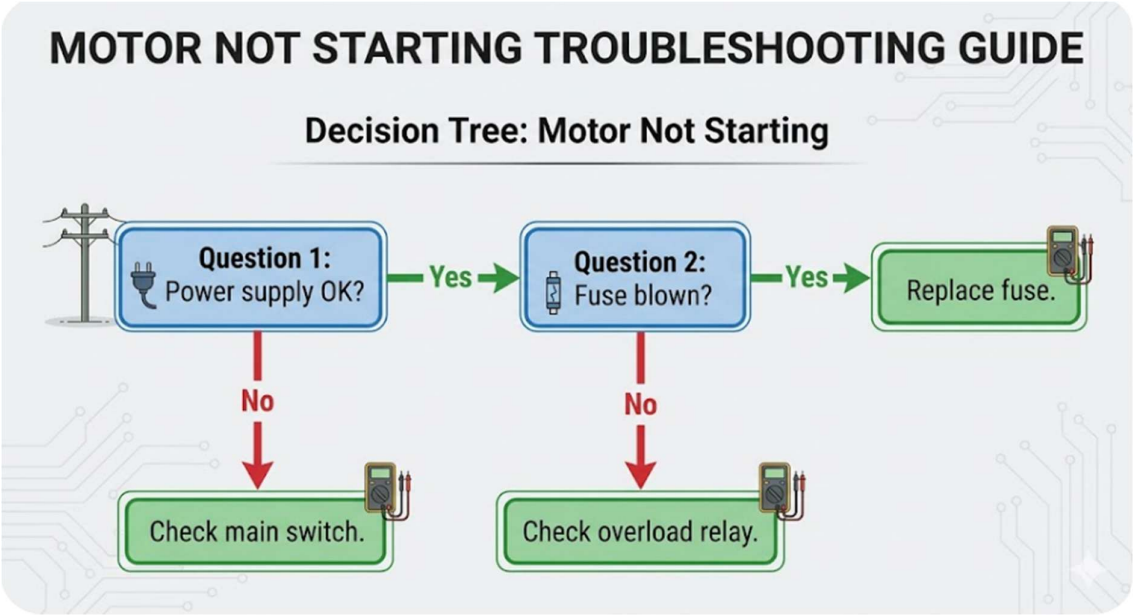
Prevention methods: Material selection, protective coatings, corrosion inhibitors, cathodic protection, environmental control, regular maintenance.

Unit-V: Fault Tracing

1. Concept & importance of fault tracing.
Fault tracing = systematic logical process to identify the root cause of a malfunction without guesswork. **Importance:** Reduces downtime, prevents repeat failures, lowers repair cost, ensures safety.

2. Decision tree in fault tracing – needs & applications.
A decision tree is a flowchart that guides the troubleshooter through yes/no questions to isolate the fault.

Diagram:



Needs: Standardization, training tool, quick diagnosis.
Applications: Electrical motors, PLC systems, hydraulic circuits.

3. Sequence of fault tracing activities.

1. Observe symptoms
2. Check operator inputs
3. Verify safety & power
4. Collect data (meters, logs)
5. Analyze possible causes
6. Test hypotheses (one at a time)
7. Isolate defective component

8. Repair/replace & verify
9. Document findings

4. Types of faults in machine tools & general causes.

Fault	General cause
Vibration	Misalignment, imbalance, loose parts
Overheating	Poor lubrication, overload
Inaccurate cut	Wear in leadscrew, dull tool
Sudden stop	Electrical trip, mechanical jamming
Noise	Bearing wear, gear damage

Unit-VI: Periodic and Preventive Maintenance

1. Definitions:

Term	Definition
Periodic inspection	Scheduled examination of equipment at fixed intervals
Degreasing	Removal of oil, grease using solvents or detergents
Cleaning & repairing	Removal of dirt and restoring function
Overhauling	Complete disassembly, inspection, replacement of worn parts
Preventive maintenance	Planned maintenance to prevent failure before it occurs

2. Steps in overhauling of mechanical components.

1. Isolation & lockout-tagout
2. Dismantle and clean
3. Inspect each part (measure wear)
4. Replace worn/broken components
5. Reassemble with proper torque
6. Lubricate & align
7. Test run & performance check
8. Update maintenance records

3. Overhauling of an electrical motor.

- External cleaning & terminal check
- Remove rotor, inspect bearings (replace if noisy)
- Check stator winding insulation (megger test)
- Clean and re-grease/grease bearings
- Replace brushes (if DC motor)
- Reassemble, align, test no-load current

4. Common troubles & remedies of electric motor.

Trouble	Remedy
Motor fails to start	Check supply, fuse, overload relay
Overheating	Reduce load, clean vents, check voltage
Vibration	Align coupling, balance rotor
Excessive current	Check winding, reduce load
Bearing noise	Replace bearing, relubricate

5. Need, steps, and advantages of preventive maintenance (PM).

Need: Avoid sudden breakdown, ensure safety, reduce repair cost.

Steps:

1. Inventory of equipment
2. Develop PM schedule (daily/weekly/monthly)
3. Assign tasks & checklists
4. Execute & document
5. Analyze failures & improve

Advantages:

- Reduced unplanned downtime
- Extended equipment life
- Lower total maintenance cost
- Safer operation
- Better spare parts planning

6. Periodic maintenance steps for:

(i) Machine tools – Lubricate ways; check belts, guards; align tools; clean coolant system.
(ii) Pumps – Check packing/seals; lubricate bearings; measure vibration & temperature;

clean strainer.
(iii) Air compressors – Drain moisture; check oil level; inspect belts; clean air filter; test safety valve.
(iv) DG sets – Check fuel/water levels; inspect battery; test alternator output; measure oil pressure; run at no-load periodically.

7. Program & schedule of preventive maintenance (mech & elec).
Use software or CMMS to schedule:

- **Daily:** Visual inspection, cleaning, log readings
- **Weekly:** Lubrication, minor adjustments
- **Monthly:** Filter change, belt tension check
- **Quarterly:** Electrical insulation test, alignment check
- **Yearly:** Overhaul, calibration, major bearing replacement

8. Repair cycle concept & its importance.

Repair cycle = Interval between two successive overhauls of a machine. It consists of:

- Inter-overhaul periods (daily/weekly PM)
- Minor repairs
- Scheduled inspections

Importance: Helps plan budgets, spare parts, shutdowns; increases predictability of equipment performance; reduces emergency maintenance.

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