CME 388 INDUSTRIAL SAFETY L T P C 3 0 0 3

COURSE OBJECTIVES

1. To study the fundamental concept and principles of industrial safety.
2. To study the principles of maintenance engineering.
3. To analyzing the wear and its reduction.
4. To study the faults in various tools, equipments and machines.
5. To study the periodic maintenance procedures in preventive maintenance.

UNIT – I INDUSTRIAL SAFETY 9

Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc., Safety color codes. Fire prevention and firefighting, equipment and methods.

UNIT- II MAINTENANCE ENGINEERING 9

Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

UNIT - III WEAR AND CORROSION AND THEIR PREVENTION 9

Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii.Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

UNIT – IV FAULT TRACING 9

Fault tracing-concept and importance, decision tree concept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic, automotive, thermal and electrical equipment's like, i. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes

UNIT – V PERIODIC AND PREVENTIVE MAINTENANCE 9

Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: i. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, Advantages of preventive maintenance. Repair cycle concept and importance

TOTAL: 45 PERIODS

TEXT BOOK:

1. L M Deshmukh, Industrial Safety Management, Tata McGraw-Hill Education, 2005.
2. Charles D. Reese, Occupational Health and Safety Management: A Practical Approach, CRC Press,

REFERENCES:

1. Edward Ghali, V. S. Sastri, M. Elboujdaini, Corrosion Prevention and Protection: Practical Solutions, John Wiley & Sons, 2007.
2. Garg, HP, Maintenance Engineering, S. Chand Publishing.
3. J Maiti, Pradip Kumar Ray, Industrial Safety Management: 21st Century Perspectives of Asia, Springer, 2017.
4. R. Keith Mobley, Maintenance Fundamentals, Elsevier, 2011.
5. W. E. Vesely, F. F. Goldberg, Fault Tree Handbook, Create space Independent Pub, 2014.

UNIT I

PART A

1. **Define safety.**
   - ✓ Safety is the state of being "safe", the condition of being protected from harm or other non-desirable outcomes.
2. **What is meant by risk?**
   - ✓ Risk associated with industrial processes can be defined as a measure of probability of harmful event such as death, injury, loss, etc. arising from exposure to chemical or physical agent may occur under the specific conditions of manufacture.

   Risk = Hazard x Exposure x Vulnerability.
3. **What is meant by hazard?**

   Hazard is a term associated with a substance that is likelihood to cause an injury in a given environment or situation.
4. **What is meant by Industrial Hazard?**

   Industrial hazard may be defined as any condition/substance produced by industries that may cause injury or death to personnel or loss of product or property.
5. **What is meant by Industrial safety?**
   - ✓ Industrial safety is primarily a management activity which is concerned with reducing, controlling and eliminating hazards from the industries or industrial units.
   - ✓ Industrial safety refers to the protection of workers from the danger of industrial accidents.
6. **Why safety is required in Industry?**
   - ✓ To avoid accidents or incidents
   - ✓ Better quality control
   - ✓ To achieve Zero defect
   - ✓ Protection of Environment
7. **What are the benefits of Industrial safety?**
   - ✓ Reduced workers' compensation claims
   - ✓ Reduced expenses related to injuries and illnesses
   - ✓ Reduced absenteeism
   - ✓ Lower employee complaints
8. **What are the various measures to ensure Industrial Safety?**

- ✓ Safety Policy

- ✓ Safety Committee
- ✓ Safety Engineering
- ✓ Safety Education & Training
- ✓ Role of Government

9. What is the difference between hazard, danger and risk?

- ✓ The hazard is something that can cause the possibility to harm. Eg. Electricity, chemicals, working up a ladder, noise, etc. The hazard gives you an alarm.
- ✓ The risk is the probability or chance of the hazardous event to occur. (Low or high)
- ✓ The danger is the possibility that you will get hurt or killed.

10. What is meant by risk assessment?

- ✓ Risk assessment is a method for confirming safety in order to ensure the safety of workers and other individuals and to reduce to the absolute minimum the possibility of harm.
- ✓ It indicates the following process.

  (1) Make clear the intended use and usage conditions of the machine and estimate incorrect usage such as operation mistakes.

  (2) Identify the hazards present in the machine.

  (3) Estimate the degree of risk and the frequency of situations in which risk is present.

  (4) Judge whether the degree of risk has been reduced to an acceptable level.

11. Define accident.

An accident is an unplanned and uncontrolled event which causes or is likely to cause an injury. It is something which is unexpected, unpredictable, or intended or not desired.

12. What is meant by industrial accident?

An industrial accident is any accident that happens to a person in the course of their work that results in an injury.

According to Factories Act, 1948, an industrial accident has been defined as "an occurrence in an industrial establishment causing bodily injury to a person which makes him unfit to resume his duties in the next 48 hours."

13. What are the causes for Industrial accidents?

- ✓ Unsafe conditions
  - a. The job itself
  - b. Work schedules
  - c. Psychological conditions
  - d. Machinery & Equipment
- ✓ Unsafe Acts
- ✓ Miscellaneous Causes

14. What are the objectives of industrial safety?

- ✓ To prevent accidents in the plant by reducing the hazard to minimum.
- ✓ To eliminate accident caused work stoppage and lost production.
- ✓ To achieve lower workmen's compensation, insurance rates and reduce all other direct and indirect costs of accidents.
- ✓ To prevent loss of life, permanent disability and the loss of income of worker by eliminating causes of accidents.

15. Identify and state the 4 E's of safety. [Nov/Dec 2022]

- ✓ **Engineering** : safety at the design, equipment installation stage.
- ✓ **Education** : Education of employees in safe practices.
- ✓ **Enlistment** : It concerns the attitude of the employees and management towards the programmed and its purpose. This necessary arise the interest of employees in accident prevention and safety consciousness.
- ✓ **Encouragement**: To enforce adherence to safe rules and practices

16. What are the personnel characteristics that are associated with causing Industrial accident?

- ✓ Untrained and unskilled persons are more prone to accidents than trained and skilled ones.
- ✓ Emotionally maladjusted persons are more prone to accidents than emotionally well-adjusted ones.
- ✓ Alcoholic and drug addict persons are more prone to accidents than those who are away from such vices.

17. How the accidents are measured in an industry?

Two main ratios used to measure accidents are

1. Accident Frequency Rate (AFC)
2. Accident Severity Rate (ASC)

AFC = No. of injuries * 10,00,000 / Total no. of man hours worked

ASR = no. of man day lost * 10,00,000 / Total no. of man hours worked

18. What is meant by fire?

Fire is the rapid oxidation of a material in the exothermic chemical process of combustion, releasing heat, light, and various reaction products.

19. What are the essentials of fire?

- ✓ Oxygen
- ✓ Fuel
- ✓ Heat (Source of Ignition)

20. Draw the fire triangle.

21. What are the safety facilities required in an industry?

- ✓ Treatment: industrial safety management provides treatment for injuries and illness at the work place.
- ✓ Medical Examination: it carries out medical examination of staff joining the organization or returning to work after sickness or accident.
- ✓ Hazards identification.
- ✓ Provision of protective devices.

22. What are the different sources of fuel?

Fuel sources include combustible materials, such as wood, paper, trash and clothing; flammable liquids, such as gasoline or solvents; and flammable gases, such as propane or natural gas.

23. Classify the different classes of fire.

Fire Classifications:

Fires are classified as A, B, C, D or K based on the type of substance that is the fuel for the fire, as follows:

- ✓ Class A — fires involving ordinary combustibles, such as paper, trash, some plastics, wood and cloth. A rule of thumb is if it leaves an ash behind, it is a Class A fire.
- ✓ Class B — fires involving flammable gases or liquids, such as propane, oil and gasoline
- ✓ Class C — fires involving energized electrical components
- ✓ Class D — fires involving metal. A rule of thumb is if the name of the metal ends with the letters “um,” it is a Class D fire.
- ✓ Examples of this are Aluminium, Magnesium, beryllium and sodium. Class D fires rarely occur in the roofing industry.
- ✓ Class K — fires involving vegetable or animal cooking oils or fats; common in commercial cooking operations using deep fat fryers.

24. What is meant by fire prevention?

Fire prevention is a function of many fire departments. The goal of fire prevention is to educate the public to take precautions to prevent potentially harmful fires, and be educated about surviving them. It is a proactive method of preventing emergencies and reducing the damage caused by them.

25. What is meant by fire safety?

Fire safety is the set of practices intended to reduce the destruction caused by fire. Fire safety measures include those that are intended to prevent ignition of an uncontrolled fire, and those that are used to limit the development and effects of a fire after it starts.

26. What are the conditions to not to fight with fire?

- ✓ If the fire is bigger than a waste paper bin
- ✓ One extinguisher is not enough
- ✓ Smoke is affecting your breathing
- ✓ You cannot see the way out
- ✓ Gas cylinders or chemicals are involved
- ✓ Your efforts are not reducing the size of the fire

27. List out the industrial fire fighting system.

- ✓ High velocity water spray
- ✓ Medium velocity water spray
- ✓ Foam
- ✓ Dry chemical powder
- ✓ Carbon dioxide
- ✓ Alarm Gong
- ✓ Portable Fire Extinguisher
- ✓ Fire alarm system

28. What are the different types of hazards?

- ✓ Chemical hazard
- ✓ Physical hazard
- ✓ Biological hazard
- ✓ Ergonomic hazards

29. What is the procedure for Hazard analysis?

- ✓ Examine the job and determine the components
- ✓ Identify tasks likely to present hazards
- ✓ Identify and assess hazards
- ✓ Determine and devise controls measures

30. How to identify and analyze hazard?

- ✓ Identify the hazards of each step.

  For each hazard, ask:

  - ➢ What can go wrong?
  - ➢ What are the consequences?
  - ➢ How could it arise?

31. How to control hazard?

The order of precedence and effectiveness of hazard control is the following:

- ✓ Engineering controls.
- ✓ Administrative controls.
- ✓ Personal protective equipment.

32. What are the various physical hazards?

- ✓ Physical hazards include mechanical, electrical, heat, sound, and radiation hazards that may occur in physics laboratory activities, as well as a variety of other science activities.
- ✓ This category includes the hazards from working in confined spaces, being hit by flying objects, caught in explosions, hurt by collapsing machinery, falling from heights and tripping on obstacles.
- ✓ Hazards in each of these categories have the potential to cause injuries (or, in some extreme cases, even death), but by taking general precautions, such as using appropriate protective equipment and emphasizing routine safety, physical hazards can be easily minimized.

33. What are chemical hazards?

- ✓ Chemicals can affect skin by contact.
- ✓ Chemicals can also enter our body either through the inhalation or digestive system if air is contaminated with chemicals, vapour, mist or dust.
- ✓ The accumulation of chemicals in or on our body will cause acute (immediate) effect or chronic (long-term) effect.

34. What are bio-hazards?

- ✓ Biohazards refer to biological substances that pose harm to the health of living organisms.
- ✓ Sources of biological hazards may include insects, bacteria, fungi, plants, worms, animals and viruses.
- ✓ These sources can cause a variety of health effects ranging from skin irritation and allergies to infections, cancer and so on.

35. What are ergonomic hazards?

- ✓ Ergonomic hazards refer to workplace conditions that pose the risk of injury to the musculoskeletal system of the worker.
- ✓ These injuries can be caused by performing repetitive and forceful movements and awkward postures that arise from improper work methods and improperly designed workstations, tools, and equipment.

36. What are mechanical hazards?

- ✓ Mechanical hazards are those associated with power-driven machines, whether automated or manually operated.
- ✓ In an industry, people interact with machines that are designed to drill, cut, shear, punch, etc.

37. Categorize the common mechanical hazards. [Nov/Dec 2022]

Mechanical Hazard Motions

1. Rotating 2. Reciprocating 3. Transverse

Mechanical Hazard Actions

1. Cutting 2. Shearing 3. Bending 4. Punching 5.Breaking

38. How to safeguard from mechanical hazards?

- ✓ The National Safety Council (NSC) defines safeguarding as follows:
  - ➢ Machine safeguarding is to minimize the risk of accidents of machine- operator contact.
  - ➢ The contact can be either
    - ❖ A direct Contact with Moving part.
    - ❖ Contact with chips, chemical and hot metal splashes,
    - ❖ Caused by the direct result of a machine malfunction.

39. What is a pressure vessel?

A pressure vessel is considered as any closed vessel that is capable of storing a pressurized fluid, either internal or external pressure, regardless of their shape and dimensions. They are usually made from carbon or stainless steel and assembled by welding.

40. Classify the types of pressure vessels.

- ✓ According to use
  - ➢ Storage pressure vessels, Process pressure vessels
- ✓ According to shape
  - ➢ Cylindrical pressure vessels, Spherical pressure vessels.

41. What are the operating requirements for a pressure vessel?

- ✓ **Operating pressure**. As well as the normal steady operating pressure, the maximum maintained pressure needs to be defined. Regulations and/or standards will define how this maximum pressure is translated into vessel design pressure.
- ✓ **Fluid conditions**. Maximum and minimum fluid temperatures will need to be specified and translated into metal design temperatures. Fluid physical and chemical properties will influence material choice and specific gravity will effect support design.
- ✓ **External loads**. Loads to be considered include wind, snow, and local loads such as piping reactions and dead weight of equipment supported from the vessel.
- ✓ **Transient conditions**. Some vessels may require an assessment of cyclic loads resulting from operational pressure, temperature, structural and acoustic vibration loading

42. Define electric hazard.

An electrical hazard can be defined as a serious workplace hazard that exposes workers to electrical injuries.

43. List out the various electrical injuries.

- ✓ Direct injury:
  - ➢ Electrocution or death due to electrical shock
  - ➢ Electrical shock
  - ➢ Burns
- ✓ Indirect injury
  - ➢ Falls
  - ➢ Fire

44. What are the common electrical hazards?

- ✓ Improper Grounding
- ✓ Exposed Electrical Parts
- ✓ Inadequate Wiring
- ✓ Damaged Insulation
- ✓ Overloaded Circuits
- ✓ Damaged Tools
- ✓ Equipment Wet Conditions

45. What is meant by burn?

A burn is the most common shock related injury. Burns from electricity are one of three types:

- ✓ Electrical
- ✓ Arc/Flash
- ✓ Thermal Contact

46. What is meant by a electric shock?

- ✓ Shock results when the body becomes part of the electrical circuit;
- ✓ Electric shock is a sudden stimulation of the body nervous system by an electric current which can cause pain, injury or death
- ✓ Electrical shock is defined as a reflex response to the passage of electric current through the body.

47. When an electric fire occurs?

Most electrical fires result from problems with faulty electrical outlets, old wiring, problems with cords (such as extension and appliance cords), plugs, receptacles, and switches.

48. How to reduce electrical hazards?

- ✓ Inspection and testing
- ✓ Use correct tools and equipment
- ✓ Reduced voltage
- ✓ Installation of emergency controls
- ✓ Residual current device (RCD)

49. Define incident rate. (Nov/Dec 2020)

Incident rates are **an indication of how many incidents have occurred, or how severe they were**. They are measurements only of past performance or lagging indicators. The most common rate used is the Recordable Incident Rate. This is commonly called either the "total case incident rate" or just the "incident rate".

50. What is safety color code?

Red: Fire protection equipment. Danger, high risk of injury or death. ...

Orange: Moderate risk of injury. Guarding devices.

Yellow: Caution statements. Minor risk of injury.

Green: Safety equipment or information.

Blue: No immediate hazard.

White – poison or toxic.

PART B & C

1. Explain the malfunctions in traditional safety management?

- ✓ Progress is not measured by injury ratios.
- ✓ Safety becomes a system, more than a program.
- ✓ Statistical techniques drive the efforts of continuous improvement.
- ✓ The investigation of accidents and injuries is renewed or is eliminated.
- ✓ Technical principles and tools for the statistical control of the process are used.
- ✓ Emphasis is placed on improving the system.
- ✓ Benefits are provided for people that discover illegal situations.

- ✓ The participation of workers in the resolution of problems and making decisions is formalized.
- ✓ Ergonomic well-being is projected inside the place of work.
- ✓ The traps within the system that cause human errors are eliminated.

2. What are the significances of Industrial safety?

Industrial causes a great loss to both the Employer & Employee, that's it is having importance to

- ✓ Cost of compensation
- ✓ Cost of medical-aid
- ✓ Cost of training a new worker
- ✓ Cost of the lost time
- ✓ Cost of investigation
- ✓ Cost of supervision & inspections
- ✓ Cost to the Govt. in terms of factory inspectors, & public health services Cost of spoilage of materials
- ✓ Cost of the damage of machinery
- ✓ Cost of cost of wages payable during injury
- ✓ Cost of loss of morale; &
- ✓ Cost of loss to the worker and his family

3. What are the objectives and aims of Industrial safety?

Objectives of Industrial Safety

- ✓ To prevent accidents in the plant by reducing the hazard to minimum.
- ✓ To eliminate accident caused work stoppage and lost production.
- ✓ To achieve lower workmen's compensation, insurance rates and reduce all other direct and indirect costs of accidents.
- ✓ To prevent loss of life, permanent disability and the loss of income of worker by eliminating causes of accidents.
- ✓ To evaluate employee's morale by promoting safe work place and good working condition
- ✓ To educate all members of the organization in continuous state of safety mindless and to make supervision competent and intensely safety minded.

Aim of Industrial safety

- ✓ Provide workers with a safe work environment.
- ✓ Conduct routine/regular workplace inspections.
- ✓ Provide Personal Protective Equipment.
- ✓ Develop and implement safe work procedures and rules.

- ✓ Provide on-going safety training
- ✓ Enforce safety rules and appropriate discipline.
- ✓ Provide on-going property conservation practices

4. What are the various measures to be adopted for fire prevention?

The measures need to be adopted are given below:

- ✓ Prohibit smoking in storage areas of flammable materials.
- ✓ If electrical equipment is not working properly or if it gives off an unusual odour disconnect the equipment and call an approved electrician.
- ✓ Properly replace any electrical cord that is cracked or has broken connection.
- ✓ When using extension cords, protect them from damage.
- ✓ Do not put them across doorways or any place where they will be stepped on or chafed. Check the amperage load specified by the manufacturer.
- ✓ Do not plug an extension cord into another, and do not plug more than one extension cord into one outlet.
- ✓ Keep all heat producing appliances away from the wall and away from anything that might burn. Leave plenty of space for air to circulate around equipment that normally gives off heat.
- ✓ Make sure all appliances in your area such as hot plates, ovens, toasters, mixers, grinders, geezers, clothing irons are turned off when not in use.
- ✓ Use ash trays and empty them only when you are sure the ashes, matches and butts are cold.
- ✓ Make sure that no one including visitors, has left cigarettes smolderings in waste – baskets or on furniture's, sofas, beds, etc.
- ✓ Keep storage areas, stairway landings and other out of way locations free of waste paper, empty cartons, dirty rags and other material that could fuel a fire.
- ✓ Report all fire hazards to the officer or any person authorized.
- ✓ Create awareness to use fire retardant furniture's, carpets, curtains, etc.
- ✓ Follow good housekeeping practices – because a clean house is a safe house.

5. Explain the various causes for Industrial accidents.

Industrial accidents may take place due to the carelessness of workers, defective machinery, dirty and slippery floors, defective lightening system, inadequate training to workers etc.

An accident is no doubt an unpleasant, unexpected and sudden incident, yet it does not just happen, it is caused and therefore it is essential to find out if possible specific cause/causes for each particular incident leading to an accident for its future preventions.

I. Technical causes

These causes include the following:

(i) Defective and old machines

(ii) Poor maintenance of machines, tools, and implements

(iii) Not using the safety guards while working on the machines

(iv) No fencing of dangerous machines

(v) Lack of good working conditions available to the workers at their work place

(vi) Unguarded and improperly adjusted machines

(vii) Hazardous arrangement of machines i.e., overcrowding machines

(viii) Defective and inadequate safety devices

(ix) Unsuitable tools

(x) Defective tools i.e. dull, damaged and without handle tools

(xi) Inflammable material

(xii) Hot and poisonous material.

Other Technical Causes:

(i) Job Itself – Some jobs are inherently more dangerous and complicated than others, such as the job of crane man in comparison to that of supervisor.

(ii) Work Schedules – The occurrence of accident is also affected by the work schedule. Accidents usually do not occur in the early hours of the work day, but occur late in the day.

(iii) Psychological Climate of Work Place – Psychological climate of the work place also affects the accident rate. According to psychologists, the root causes of accident are psychological, mental, and emotional imbalances.

II. Psychological Causes:

The second category includes the psychological causes which lead to the accidents in the industry. Some of these causes are listed below:

(i) Fatigue

(ii) Over work

(iii) Monotony

(iv) Mental disorder

(v) Emotional imbalance

(vi) High anxiety level

(vii) Fear, nervousness, and impulsiveness

(viii) Carelessness.

III. Personal Causes:

The third category of causes of accidents is personal causes which can be listed as follows:

(i) Improper recruitment and selection

(ii) Defective placement

(iii) Personal and social factors

(iv) Carelessness

(v) Ignorance

(vi) Family problems

(vii) Relationships with workers, subordinates, and supervisors

(viii) Age

(ix) Health

(x) Eye Sight

IV. Non Observance:

Following are the non-observance causes:

(i) Not using safety equipment

(ii) Not observing the measures prescribed under section 21 to 41 of the Factories Act.

V. Other Causes:

This category includes the following causes of accidents:

(i) Inability of the workers to grasp the implementation of a process

(ii) Undue haste

(iii) Inadequate lightening arrangements

(iv) Excessive noise

VI. Unsafe Acts:

Unsafe acts are the result of lack of knowledge/skill on the part of an employee and happen due to:

(i) Operating without authority

(ii) Failing to secure equipment or warning other employees of possible danger.

(iii) Failing to use safe attire or personal protective equipment.

(iv) Throwing materials on the floor carelessly

(v) Operating or working at unsafe speeds, either too fast or too low.

6. Explain the factors contributing to industrial fire.

The Common Causal Factors:

- ✓ Design flaws in ventilation system
- ✓ Lack of hazard assessment
- ✓ Lack of prevention

May cause explosion when:

- ✓ Dispersed in air or other oxidant
- ✓ Concentration is at or above minimum explosible
- ✓ Concentration
- ✓ Ignition source is present
- ✓ Dust is confined
- ✓ Explosions can cause major damage and even trigger secondary explosion.

7. Explain in detail about the steps and benefits of implementing fire safety plan.

A Fire Safety Plan is a detailed document designed to deal with all aspects of fire safety relating to a specific building or property. The document is intended to be a reference manual outlining the fire safety practices to be routinely used

Steps in Safety Plan

Step 1 - Conduct a Fire Safety Audit

Step 2 - Appointment and Organization of Supervisory Staff

Step 3 - Develop Emergency Procedures

Step 4 - Fire Drill Procedures and Training

Step 5 - Maintenance of Building Facilities and Fire Protection Equipment

Step 6 - Alternate Measures for Temporary Shutdown of Fire Protection Equipment or Systems

Step 7 - Control of Fire Hazards

Step 8 - Fire Department Access for Fire Fighting and Related Fire Suppression Information

Step 9 - Preparing Schematic Diagrams and Site Plans

Step 10 - Posting Emergency Procedures and Emergency Phone Number

Benefits of Implementing a Fire Safety Plan

- ✓ Reduces the incidence of fire
- ✓ Promotes fire hazard identification and elimination
- ✓ Promotes employee safety and awareness
- ✓ Increases employee morale by allaying safety concerns
- ✓ Coordinates business and fire department resources during a fire emergency
- ✓ Reduces the potential impact of a fire on the business and community (injuries, liability, etc.)
- ✓ Enhances Fire Code compliance

8. Explain in detail about various types of fire extinguishers.

- ✓ There are different types of fire extinguishers designed to put out the different classes of fire.
- ✓ Selecting the appropriate fire extinguisher is an important consideration for a roofing contractor. The wrong extinguisher actually may make a fire emergency worse.
- ✓ For example, failing to use a C-rated extinguisher on energized electrical components may endanger workers by causing the extinguishing material to be electrified by the energized components that are on fire. C-rated fire extinguishers put out the fire by using a chemical that does not conduct electricity.
- ✓ The following table illustrates the types of extinguishers, fire classes for which each is used and the limitations of each extinguisher.

Fire Extinguisher type	**Class of fire it Extinguishes**	**Extinguisher Limitations Comments**
Dry Chemical (multipurpose)	A, B, C	Generally good for use in roofing industry
Foam—alcohol-resistant foam (AFFF) types	B	Expensive; effective on Class B only; and aqueous film-forming limited shelf life; generally not needed in roofing industry
Water	A	Good only for Class A fires
Metal X	D,B,C	Expensive; must be kept dry; ineffective on A, B, C; typically not needed in roofing industry
Carbon dioxide	B,C	If used in confined areas, will create oxygen deficiency; not effective in windy conditions; can cause frostbite during discharge; typically not used in roofing industry
Halon	B,C	Expensive; not effective in windy conditions; toxic gases may be released in extremely hot fires because of decomposition; generally not used in roofing industry
Potassium Acetate	K	Expensive, wet chemical extinguisher for commercial cooking operations using oils and fats

Using Fire Extinguishers

When using fire extinguishers, employees should employ the "PASS" system of early-stage fire fighting.

P—Pull the pin on the extinguisher

A—Aim at the base of the fire S—

Squeeze the handle

S—-Sweep at the fire, moving from side to side

Employees should be instructed that if a fire cannot be extinguished using one full extinguisher, they should evacuate the site and let the fire department handle the situation.

9. Explain in detail about fire prevention.

- ✓ Fire prevention requires segregating the three elements of the fire triangle.
- ✓ In practice, a method to achieve that goal is to post—and enforce—no-smoking signs around flammable liquids and gases and have fire watches on all work involving torch-applied materials of a minimum of two hours after the last torch is turned off.

Flammable and Combustible Liquids

- ✓ A combustible liquid has a flash point, above normal working temperature, from 37.8 to 93.3° C (100 to 200° F). Flammable liquids give off vapour that can easily be ignited at normal working temperatures. A combustible liquid does not catch fire as easily as a flammable liquid.
- ✓ Keep Liquids Out of Sunlight - Heating a flammable or combustible liquid can cause it to vaporize. Liquids stored in airtight containers may build pressure and explode. Even if containers are ventilated, sunlight could cause vapour-rich air mixtures, leading to health hazards for workers.

Static electricity

- ✓ **Static electricity** may be generated when transferring liquids, gases or solids through pipes or hoses. It is important to dissipate this electric charge when handling flammable and combustible materials.
- ✓ When transferring flammable or combustible liquids from one container to another, the two containers must be "bonded" together. The bonding process involves attaching a wire with alligator clips on each end to both containers. The clips must penetrate the container coating and touch metal. You may need to score the paint with the alligator clips.
- ✓ To dissipate static, the container receiving the liquid must be in contact with the ground and not insulated from contact with the ground.
- ✓ For example, plastic or composite pickup truck bed liners prevent the flow of static electricity to ground because the liner does not conduct electricity. The receptacle

container must have a clear path to ground, by direct contact or use of a grounding strap or wire, to effectively eliminate static.

- ✓ Service or fuelling areas at job sites must have a 20BC-rated fire extinguisher within 75 feet of each pump.
- ✓ Safety cabinets allow for greater quantities of flammable and combustible liquids to be stored safely inside buildings. Up to 60 gallons of a flammable liquid or as much as 120 gallons of a combustible liquid may be stored indoors in a safety cabinet. Each cabinet must be labelled "Flammable—Keep Fire Away." Up to three cabinets may be stored in one room. Without a safety cabinet, only 25 gallons of either flammable or combustible liquids are allowed to be stored inside a building.

Liquefied Petroleum Gas

- ✓ Liquefied petroleum gas (LP gas) is used widely in the roofing industry to heat kettles and torches. Because LP gas is a compressed gas, fairly large quantities can be stored in relatively small containers. As a point of reference, LP gas expands at a ratio of 270-to-1. This means that one liquid drop of LP gas would expand to a gas state 270 times greater in volume.
- ✓ LP gas collects in low-lying areas because its vapour density is heavier than air. Employees should be warned that if they suspect a leak in a cylinder, they must not use fire to attempt to find the hole. Instead, they are to use soapy water and look for bubbles.
- ✓ Employees should not attempt to extinguish fires involving LP gas. If an LP gas fire breaks out, employees should evacuate the area immediately and call the fire department. Fighting an LP gas fire requires specialized training that only the fire department can provide. Employee attempts to extinguish the fire could create larger hazards.

Torch-applied Roofing Materials

- ✓ Torch-applied roofing materials pose a serious fire hazard to roofing contractors and building owners. Sometimes the hazards are obvious—such as torching to a combustible deck or near flammable liquids, while other concerns are less obvious—such as torching around drains or penetrations where flames can be drawn into a building.

Roofing contractors

Roofing contractors must instruct employees that they must:

- ✓ Never torch directly to combustible decks or materials
- ✓ Never torch to areas that cannot be seen fully
- ✓ Not use torches near vents or air intakes

- ✓ Never use a torch to heat a propane tank that begins to frost on the outside
- ✓ Have appropriate fire extinguishers within easy reach at all times

Fire Alarm Devices

- ✓ OSHA requires an alarm system be established by an employer to alert workers on the job site and local fire departments of fire emergencies. Job-site telephones and employee entrances must have alarm codes and reporting instructions at employee entrances.

Employee Training

- ✓ It requires that all employees be trained to use fire extinguishers. Training is required upon employment and at least annually thereafter.
- ✓ It is recommended the training session cover how to determine when a fire is too big to handle; what type of extinguisher to use; and the PASS system of early-stage firefighting.
- ✓ It is also recommended that live fire training be conducted periodically (this level of training is not needed each year).
- ✓ Live training exposes employees to the pressure released from a fire extinguisher when the handle is squeezed and provides hands-on practice extinguishing a fire. Some local fire departments and most fire extinguisher suppliers offer this type of training.

10. Explain in detail about fire protection and safe work practices.

What is fire triangle? Explain the different components. Also summarize OSHA fire standards for Fire Protection and Fire Prevention. [Nov/Dec 2022]

Fire Triangle:

The fire triangle or combustion triangle is a simple model for understanding the necessary ingredients for most fires. The triangle illustrates the three elements a fire needs to ignite: heat, fuel, and an oxidizing agent. A fire naturally occurs when the elements are present and combined in the right mixture.

The fire triangle consists of three components. They are

- Oxygen
- Heat
- Fuel

Four things must be present at the same time in order to produce fire:

- ✓ Enough oxygen to sustain combustion,
- ✓ Enough heat to raise the material to its ignition temperature,
- ✓ Some sort of fuel or combustible material, and
- ✓ The chemical, exothermic reaction that is fire.

Reporting and Extinguishing a Fire

- ✓ The fire department and area supervisor will be notified when a fire is spotted.
- ✓ All workers will be alerted and evacuated as needed.
- ✓ The PASS method will be used to extinguish the fire by those employees who have been properly trained.
- ✓ The area will be evacuated immediately if the fire is large.

Fire Protection

- ✓ Before each project begins, the project manager or designee will contact the local fire department and determine whether any variations from the company's standard fire-prevention procedures are required.
- ✓ No-smoking signs will be posted in all regulated areas.
- ✓ Only approved containers will be used to store flammable or combustible materials.
- ✓ All containers will be bonded together and grounded when transferring flammable or combustible liquids.
- ✓ All work areas will be kept free of debris and other combustible materials.
- ✓ Inside company-owned or leased buildings, fire extinguishers will be spaced no more than 100 feet apart and will have no less than a 2A rating for every 3,000 feet of protected building.
- ✓ All employees will be trained on the use of fire extinguishers initially upon hire and annually thereafter.
- ✓ No employee will be permitted to use an extinguisher without having been fully trained.
- ✓ Fire extinguishers will be stored at a distance no greater than 10 feet from torch users.

- ✓ A fire extinguisher, rated not less than 10B, will be provided within 50 feet of the location where more than 5 gallons of flammable or combustible liquids or 5 pounds of a flammable gas are used on a job site.
- ✓ Mops will be "spun out" and placed on a non-combustible surface at the end of each day on projects involving hot bitumen.
- ✓ A fire watch will be posted for two hours after work has concluded for torch-applied roof systems.

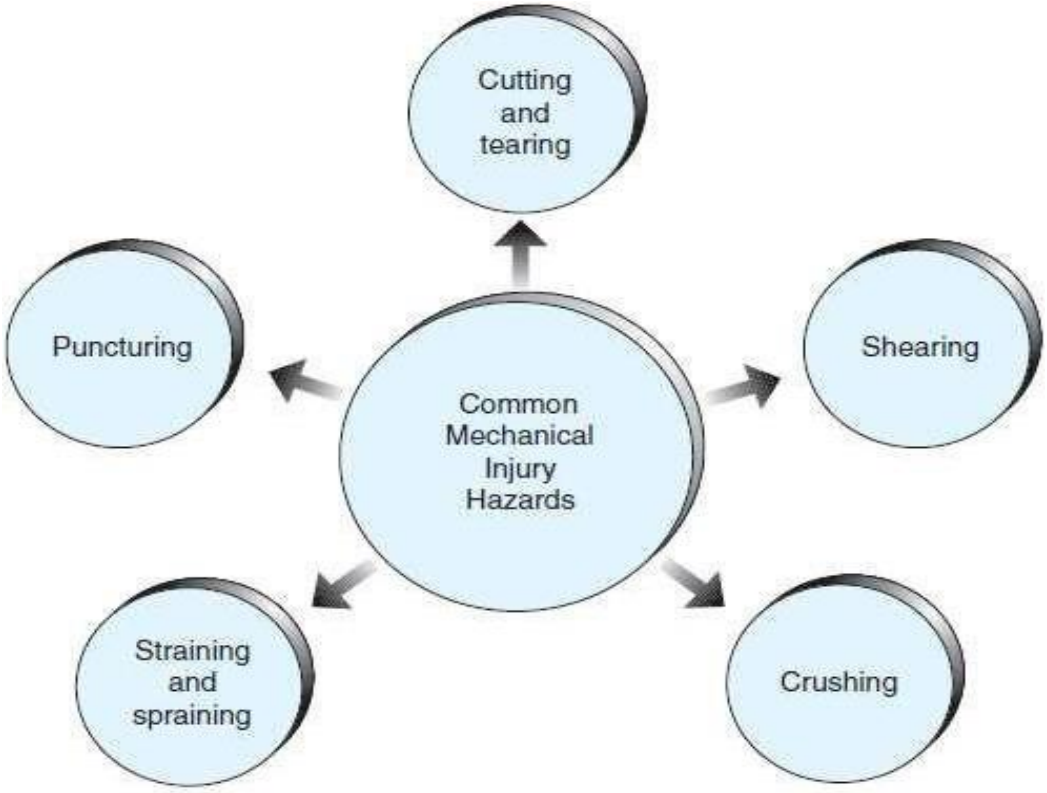
Fire Extinguishers

- ✓ In buildings, all fire extinguishers will be mounted on a wall and properly marked.
- ✓ All vehicles will carry at least one ABC-rated extinguisher.
- ✓ When at a job site, all employees will know the location of each fire extinguisher.
- ✓ Before using an extinguisher, all employees will be trained and familiar with the PASS method of firefighting.
- ✓ Each fire extinguisher will be inspected monthly to make sure it is in its designated location and has not been tampered with or actuated.
- ✓ Each fire extinguisher will be clearly visible with nothing obstructing or obscuring it from view.

11. Explain in detail about Mechanical hazards.

Mechanical hazards are those associated with power-driven machines whether automated or manually operated. In an industry, people interact with machines that are designed to drill, cut, shear, punch, etc. If appropriate safeguards are not in place or if workers fail to follow safety precautions, machines can cause major human injuries.

The more common sources of mechanical hazards are unguarded shafting, shaft ends, belt drives, gear trains, and projections on rotating parts, chain and sprocket drives, any exposed component parts of machine s or power-driven equipment which rotate rapidly or have considerable power and may catch the worker tangling him or her in the machine before he or she can get free.



Mechanical Injuries/Hazards

COMMON MECHANICAL INJURIES/HAZARDS

Cutting and Tearing

A cut occurs when a body part comes in contact with a sharp edge. The seriousness of cutting or tearing the skin depends on how much damage is done to the skin, veins, arteries, muscles, and even bones.

Shearing

- ✓ To understand what shearing is, think of a paper cutter. It shears the paper. Power-driven shears for severing paper, metal, plastic, elastomers, and composite materials are widely used in manufacturing. In times past, such machines often amputated fingers and hands.
- ✓ These tragedies typically occurred when operators reached under the shearing blade to make an adjustment or placed materials there and activated the blade before fully removing their hand.

Crushing

- ✓ Injuries from crushing can be particularly debilitating, painful, and difficult to heal. They occur when a part of the body is caught between two hard surfaces that progressively move together, thereby crushing anything between them. Crushing hazards can be divided

into two categories: squeeze-point types and run-in points.

- ✓ Squeeze-point hazards exist where two hard surfaces, at least one of which must be in motion, push close enough together to crush any object that may be between them. The process can be slow, as in a manually operated vise, or fast, as with a metal-stamping machine.
- ✓ Run-in point hazards exist where two objects, at least one of which is rotating, come progressively closer together. Any gap between them need not become completely closed. It need only be smaller than the object or body part lodged in it.
- ✓ Meshing gears and belt pulleys are examples of run-in point hazards Body parts can also be crushed in other ways—for example, a heavy object falling on a foot or a hammer hitting a finger.

Breaking

- ✓ Machines used to deform engineering materials in a variety of ways can also cause breaking of bones. A break in a bone is known as a fracture. Fractures are classified as simple, compound, complete, and incomplete.
- ✓ A simple fracture is a break in a bone that does not pierce the skin. A compound fracture is a break that has broken through the surrounding tissue and skin. A complete fracture divides the affected bone into two or more separate pieces. An incomplete fracture leaves the affected bone in one piece but cracked.
- ✓ Fractures are also classified as transverse, oblique, and comminuted. A transverse fracture is a break straight across the bone.
- ✓ An oblique fracture is diagonal. A comminuted fracture exists when the bone is broken into a number of small pieces at the point of fracture.

Straining and Spraining

- ✓ There are numerous situations in an industrial setting when straining of muscles or spraining of ligaments is possible.
- ✓ A strain results when muscles are overstretched or torn. A sprain is the result of torn ligaments in a joint. Strains and sprains can cause swelling and intense pain.

Puncturing

- ✓ Punching machines that have sharp tools can puncture a body part if safety precautions are not observed or if appropriate safeguards are not in place.
- ✓ Puncturing results when an object penetrates straight into the body and pulls straight out,

creating a wound in the shape of the penetrating object. The greatest hazard with puncture wounds is the potential for damage to internal organs.

12. Explain in detail about Electrical exposure.

Electricity, like fire, is a useful servant when it is under control. Obtaining the maximum utility and providing the necessary protection from this source of energy are the duties of electrical engineers, but certain elements of information are essential to safety specialists in order that they may understand the subject and assist in making certain that the basics of control are provided and maintained.

Electricity may create a hazard and be responsible for injury or damage when,

1. A person becomes a part of an electrical circuit. Electric shock may be the result.

2. Unprotected elements of an electric circuit are subjected to overload and become hot. Fire may result if the ignition temperature of the materials adjacent to the hot surfaces is reached.

3. Arcing or sparking occurs, generally due to the jumping of electricity from one conductor to another during the making and breaking of contact, as in the operating of switches or in the discharge of static electricity. Fire may occur if the arcing takes place in an atmosphere that contains an explosive mixture.

13. What is the safe procedure for the use of electrical equipment?

Use it in the intended manner as per manufacturer's instructions, in its intended environment and never overload it.

- ✓ It should be maintained only by competent personnel and in accordance with the manufacturer's instructions.
- ✓ Transport it in a secure manner (so that it is not subject to unnecessary shocks or vibrations).
- ✓ Keep the power cord away from heat, oil, sharp edges and moving parts.
- ✓ Assess all risks of the equipment as damage source to nearby electrical cables (including supply cables to the equipment) and water pipes.
- ✓ Never use in rain or in wet conditions (refer to the IP rating).
- ✓ Only use in explosive atmosphere if rated for such conditions (refer to the Ex Rating).
- ✓ When in use be aware of the following danger signs: Dim or flickering lights Arcs/sparks Sizzling / buzzing sounds Odours that smell of burning material, e. g. plastic, rubber Frequent tripping of circuit breakers/fuses
- ✓ Use rated protective device correctly and never by-pass the device.

- ✓ Store it in a careful manner when not in use.

14. What are the major causes of electrical fire?

Some of the major causes of electrical fires are:

(1) Use of fuses too large for the circuit they are protecting, or a circuit breaker with too high a setting.

(2) Adjustable-type circuit breakers with a blocked tripping element.

(3) Pennies inserted behind plug fuses.

(4) Nails or bolts substituted in place of cartridge fuses.

(5) Refillable fuses in which additional strips have been placed.

(6) Corrosion of fuses, circuit breakers, or conductors.

(7) Insulation of conductors deteriorated from age or mechanical injury and exposure to heat, moisture, or vapours.

(8) Joints not properly soldered and taped.

(9) Burned and pitted contacts.

(10) Overheating due to poor contactor overload

15. Explain in detail about various mechanical injuries.

- ✓ **Cutting and Tearing**

A cut occurs when a body part comes in contact with a sharp edge. The seriousness of cutting or tearing depends on how much damage is done to the skin, veins, arteries, muscles, and even bones.

- ✓ **Shearing**

Injury occurs due to mechanical force that acts on an area of skin in a direction parallel to the body's surface. It depends on the pressure exerted.

- ✓ **Crushing**

Injury occurs when body part is caught between two hard surfaces that progressively move together, thereby crushing anything between them. It is mostly painful, and difficult to heal.

Common Mechanical Injuries

- ✓ **Breaking**

Machines used to deform engineering materials in a variety of ways can also cause broken bones. A break in a bone is known as a fracture. Fractures are classified as simple, compound and complete fracture.

- ✓ **Puncturing**

Puncturing results when an object penetrates straight into the body and pulls straight out, creating a wound in the shape of the penetrating object.

- ✓ **Straining and spraining**

A strain results when muscles are overstretched or torn. Strains and sprains can cause swelling and intense pain.

16. Explain in detail about the safety precautions to be followed in pressure vessel. [Nov/Dec 2022]

For a better and safe operation of pressure vessels, they need to be handled with utmost care and certain precautions.

- ✓ **Timely Maintenance**:
  - ➢ For a pressure vessel to function properly, it requires regular maintenance. You should have a proper maintenance program of the entire pressure system, which checks the age of the vessel.
  - ➢ One thing should keep your eye on is the signs of problems. If a safety valve is discharging rapidly, then it is either a sign of a faulty safety valve or over-pressurizing system. Besides this, you should also check for any signs of wear or corrosion.
- ✓ **Proper Knowledge and Training**:
  - ➢ The person operating or handling pressure vessels should have a proper skill set, as well as knowledge about the equipment.
  - ➢ Necessary training must be given to those who are responsible for repairing, maintaining, installing, or checking the pressure of the equipment.
  - ➢ You cannot afford to let a person of little knowledge about the equipment handle it, for obvious reasons.
- ✓ **Understanding Operating Conditions**:
  - ➢ This is one of the most important factors to be considered. You should have a proper understanding about the gases or liquids contained in pressure vessels, along with its nature – toxic or flammable.

- Once you know the content of the pressure vessel, you need to know the operating conditions, which include temperatures and pressures.
- Having the correct information about system's operating limits it extremely important.

✓ **Installing Protective Devices**:

- When it comes to taking precautions of pressure vessels, you need to ensure that suitable protective devices are installed, and adjusted to the correct settings.
- These protective devices can be safety valves or any device which shuts down the operation, when the temperature or pressure exceeds the maximum value.
- The option for warning devices, which send out signals by lighting or sound, so that it grabs your attention.
- It is also necessary to keep these protective devices in good working condition, only then you can expect their proper functioning. One thing should always be followed – the protective devices should only be operated or altered by an authorized person.

17. Formulate the methods for the reduction of electrical hazards. (Nov/Dec 2020)

A number of methods may be used for guarding personnel against accidentally contacting live electrical elements. In general, exposed electrical equipment operating at 50 volts or more should be guarded by enclosures or location

1. At an elevation 8 feet or higher above the floor.
2. In a locked enclosure or room which can be entered only by qualified persons.
3. On a balcony, platform or gallery arranged and at a height so that persons who are not qualified will not trespass upon it.
4. If the equipment is operating at 600 volts or less; it may be guarded by a rail, posted with danger signs. Guards should be sufficiently strong and rigid to prevent their being displaced if a worker should bump against them.

Electrical Wiring, Switches, and Fuses

✓ Where it is practical, all inside wiring should be enclosed in conduit, or equal protection, and firmly anchored to sturdy structural elements. Protection from mechanical injury should be provided.

- ✓ The conduit should be grounded effectively, and all switches and disconnectors, as well as switches in circuits supplying hazardous operating equipment which must be shut down for maintenance, should be arranged so that they can be locked in the open position to safeguard against their being closed when work is in progress on a unit which they control.

- ✓ Switches, fuses, circuit breakers, and other control devices should be identified so that (with the exception of fuses) their open and closed positions are quickly recognized and so that the circuits they control are easily established.

- ✓ Switches should be carefully considered so that they will be in-stalled in locations where there is the least possibility of their being operated accidentally. When it is practical, the blades of knife switches should not in locations where there is the least possibility of their being operated accidentally.

- ✓ When it is practical the blades of knife switches should not be live when the switch is open.

Grounding

- ✓ Electricity follows the path of least resistance. Protection against stray electric currents due to shorts or other faults in electrical systems usually can be effectively provided by arranging for a previously determined safe path for the stray currents to follow to the ground.

- ✓ Regardless of the quality of insulation in electrical equipment, there always exists the possibility that this protection will break down and short the circuit. Ordinarily, fuses or circuit breakers may be depended upon to automatically disconnect the circuit if a short occurs.

Ground Fault Interrupters

- ✓ In order to optimize the protection against electric shock, a ground fault interrupter (GPI), or ground fault circuit interrupter, is used.
- ✓ The GFI is a supersensitive, rapid-action power switch that in a few milliseconds disconnects the circuit when it detects that current is leaking to ground.
- ✓ In its correct application, a person may receive an uncomfortable, but not fatal, shock since the circuit would be interrupted before a lethal dose was received.

Work Areas

- ✓ Working spaces around electrical power supply equipment should be adequate for the comfortable performance of normal operating and maintenance tasks. Secure footing should be certain when the equipment is ex-posed while in service.
- ✓ Illumination should be adequate at least 50 (foot candles) in work areas and an auxiliary

power system should be provided (i.e. storage batteries) to supply the lighting circuit in these work areas in the event of an emergency shutoff of the main power supply.

- ✓ First-aid fire-extinguishing equipment suitable for use on electrical fires, should be readily available in conspicuous locations.

Hazardous Locations

- ✓ Operations where flammable vapors, gases or dusts. or explosive substances are present, or locations where such materials are apt to occur in flammable concentrations, require that electrical equipment (i.e., switches, motors, wiring, and so on be safely installed so as to reduce the possibility of arcs, sparks, or overheating causing the ignition of the materials.

- ✓ The specifications of OSHA 1910 for electrical wiring should be considered the minimum requirements for such situations.

- ✓ Conductor wires, when exposed to corrosive or damp conditions, should be of a type that is resistant to the exposure. Particular reference to the employment of portable lamps in damp places is merited because of the extensive use of this equipment.

- ✓ They should be equipped with a socket of noncombustible, nonabsorbent insulating material; a handle and approved cord protected by a nonabsorbent insulator; and a basket-type guard to protect the bulb.

Storage Batteries

- ✓ Storage Batteries when being charged, evolve hydrogen (a flammable gas) as a product of the chemical change that takes place in the electrolyte.
- ✓ In some cases the gas may accumulate in the battery to such a degree that when the caps to the battery's cells are removed, the electrolyte (which is composed of a strong acid. i.e. sulfuric) will spray nut of the opening.
- ✓ Care is required therefore, in maintenance operations on storage batteries. Rooms or enclosures where storage batteries are charged should be ventilated to remove explosive gas concentrations.
- ✓ Unless it has been determined that there is sufficient ventilation to remove dangerous accumulations of gases, smoking, the use of open flames, or of tools which are not manufactured of non-sparking metal (nonferrous), and power tools should be avoided in the room.
- ✓ The electric system (i.e., wiring, switches, ventilation fan motor, and soon) should meet the specifications of the National Electrical Safety Code (C-2) for this type of hazardous

location. This code is among those obtainable from the American National Standards Institute.

24. Explain the Health provisions and safety provisions for workers in Factory Act 1948.

List all the provisions made to provide the safe working environment in the factories as per the Factories Act, 1948 and explain any four in detail [Nov/Dec 2022]

Health Provisions

Chapter III of Factories Act contain details regarding health of workers

- **Cleanliness (Section 11)**
  - The working conditions should be clean and safe.
  - Clean the floor at least once a week by washing, or by some effective method.
  - Effective means of drainage shall be provided.
  - Do white wash for every 14 weeks Paint and varnish for every 5 years
- **Disposal of wastes and effluents (Section 12)**
  - There should be proper arrangements or disposal of wastes and effluents.
  - Follow state govt. rules and regulations for the disposal of wastes
- **Ventilation and Temperature (Section 13)**
  - Proper level of ventilation temperature and humidity must be maintained.
  - Make provisions for reducing excess heat
- **Dust and Fume (Section 14)**
  - Effective measures should be taken to prevent inhalation or accumulation of dust & fume by the workers.
  - If any exhaust appliance is necessary for, it shall be applied as near as possible to the point of origin of the dust, fume or other impurity.
- **Artificial Humidification (Section 15)**
  - Factories in which the humidity of the air is artificially increased (like in textile units), keep it in limits.
  - The water used for artificial humidification to be clean.
- **Overcrowding (Section 16)**
  - 14.2 cubic metres space per worker should be adopted between workers to avoid overcrowding
  - While calculating this space, space above the worker beyond 4.2 meters will not be taken into account.

- **Lightning (Section 17)**
  - There must be sufficient & suitable lighting in every part of factory. There should natural lighting as far as possible.
  - All glazed windows and skylights used for the lighting of the workroom shall be kept clean.
  - Formation of shadows to such an extent as to cause eye-strain or the risk of accident to any worker shall be prevented.
- **Drinking water (Section 18)**
  - There should be drinking water (wholesome water). The Drinking points to be marked as drinking water.
  - They should be at least 6 meters away from wash room/urinal/ latrine/spittoons.
  - If more than 250 workers are working, then have cool water facility also.
- **Latrines and Urinals (Section 19)**
  - There should be separate facility for male and female.
  - Proper cleaning should be maintained.
- **Spittoons (Section 20)**
  - There should be sufficient number of spittoons.
  - No person shall spit within the premises of a factory except in the Spittoons provided for the purpose.

UNIT II

PART A

1. **Define maintenance.**

   Maintenance is the routine and recurring process of keeping a particular machine or asset in its normal operating condition so that it can deliver the expected performance or service without any loss or damage.

2. **What are the types of maintenance**?

   Preventive maintenance – includes regular and **periodic (time-based)** schedules.

   Corrective maintenance – occurs when an issue is noticed.

   Predetermined maintenance – follows a factory schedule.

   Condition-based maintenance – occurs when a situation or condition indicates maintenance is needed.

   Predictive maintenance – is data-driven and impacted by preset parameters.

   Reactive maintenance – occurs when a total breakdown or failure appears.

3. **What are the benefits of maintenance?**

   - Minimization of downtime
   - Improvement in availability of system
   - Extended life of equipment
   - Safety and smooth operation of the process
   - Provide adequate back up supply

4. **What is Reliability in maintenance?**

   Reliability is define as the probability that a components/ system. When operating under given condition, will perform its intended functions adequately for a specified period of time. It refers to the like hood that equipment will not fail during its operation.

5. **Define maintenance planning.**

   Maintenance Planning involves the assignment of jobs to the maintenance crew. Job assignment must be done on the basis of proper scheduling of the maintenance work.

6. **Objectives of maintenance planning.**

   - To keep the time schedule of delivery to the customers or section for further processing.
   - To meet the arability requirements for the critical requirements.

- To control the cost of maintenance related activities.

7. What are the functions of maintenance?

- Identify areas for implementation of preventive maintenance program.
- Making suitable arrangements for maintenance facilities for carrying out the maintenance Work properly.
- Ensuring proper and timely supply of spare parts.
- Managing proper inventory control of material spares and tools required for the maintenance.

8. What are the tools used for maintenance.

Safety gear – gloves, ear protection, dust mask.

Power tools – power drill, circular saws.

Hand tools – screw drivers, hammers.

Electrical tools – wires, multimeters, crimpers

9. Benefits Of Preventive Maintenance.

- Prevention of major repairs.
- Keeps businesses open by preventing most emergency repairs.
- Adds to the **product's lifecycle** by reducing wear.

10. What Is Maintenance Cost?

- Maintenance costs are the one-time or recurring costs a company incurs related to maintaining company facilities, property, vehicles or equipment.
- Some companies incur these costs for general or preventative maintenance that help keep their assets in proper working order.

11. What Is Equipment Lifecycle?

- "Equipment lifecycle" describes the overall lifecycle of a physical asset such as a piece of machinery or equipment.
- An asset can be as small as a power drill or as large as a jet plane. Regardless of size, every physical asset plays a critical role in supporting the overall productivity of an organization.

PART B & C

1. Write down the importance and benefits sound maintenance management system. (Apr-08, Nov-09)

Maintenance

Maintenance is the routine and recurring process of keeping a particular machine or asset in its normal operating condition so that it can deliver the expected performance or service without any loss or damage

Maintenance Importance

- The profit of any industry depends solely on the return on the investments. The capital cost and operating costs are the major factors involved in any industrial investment.
- The higher return on investment is possible to achieve only if the equipments and other machineries are in proper working condition to meet the designed as well as desired levels of performance.
- The life of the equipment and maintenance schedule information provided by manufacturer may not realized in practice to make the need for having a sound management.

The following are the benefits of the maintenance:

- Minimization of downtime
- Improvement in availability of system
- Extended life of equipment
- Safety and smooth operation of the process
- Provide adequate back up supply
- Minimization of normal expected wear and tear of the equipment
- Safety of the personal involved in the organization
- Increased reliability of the system
- Provide proper working environment
- Cost effective maintenance boosts the profit of the production system.

(b) Explain about the Reliability in maintenance in detail. (April/May '19)

Reliability:

Reliability is define as the probability that a components/ system. When operating under given condition, will perform its intended functions adequately for a specified period of time. It refers to the like hood that equipment will not fail during its operation. The four importance required in the determination of reliability are:

a. Reliability expressed as probability
b. Adequate performance requirements
c. Duration of adequate performance

d. Environmental or operating conditions

a. Reliability Expressed as probability:

It can express as probability. a reliability factor equal to one means that device performs satisfactorily for the prescribed duration under the given environmental condition. a reliability factor to zero means that all cases the equipment would fail to meet the required performance level.

b. Adequate Performance Requirements:

This defines the role expected device or system. a system may perform satisfactorily even though one or more components may not be functioning. in reliability analysis there is a need to define the magnitude of satisfactory or adequate performance system.

c. Duration of adequate Performance:

The duration of adequate performance is used to state the time up to which the desired performance of the system is achieved under the given operating conditions.

d. Environmental or Operating Conditions:

Environmental conditions indicate the prevailing conditions at which the system is under operation.

2. Explain briefly about the Principles of maintenance and maintenance planning objectives? (Or)

What are the objective and principles of planned maintenance activity? (April-10, 11, 12, 14, 15, Nov-09, 15, 18)

Maintenance planning

Maintenance Planning involves the assignment of jobs to the maintenance crew. Job assignment must be done on the basis of proper scheduling of the maintenance work.

Objectives of Maintenance Planning:

1. To achieve minimum breakdown and to keep the plant in good working condition at the lowest possible cost.
2. To ensure the availability of the machines and services in an optimum working conditions
3. To keep the machines and other facilities in a condition to be used to achieve the maximum profit without any interruption or hindrance.
4. To keep the time schedule of delivery to the customers or section for further processing.
5. To meet the arability requirements for the critical requirements.
6. To control the cost of maintenance related activities.

Principles of maintenance: It is followed in the system to guide the staff to work efficiently to achieve the overall objectives of the maintenance system.

Plant management in maintenance work:

The main role of the maintenance function is to provide safe and effective operation of the equipment to achieve the desired targets on time with economic usage of resources.

Production and maintenance Objectives:

The plant operation is driven by the production targets. The objective of the maintenance function is to support these targets. The Achievement of desired goals of the production system is to be supported by the both maintenance department to ensure the smooth and successful operation of the industry.

Establishment of work order and recording system:

The maintenance system should have proper work order and recording system. The work order for the maintenance function indicates the nature of work to be performed and the series of operations to be followed to execute a particular job.

Information based decision making:

The maintenance objectives are successfully achieved by the use of reliable information systems. This information is used to meet the manpower and spare parts requirements of the industry.

Adherence to planned maintenance strategy:

A sound maintenance management should here to the planned maintenance strategy. this also includes the use of the manufacturer's information on the life and maintenance schedules of the equipment and other material resources available.

Planning of maintenance Functions

All the maintenance functions are to be carefully executed by a way of proper planning to ensure the effective utilization of manpower and materials.

Man power for maintenance:

The manpower requirements of the maintenance system must be carefully evaluated based on the time and motion study. The requirements should also satisfies the need arising in cases of overhauls, components replacement, emergency and unscheduled repairs.

Work force control:

Determination of exact workforce required to meet the maintenance objectives of this system is difficult task due to the element of uncertainty. Hence the proper of workforce are needs to be ensured.

Role of spare parts

A good maintenance management system requires appropriate tools. so the system should have good quality tools and that too available in required quantities to ensure the proper function of the maintenance works.

Training of the maintenance Workforce:

Training of the workforce must be integral part of any good maintenance management system. Training helps the workforce to learn about the modern techniques, recent trends in the maintenance, knowledge of sophisticated instruments and to chalk out a strategy to meet the growing demands of the industry.

3. Explain the maintenance functions and Maintenance department?

Maintenance:

Maintenance is the routine and recurring process of keeping a particular machine or asset in its normal operating condition so that it can deliver the expected performance or service without any loss or damage. The functions and activities of the maintenance organization are as follows:

1. Identify areas for implementation of preventive maintenance program.
2. Making suitable arrangements for maintenance facilities for carrying out the maintenance work properly.
3. Ensuring proper and timely supply of spare parts.
4. Managing proper inventory control of material spares and tools required for the maintenance.
5. Standardization of maintenance work.
6. Implementing modification to the existing equipment wherever possible.
7. Analysis of future demands and forecast the role of maintenance activities.
8. Training of maintenance personnel.
9. Ensuring safety of personnel and equipment.
10. Identification of obsolete and surplus equipment for replacement and disposal.
11. Analysis of future demands and forecast the role of maintenance activities.

Maintenance Department:

The general organization structure of a maintenance department is:

External Maintenance services:

External maintenance services are availed in two forms: Contract maintenance services and manufactures after sale services.

Advantages:

- It is very economical.
- Technically better and specialist are responsible for maintenance activities.
- Skill preservation.
- Better service.
- Updating to modern and existing trends and needs.

4. What are the different Types of Maintenance?

1. There are six general types of maintenance strategies that companies use.
2. They are a range of proactive and reactive methodologies.
3. Depending on how you form your business structure, maintenance can become costly or affordable, create problems or solve them.
4. Part of why the right maintenance program is important is how you manage them, the impact on customers, and the total cost based on the investment return.

The different types of maintenance strategies include:

1. **Preventive maintenance** – includes regular and **periodic (time-based)** schedules.
2. **Corrective maintenance** – occurs when an issue is noticed.
3. **Predetermined maintenance** – follows a factory schedule.
4. **Condition-based maintenance** – occurs when a situation or condition indicates maintenance is needed.
5. **Predictive maintenance** – is data-driven and impacted by preset parameters.
6. **Reactive maintenance** – occurs when a total breakdown or failure appears.

Preventive Maintenance

- This type, **preventive maintenance, seeks out and repairs more minor issues and decreases the occurrence of major repairs**.
- Preventive maintenance may take on aspects of all other maintenance types.
  For example, maintenance inspections may change based on the age of the equipment.
- When it is new, the procedure may be more of a predetermined maintenance style, but as it ages, more frequent inspections, both physical and through data, may prevent more minor performance issues from becoming extensive and more costly repairs.

Example of Preventative Maintenance

- An excellent example of preventative maintenance is **the seasonal cleaning of an HVAC unit** (**Heating, Ventilation and Air Conditioning)**.
- In spring, you schedule maintenance to ensure that grit and sand are not inside the casing or leaves are not blocking the air intake in the fall.
- There is no specific issue, but we know that leaves can accumulate and cause problems later in the fall.
- Removing the grit or leaves now prevents a later difficulty, such as poor performance, increased energy usage, etc.

Benefits of Preventative Maintenance

- Prevention of major repairs.
- Keeps businesses open by preventing most emergency repairs.
- Adds to the **product's lifecycle** by reducing wear.
- Keeps energy costs at their lowest possible rates.

Corrective Maintenance

- Maintenance teams activate after the uncovering of a problem.

- The goal of corrective maintenance is **to bring systems back to regular operation as quickly as possible**.
- With corrective maintenance, there is no program for regular maintenance. A problem must be present before maintenance occurs.

  Examples of corrective maintenance include:

- Repairing a broken HVAC unit rather than maintaining it.
- Repairing an HVAC unit after data from the unit shows it is not functioning at peak performance.

Benefits of Corrective Maintenance

- Decreased monthly maintenance costs.
- Decrease in time for managing maintenance.
- Focuses on non-critical elements.
- A more straightforward maintenance process.

Predetermined Maintenance

Predetermined maintenance **follows a plan of action created by the manufacture of equipment,** rather than scheduled maintenance laid out by a maintenance team.

Examples of Predetermined Maintenance

- An excellent example of predetermined maintenance is **when machinery maintenance is scheduled at time intervals based on the manufacture's recommendations**.
- For example, oil changes will be every fourth month. Transmission service will occur at X number of hours of run time.
- After one year of use, Parts X, Y, and Z are checked for wear. Engine replacement occurs after X number of years.

Predetermined Maintenance Benefits

- Much easier to schedule and manage, including labor.
- The manufacturer outlines the maintenance plan.
- You can schedule technicians rather than hire maintenance personnel.

Condition-Based Maintenance

- As the name implies, condition-based maintenance **focuses on outcomes through measurement or observation.**
- Machines have a range of normal operating conditions.
- Within that range, the operation is acceptable. Near the edges of that range, maintenance may be required.

Examples of Condition-Based Maintenance

- An excellent example of condition-based maintenance is that **pesky check engine light in your car**.
- When it comes to the car's system has indicated that something is out of the normal range and maintenance is scheduled.
- The exact process may occur with machines that self-monitor through smart technology or physical inspections in a business.

Benefits of Condition-Based Maintenance

- Less downtime.
- Decreased energy consumption.
- Greater productivity — the equipment runs in the range of peak performance for longer.
- Fewer complete failures as equipment maintenance occur as the performance drops.

Predictive Maintenance

- One of the more advanced ways that maintenance occurs, **predictive maintenance**, is data-driven.
- **Data supplied by the equipment indicates when maintenance occurs**.
- Data also is a means to map **when the failure of the machine may occur.**

Examples of Predictive Maintenance

- Technology is all around us, and many businesses put it to work for them.
- The examples of predictive maintenance would include:
- Alarms that sound when the temperature on a machine or in an environment begin to move outside the safe parameters set up per the manufacturer's guidelines. The enteral temperature in a data center's server room becomes too hot, and sensors in that room alter maintenance.
- A sensor in an engine monitors misfires and alerts maintenance that engine service is needed.

- A sensor on a refrigeration truck monitors the enteral temperatures of the truck and alerts the driver when the internal temperature falls outside acceptable parameters.

These alerts do not necessarily mean a complete failure occurs, but that condition is approaching a range where catastrophic failure can occur.

Benefits of Predictive Maintenance

There is a **higher cost at set up for predictive infrastructure**, but overall, predictive maintenance can save money by:

- Improving product quality.
- Reducing catastrophic failures.
- Improved equipment performance.
- Higher customer satisfaction.

There can also be a reduction in maintenance labour since automation can also become part of the predictive process.

Reactive (Run-to-Failure) Maintenance

- Reactive maintenance is **a maintenance system that responds when a failure of machinery or systems occurs**.
- The repairs may be handled in-house or by the manufacturer, or through a combination of in-house maintenance and the manufacture's technicians.

Unlike preventive maintenance, reaction maintenance occurs when a breakdown happens.

Examples of Reactive Maintenance

- The car wash at the local gas station breaks, and the maintenance team is notified.
- The printing press that handles varnish applications fails, and maintenance or the factory service team is notified, and repairs are scheduled.

However, there are some cost savings associated with Reactive Maintenance. Those include:

- Less maintenance staff, fewer employees, fewer wages paid out regularly, etc.
- Fewer costs to implementation – No regular maintenance means no labor or part costs until failure occurs.
- Fewer management hours are needed for maintenance planning.

5. What are the types and applications of tools for maintenance?

Depending on your specific tasks, you may require a variety of different tools. These are some of the most common tools that maintenance professionals use:

1. Safety gear

- Safety gear is an important part of maintenance equipment.
- It ensures the protection of maintenance workers when using chemicals and power tools.
- These are some pieces of safety gear that are useful for maintenance employees:

Gloves- Gloves are useful for protecting employees who commonly use cleaning chemicals, sealants, lubricants and adhesives.
Google-Eye protection can help maintenance professionals avoid injury when working with chemicals or sanding.
Ear Protection- Many maintenance employees use loud power tools and ear protection can help them avoid hearing loss.
Dust mask and respirator- Dust masks and respirators can help maintenance professionals avoid inhaling chemical fumes, dust and other particles while working.

2. Storage equipment

- Maintenance professionals usually need a place to safely store the tools that they use in their daily work.
- They may also require travel equipment if they work in multiple locations.
- These are some pieces of equipment that maintenance professionals can use to store their tools and supplies:

Toolbox - Toolboxes are small portable cases that allow maintenance professionals to store and transport their gear.
Shelving units- Shelving units are a useful way to organize tools and supplies in a permanent shop setting.
Lockers - Many maintenance professionals use lockers to safely store and organize large equipment and chemicals.
Tool belts - Tool belts are a good way for maintenance professionals to transport their tools and to carry them while they work.

3. Power tools

- Power tools are often an essential part of maintenance work.

- They allow professionals to complete tasks effectively with minimal effort in less time.
- These are some important power tools for maintenance professionals:

Power drill - Power drills allow maintenance professionals to drill holes and drive screws using a variety of interchangeable bits.

Orbital sanders - Power sanders use rapid rotary motion and replaceable sanding pads to smooth surfaces, including wood, paint and varnish.

Circular saws - Circular saws allow maintenance professionals to easily cut a wide variety of materials, including wood, plastic, plywood and sometimes metal.

Impact wrenches - Impact wrenches are power tools that allow maintenance employees to tighten and remove nuts and bolts.

4. Hand tools

- While power tools are important, many maintenance professionals use a variety of hand tools in their daily work.
- These tools have the advantage of not requiring power sources and are often more portable.
- These are some of the most common hand tools for maintenance professionals:

Screwdrivers - Screwdrivers are common tools that allow maintenance employees to tighten and remove screws during repair, construction and assembly.

Hammers - Many maintenance professionals use hammers to drive and remove nails.

Crescent wrenches- Crescent wrenches are common hand tools that allow professionals to tighten and remove nuts and bolts with hexagonal heads.

Hand saws - Many maintenance professionals use hand saws and hacksaws to cut materials such as wood, metal and plastic.

5. Electrical tools

- While electricians normally complete most electrical maintenance and repair, some maintenance professionals complete minor electrical repairs.
- This can include installing lighting fixtures, outlets and switches and replacing light bulbs.
- These are some electrical tools that maintenance employees might use:

Wire and cable strippers - These tools allow electricians and maintenance professionals to remove the rubber coating from the outside of electrical wires.

Multimeters - Multimeters are tools that can test the functionality of electrical circuits by measuring voltage, resistance and current.

Crimpers - Crimpers are tools that allow maintenance professionals to join wires, connectors and other electrical components.

6. Cleaning supplies

- Cleaning is often an important part of maintenance work.
- Maintenance professionals use a wide variety of supplies to clean interior and exterior surfaces and their tools.
- These are some common cleaning supplies for maintenance professionals:

Vacuum cleaner - Maintenance employees often use vacuum cleaners to clean carpets and other surfaces.

Cleaning chemicals - Maintenance professionals often use a wide range of cleaning chemicals, including bleach, ammonia, degreaser and other surface cleaners.

Brooms and mops - Brooms and mops are some of the most important tools that maintenance professionals use to clean floors.

Window washing tools - Window washing is often an important part of maintenance and custodians often keep window scrubbers, squeegees and extension handles for this task.

7. Landscaping equipment

- Maintenance work often involves working indoors and outdoors.
- Professionals who provide maintenance services often require a variety of specialized tools for mowing lawns, trimming trees and other landscaping tasks.
- These are some common landscaping tools for maintenance professionals:

Lawn movers - Maintenance professionals use a variety of push and riding lawnmowers to cut grass on their properties.

Trimmers - Trimmers are tools that allow professionals to cut grass and trim plants in hard-to-reach areas.

Aerators - Aerators are tools that remove small plugs of soil from the ground to increase irrigation and fertilization.

Clippers - Maintenance employees often use different types of clippers to trim hedges, trees and other plants.

6. Write an Essay about Replacement and Maintenance analysis.

- Maintenance costs are the one-time or recurring costs a company incurs related to maintaining company facilities, property, vehicles or equipment.
- Some companies incur these costs for general or preventative maintenance that help keep their assets in proper working order.
- Understanding the upkeep costs associated with a piece of equipment or facility can help a company allocate funds for maintenance costs.

- They can also review these expenses to help them decide on purchasing a piece of equipment or a vehicle.
- Organizations providing goods/services use several facilities like equipment and machinery which are directly required in their operations.
- In addition to these facilities, there are several other items which are necessary to facilitate the functioning of organizations.
- All such facilities should be continuously monitored for their efficient functioning; otherwise, the quality of service will be poor.
- Besides the quality of service of the facilities, the cost of their operation and maintenance would increase with the passage of time.
- Hence, it is an absolute necessity to maintain the equipment in good operating conditions with economical cost.
- Thus, we need an integrated approach to minimize the cost of maintenance. In certain cases, the equipment will be obsolete over a period of time.
- If a firm wants to be in the same business competitively, it has to take decision on whether to replace the old equipment or to retain it by taking the cost of maintenance and operation into account.
- There are two basic reasons for considering the replacement of an equipment- physical impairment of the various parts or obsolescence of the equipment.
- Physical impairment refers only to changes in the physical condition of the machine itself.
- This would lead to a decline in the value of the service rendered, increased operating cost, increased maintenance cost or a combination of these.
- Obsolescence is due to improvement of the tools of production, mainly improvement in technology.
- So, it would be uneconomical to continue production.
- Sometimes, the capacity of existing facilities may be inadequate to meet the current demand. Under such situation, the following alternatives will be considered.
- Types of Replacement Problem Replacement study can be classified into two categories

  (a) Replacement of assets that deteriorate with time (Replacement due to gradual failure, or wear and tear of the components of the machines).

  This can be further classified into the following types:

  (i) Determination of economic life of an asset.

  (ii) Replacement of an existing asset with a new asset.

  (b) Simple probabilistic model for assets which fail completely (replacement due to sudden failure).

7. What is the Equipment Lifecycle?

- "Equipment lifecycle" describes the overall lifecycle of a physical asset such as a piece of machinery or equipment.
- An asset can be as small as a power drill or as large as a jet plane. Regardless of size, every physical asset plays a critical role in supporting the overall productivity of an organization.
- Therefore, enterprises that heavily rely on physical assets for their operations understand just how important it is to optimize these assets for success.
- Part of this optimization process involves maximizing the equipment lifecycle so companies can reap the benefits of their assets for as long as possible.
- The equipment lifecycle consists of four phases: planning, procurement/acquisition, operation/maintenance and disposal.
- Each equipment lifecycle phase is critical in supporting the longevity and performance of an asset.

- **Planning –**
    1. The first equipment lifecycle stage is planning for replacing or acquiring a new piece of equipment.
- Proper planning involves assessing the organization's needs and determining the most cost-effective strategy for procuring a new asset.

  Procurement/Acquisition –
    1. The second phase of the equipment lifecycle is procurement, which means acquiring or purchasing the asset.
    2. Before purchase, companies must budget for the asset and negotiate costs to ensure the purchase is as cost-effective as possible.
- Once the purchase is finalized, the asset is assembled and added to the company's inventory.

  Operation/Maintenance –
    1. This next stage is, ideally, the longest stage of the equipment lifecycle. "Operation" means using the asset for its intended purpose, and "maintenance" means carefully maintaining an asset to support its performance over time.
    2. Strategic asset maintenance often incorporates tools such as CMMS maintenance software and predictive maintenance tools to manage and optimize the maintenance process throughout the equipment lifecycle.
- Organizations can further maximize the operation/maintenance stage by using an asset management solution such as EAM software to optimize equipment performance throughout the equipment lifecycle.

Disposal –

1. The final stage of the equipment lifecycle involves properly disposing of the asset.
2. This stage cannot be overlooked, as many organizations are required to follow certain environmental and safety regulations when discarding equipment.
3. The equipment disposal phase entails safely dismantling and disposing of the asset while adhering to important regulations to protect employees and the surrounding environment from any hazards.

UNIT III

PART A

1. What is meant by wear?

- Wear is defined as the undesirable but inevitable removal of material from the rubbing surfaces.
- The term wear is used to describe the progressive deterioration of the surface with loss of shape often accompanied by loss of weight and the creation of debris.

2. What are the Classification of Wear?

The mechanisms of wear:

- Abrasive wear
- Adhesive wear
- Fatigue wear
- Corrosive wear
- Erosive wear

3. List the micro- level action followed in abrasive wear modes

- **Ploughing.** The material is shifted to the sides of the wear groove. The material is not removed from the surface.
- **Cutting.** A chip forms in front of the cutting asperity/grit. The material is removed (lost) from the surface in the volume equal to the volume of the wear track (groove).
- **Cracking (brittle fracture).** The material cracks in the subsurface regions surrounding the wear groove. The volume of the lost material is higher than the volume of the wear track.

4. What is meant by adhesive wear

- Adhesion wear is a result of micro-junctions caused by welding between the opposing asperities on the rubbing surfaces of the counter bodies.
- The load applied to the contacting asperities is so high that they deform and adhere to each other forming micro-joints.
- The motion of the rubbing counter bodies result in rupture of the micro-joints. The welded asperity ruptures in the non-deformed (non-cold worked) regions.

5. List the factors decreasing adhesive wear

Factors decreasing adhesive wear:

- Lower load.
- Harder rubbing materials.
- Contaminated rubbing surfaces.
- Presence of solid lubricants.
- Presence of a lubrication oil.
- Anti-wear additives in oil.

6. What is meant by corrosive wear

- Wear may be accelerated by corrosion (oxidation) of the rubbing surfaces. Increased temperature and removal of the protecting oxide films from the surface during the friction promote the oxidation process.
- Friction provides continuous removal of the oxide film followed by continuous formation of new oxide film.

7. What are the main Causes of Wear?

Wear is caused by simultaneous mechanical and thermal stress on the cutting edge. The major causes are as follows:

- Mechanical abrasion
- Corrosion
- Fatigue
- Adhesion

8. List the methods for reduction of wear

- Prevention of over loading
- Maintain a proper clearance
- Better lubrication
- Improving the surface finishing
- High surface hardness
- Proper surface treatment

9. List the factors influencing the wear

key factors influencing wear are

- Temperature

- sliding speed
- hardness
- modulus of elasticity
- load
- Composition of material.

9. What is meant by Lubrication and its roles

- Lubrication is the control of friction and wear by the introduction of a friction-reducing film between moving surfaces in contact.
- The lubricant used can be a fluid, solid, or plastic substance.
  The primary functions of a lubricant are to:
- Reduce friction
- Prevent wear

10. List the various types of conventional lubrication methods.

Most common methods used for lubrication in conventional methods are:

- Drip oil feed lubrication
- Splash oil feed lubrication
- Force oil feed lubrication
- Grease lubrication

11. List the various types of automated lubrication methods.

Some of Most commonly used Automated Lubrication systems are:

- Single Line Parallel
- Dual Line Parallel &
- Multi point direct Lubrication.

12. List the various classification of lubricants

Lubricants used for engines may be divided into three classes, namely :

- solid lubricants,
- semi-lubricants or greases, and
- Liquid lubricants or oils.

13. What are the advantages of automated lubrication over conventional lubrication?

- All critical components are lubricated.
- Lubrication occurring in operating condition of machinery.
- Safe operation of machinery due to proper lubrication.
- Energy consumption is less due to less friction.

- Overall productivity is increased due to reduction in down time.

14. List out the properties and testing methods of lubricants

- Viscosity
- Water content
- Specific gravity
- Wick feed test
- Flash point
- Specific heat
- Fire point
- Carbon residue

15. What are the purposes of grease lubrication?

- The purpose of grease in industrial applications is to lubricate moving parts while retaining its performance properties under extreme temperatures and pressures.
- Industrial applications where grease may be used include roller bearings, open gears, enclosed gears, centralised systems, wire ropes, slides and seals.

16. List out the components of pressure lubrication system.

- Crankcase (for oil storage)
- Oil Strainer
- Oil Pump
- Oil Troughs
- Crankshaft
- Oil Galleries
- Piston
- Cam Shaft
- Oil Pressure Gauge

17. What is meant by splash lubrication system?

- In splash lubrication systems, oil is applied to the cylinders and pistons by rotating dippers on the connecting-rod bearing caps.
- Each time they rotate, the dippers pass through an oil-filled trough.
- After running through the oil trough, the dippers splash oil onto the cylinders and pistons to lubricate them.

18. What are the major causes of the corrosion?

Corrosion are caused by

- surface imperfections

- grain orientation
- lack of homogeneity of the metal
- variation in environment
- localized stresses
- mill scale
- Existing red iron oxide rust.

19. What are the external factors that causes corrosion?

- Exposure of the metals to air containing gases like CO2, SO2, SO3 etc.
- Exposure of metals to moisture, especially salt water (which increases the rate of corrosion).
- Presence of impurities like salt (For example, NaCl).
- Temperature: An increase in temperature increases corrosion.

20. List the types of corrosion.

- Crevice corrosion
- Stress corrosion
- Intergranular corrosion
- Galvanic corrosion
- Pitting corrosion
- Uniform corrosion

. **22. What are the methods to prevent corrosion**?

- Electroplating
- Galvanization
- Anodization
- Passivation
- Biofilm Coatings.

PART B & C

1. What is wear? Explain in detail about wear.

- Wear is defined as the undesirable but inevitable removal of material from the rubbing surfaces.
- Though the removal of material from the surface is small, it leads to a reduction in operating efficiency.
- The more frequent replacement or repair of worn components and over hauling of the machinery may cost enormously in terms of labour machine down-time and energy in the manufacture of spares.
- The term wear is used to describe the progressive deterioration of the surface with loss of shape often accompanied by loss of weight and the creation of debris.

- Through, at the outset wear appears to be simple, the actual process of removal of material is very complex.
- This is because of a large number of factors which influence wear.

1. Adhesive.
2. Abrasive. Surface fatigue.
3. Corrosive.

- Through the knowledge of elementary forms of wear it is easy to understand the special forms of wear such as:

1. Oxidative.
2. Fretting.
3. Erosion.
4. Cavitation.

Factors

The major factors influencing wear are given below:

Variable connected with metallurgy.

- Toughness.
- Hardness.
- Constitution and structure.
- Chemical composition.

Variables connected with service.

- Contacting materials.
- Pressure.
- Speed.
- Temperature.

Other contributing factors.

- Lubrication.
- Corrosion.

2. What Are the Classification of Wear

The mechanisms of wear:

- Abrasive wear
- Adhesive wear

- Fatigue wear
- Corrosive wear
- Erosive wear

Abrasive Wear

Abrasive wear occurs when a harder material is rubbing against a softer material.

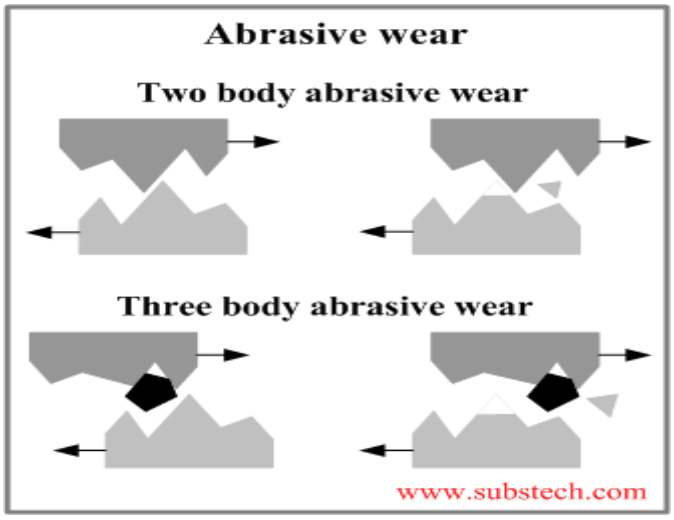
- If there are only two rubbing parts involved in the friction process the wear is called two body wear.

In this case the wear of the softer material is caused by the asperities on the harder surface.

- If the wear is caused by a hard particle (grit) trapped between the rubbing surfaces it is called three body wear. The particle may be either free or partially embedded into one of the mating materials.

In the micro-level abrasive action results in one of the following wear modes:

- Ploughing. The material is shifted to the sides of the wear groove. The material is not removed from the surface.
- Cutting. A chip forms in front of the cutting asperity/grit. The material is removed (lost) from the surface in the volume equal to the volume of the wear track (groove).
- Cracking (brittle fracture). The material cracks in the subsurface regions surrounding the wear groove. The volume of the lost material is higher than the volume of the wear track.



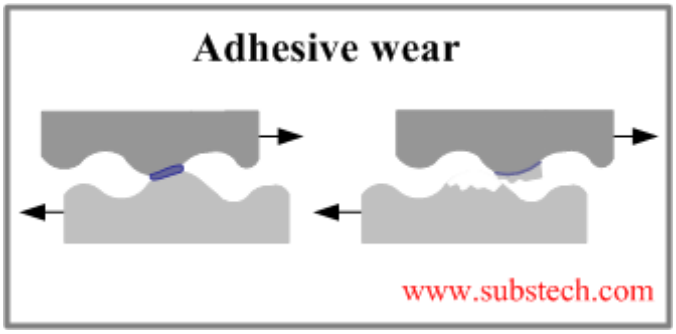
Adhesive Wear

- Adhesion wear is a result of micro-junctions caused by welding between the opposing asperities on the rubbing surfaces of the counter bodies.
- The load applied to the contacting asperities is so high that they deform and adhere to each other forming micro-joints.

- The motion of the rubbing counter bodies result in rupture of the micro-joints. The welded asperity ruptures in the non-deformed (non-cold worked) regions.
- When a considerable areas of the rubbing surfaces are joined during the friction a seizure of one of the bodies by the counter body may occur.

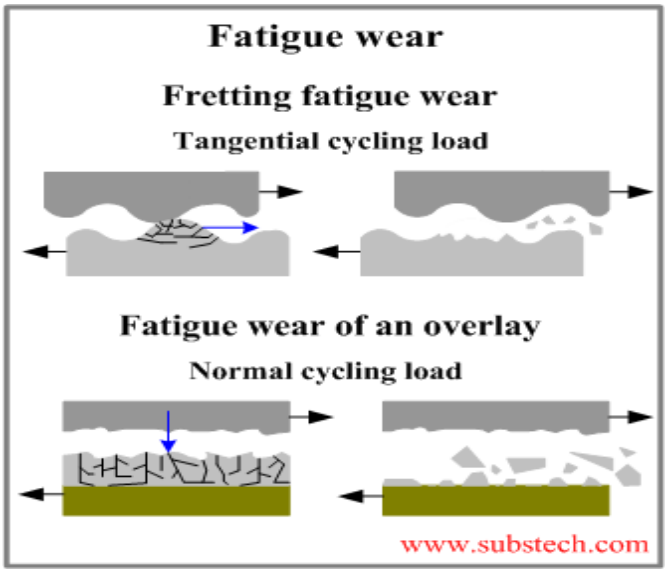
The factors decreasing adhesive wear:

- Lower load.
- Harder rubbing materials.
- Contaminated rubbing surfaces.
- Presence of solid lubricants.
- Presence of a lubrication oil.
- Anti-wear additives in oil.



Fatigue Wear

- Fatigue wear of a material is caused by a cycling loading during friction.
- Fatigue occurs if the applied load is higher than the fatigue strength of the material.
- Fatigue cracks start at the material surface and spread to the subsurface regions.
- The cracks may connect to each other resulting in separation and delamination of the material pieces.



Corrosive Wear

- Wear may be accelerated by corrosion (oxidation) of the rubbing surfaces. Increased temperature and removal of the protecting oxide films from the surface during the friction promote the oxidation process.
- Friction provides continuous removal of the oxide film followed by continuous formation of new oxide film.
- Hard oxide particles removed from the surface and trapped between the sliding surfaces additionally increase the wear rate by three body abrasive wear mechanism.

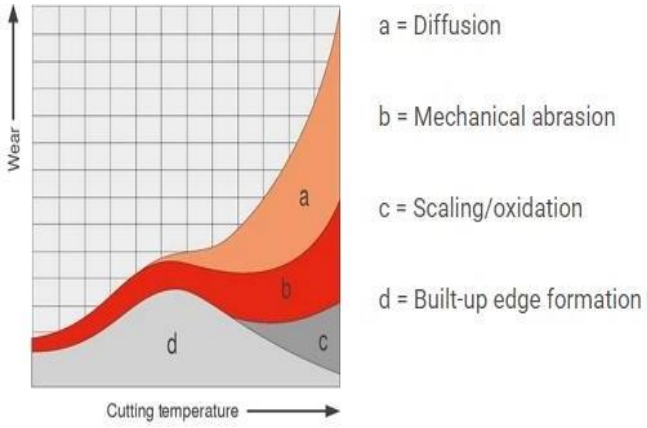
Erosive Wear

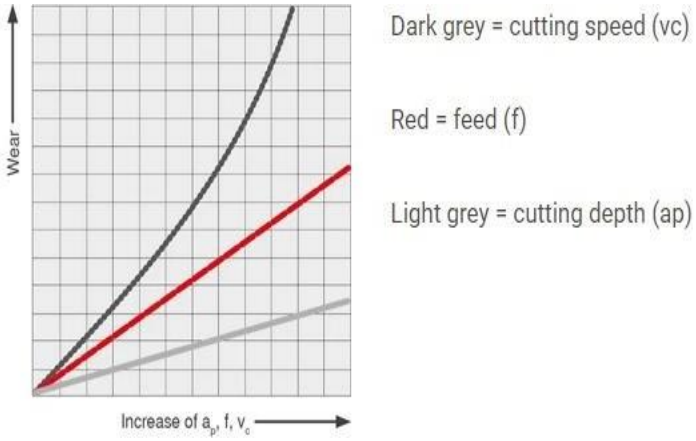
- Erosive wear is caused by impingement of particles (solid, liquid or gaseous), which remove fragments of materials from the surface due to momentum effect.
- Erosive wear of Engine bearings may be caused by cavitation in the lubrication oil.
- The cavitation voids (bubbles) may form when the oil exits from the convergent gap between the bearing and journal surfaces.
- The oil pressure rapidly drop providing conditions for voids formation (the pressure is lower than the oil vapour pressure).
- The bubbles (voids) then collapse producing a shock wave, which removes particles of the bearing material from the bearing.

3. What are the Causes of Wear?

Wear is caused by simultaneous mechanical and thermal stress on the cutting wedge. The major causes are as follows:

- Mechanical abrasion
- Corrosion
- Fatigue
- Adhesion





Abrasion –

- Abrasion is the process by which particles trapped between two sliding surfaces cut, score and gouge material from a softer machine surface.
- A good example of this would be how sandpaper cuts steel.

Corrosion –

- Corrosive wear is the result of a chemical reaction that is accelerated by temperature.
- It is typically caused by moisture or another corrosive liquid or gas.
- Rust, or oxidation, is the most well-known form of corrosive wear.

Fatigue –

- Fatigue wear is a consequence of subsurface cracking, which is caused by cumulative rolling contact loading of rollers and pitch lines of gear teeth.
- Fatigue causes chunks and platelets to break off, causing further wear as more contact occurs.

Adhesion –

- Adhesion takes place when the load between moving surfaces is transferred by metal-to-metal contact, causing friction.
- Lubrication is used to prevent this, but if lubrication is inadequate then friction rises to very high levels.
- In addition to these four root causes, there are a number of other mechanisms that, in particular applications, can contribute to component failures in industrial machinery.
- These include surface erosion, electrical discharge, cavitation, and material deposition.

- All forms of wear can pose a significant threat to the health of your machinery and the productivity of your operations.
- And unfortunately, identifying them can be extremely difficult – so the damage (to the machine itself and to your productivity) could be done before you're even aware of an issue.

4. What are the Wear Reduction Methods?

We all understand that wear can only be mitigated, not prevented. We can minimize wear, but we won't be able to eradicate it. Many strategies have been devised to minimize wear, as detailed below.

Prevention of Overloading

Overloading should be avoided since it causes lubricants to break down and puts an excess force on the worn surface.

Maintain a Proper Clearance

- When the clearance between the surfaces is too small, a lubricating oil layer cannot be applied to the worn surface, resulting in metal-on-metal contact.
- If there is more space between the surfaces, motion is lost.
- Due to the sheer absence of lubrication, the machine's parts wear down quickly, making it loud and vibrating.

Better Lubrication

- Lubrication produces a lubricant film in the space between the contacting surfaces, which improves its smoothness and avoids material contact.
- Improper lubrication leads to wear of surfaces.

Improving the Surface Finishing

- Various sorts of straight or circular lays are formed when parts are passed through the machining process that cannot be seen with the human eye.
- Because of the good surface, a line contact rather than a point contact is created, which is advantageous in processes.
- Good surface finish uniformly distributes load rather than maintaining asperity contacts leading to reduction of wear.

High Surface Hardness

- In compared to soft surfaces, hard surfaces wear down faster. Heat treatment is used to enhance the surface hardness of the shaft, bearing, and guide way, which reduces wear.

Proper Surface Treatment

- Mechanical wear can be minimized by applying a hard coating of metal, such as chromium or galvanic, on the surface.
- As a result, it may be argued that if a hard layer is applied to the surface of a wear-resistant metal, the part's wear can be minimized.

Factors Affecting Wear

- The key factors influencing wear are temperature, sliding speed, hardness, modulus of elasticity, load, and composition of material.
- The wear resistance is influenced by the contact temperature
- Since the hardness and yield strength diminish as the temperature rises abrasive wear would increase.
- The yield strength and hardness for most of the materials diminishes as the temperature rises.
- At elevated temperatures the dislocation movement in metals causes a drop in yield strength, making plastic deformation simpler.
- The wear rate is substantially influenced by the normal load.
- With an increase in the load applied, the shear force and frictional thrust rise as well, speeding up the wear rate
- In the range of 0 to 2.5 m/s sliding speed, the rate of abrasive wear increased marginally.
- Frictional heating may be to blame for the increase in wear. We cannot generalise that the increase in sliding speed would definitely increase wear as it also depends on the load being applied on the surfaces, presence of lubricant and the surface roughness of the contacting bodies.
- The elastic modulus is an indicator of the material's resistance to deformation under load, with a larger number indicating more stiffness.
- The materials' composition also has a significant impact on wear behaviour for example in composites, its mechanical behaviour can be affected based on the concentration of inorganic fillers.
- The presence of organic matrix which is responsible for low resistance to wear can be reduced by the introduction of this inorganic fillers.

Several other techniques for wear reduction include

- proper maintenance
- varying clearance adjustments over time
- good planning

- integration of preventive maintenance
- controlling the preventive maintenance tasks
- selection of appropriate material for the component
- reducing sliding pairs with the replacement of rolling pairs
- using a fully automated maintenance facility

5. What Is Lubrication? Explain In Detail About Lubrication.

- Lubrication is the control of friction and wear by the introduction of a friction-reducing film between moving surfaces in contact.
- The lubricant used can be a fluid, solid, or plastic substance.
- Although this is a valid definition, it fails to realize all that lubrication actually achieves.
- Many different substances can be used to lubricate a surface. Oil and grease are the most common.
- Grease is composed of oil and a thickening agent to obtain its consistency, while the oil is what actually lubricates.
- Oils can be synthetic, vegetable or mineral-based as well as a combination of these.
- The application determines which oil, commonly referred to as the base oil, and should be used. In extreme conditions, synthetic oils can be beneficial. Where the environment is of concern, vegetable base oils may be utilized.

The Role of a Lubricant

The primary functions of a lubricant are to:

- Reduce friction
- Prevent wear
- Protect the equipment from corrosion
- Control temperature (dissipate heat)
- Control contamination (carry contaminants to a filter or sump)
- Transmit power (hydraulics)
- Provide a fluid seal.

Types of Lubrication

- There are three different types of lubrication: boundary, mixed and full film.

- Each type is different, but they all rely on a lubricant and the additives within the oils to protect against wear.

Full-Film Lubrication

It can be broken down into two forms:

- hydrodynamic and
- Elasto hydrodynamic.
- Fluid film lubrication is the lubrication regime in which, through viscous forces, the load is fully supported by the lubricant within the space or gap between the parts in motion relative to one another object and solid-solid contact is avoided.
- In hydrostatic lubrication, external pressure is applied to the lubricant in the bearing to maintain the fluid lubricant film where it would otherwise be squeezed out.

Elasto Hydrodynamic Lubrication

- It is similar but occurs when the surfaces are in a rolling motion (relative to each other).
- The film layer in elasto hydrodynamic conditions is much thinner than that of hydrodynamic lubrication, and the pressure on the film is greater.
- It is called elasto hydrodynamic because the film elastically deforms the rolling surface to lubricate it.
- Even on the most polished and smooth surfaces, irregularities are present.
- They stick out of the surface forming peaks and valleys at a microscopic level.
- These peaks are called asperities. In order for full-film conditions to be met, the lubricating film must be thicker than the length of the asperities.
- This type of lubrication protects surfaces the most effectively and is the most desired.

Boundary Lubrication

- It is found where there are frequent starts and stops, and where shock-loading conditions are present. Some oils have extreme-pressure (EP) or anti-wear (AW) additives to help protect surfaces in the event that full films cannot be achieved due to speed, load or other factors.
- These additives cling to metal surfaces and form a sacrificial layer that protects the metal from wear.
- Boundary lubrication occurs when the two surfaces are contacting in such a way that only the EP or AW layer is all that is protecting them.

- This is not ideal, as it causes high friction, heat and other undesirable effects.

Mixed Lubrication

- It is a cross between boundary and hydrodynamic lubrication.
- While the bulk of the surfaces are separated by a lubricating layer, the asperities still make contact with each other.
- This is where the additives again come into play.
- With a better understanding of this process, it should be easier to define what lubrication actually is.
- It is a process of either separating surfaces or protecting them in a manner to reduce friction, heat, wear and energy consumption.
- This can be accomplished by using oils, greases, gases or other fluids. So the next time you change the oil in your car or grease a bearing, realize there is more going on than meets the eye

6. What Are The Methods Of Lubrication?

- Conventional lubrication methods
- Automated lubrication methods

Conventional Lubrication Methods

- Different methods are used to apply lubricants to machinery.
- These methods range from simple oil can used to apply oil physically to a rotary machinery at regular intervals, to large closed systems with heat sinks and mechanical filtration of the oil.
- Most common methods used for lubrication in conventional methods are:
- Drip oil feed lubrication
- Splash oil feed lubrication
- Force oil feed lubrication
- Grease lubrication

Drip Oil Feed Lubrication

- Systems operating on low speed, low load & low to moderate speed have bearings where small quantity of oil at regular intervals is expected.
- Drip oil feed systems consists of a loosely covered manifold of oil placed above the bearing that meters out oil at regular intervals.

Splash Oil Feed Lubrication

- Splash oil feed is a term applied to a variety of continuously lubricated bushings or pistons.

- Oil is splashed on the bearings or pistons from the action of various moving parts regularly dipped in lubricating oil.
- Splash oil feeding is practical when the housing can be positively oil tight and the rotation is not so fast enough to churn up the oil.

Grease Lubrication

- Greases are semi solid lubricants.
- They are used instead of oil when the lubricant has to stay in one place or stay adhered to the part. Greases do not leak out as easily as oils.
- Greases are also used when the component cannot be lubricated often and are not accessible during operation. Greases are thick & viscous.

Automated Lubrication Method

Generally known as Centralized Lubrication system, is a system that is automated and delivers specific amount of lubricant to multiple locations on a machine at the same time while the machine is operating.

Some of Most commonly used Automated Lubrication systems are:

1. Single Line Parallel
2. Dual Line Parallel &
3. Multi point direct Lubrication.

Single Line Parallel Automated Lubrication

- Operation begins as the controller sends signal to the pump.
- The pump begins pumping lubricant to build up pressure in the supply line.
- Once the required pressure is reached, injectors dispense a predetermined amount of lubricant to the points via feed lines. Once the entire system reaches the desired pressure, a pressure switch sends a signal to the controller and the pump shuts off.
- Pressure is vented and grease in the line is redirected back to pump reservoir, until normal pressure is restored.

Dual Line Parallel Automated Lubrication

- A Dual line parallel system is same as the single line parallel system that uses two main supply lines which are alternatively used as pressure and vent lines.
- Advantage of a dual line system is it can handle hundreds of lubrication points from single pump station over thousands of feet.
- Operation begins as the controller sends the signal.

- The pump begins pumping lubricant to build up pressure in the first pressure line, simultaneously venting the second line. Once the required pressure is reached, a fixed amount of lubricant is dispensed.

Multi - Point Direct Lubrication

- The Controller in the pump activates the drive motor, a set of cams turns and activates individual injectors or pump elements to dispense fixed amount of lubricants to each point.
- These systems are easy to design, direct pump to point without additional accessories.

Advantages of Automated Lubrication

- All critical components are lubricated.
- Lubrication occurring in operating condition of machinery.
- Safe operation of machinery due to proper lubrication.
- Energy consumption is less due to less friction.
- Overall productivity is increased due to reduction in down time. Lubrication is carried out in proper safety.

Classification of Lubricants

Lubricants used for engines may be divided into three classes, namely:

(i) solid lubricants,
(ii) semi-lubricants or greases, and
(iii) Liquid lubricants or oils.

Properties and Testing Of Lubricants

Properties of lubricating oils may be tested by chemical analysis, by physical tests and by trial in service. Following are the important tests to be carried out: —

(i) Viscosity,
(ii) Water content,
(iii) Specific gravity,
(iv) Wick feed test,
(v) Flash point,
(vi) Specific heat,
(vii) Fire point,
(viii) Carbon residue,
(ix) Pour point,
(x) Neutralization number,
(xi) Emulsification,
(xii) Saponification number,

(xiii) Precipitation number,

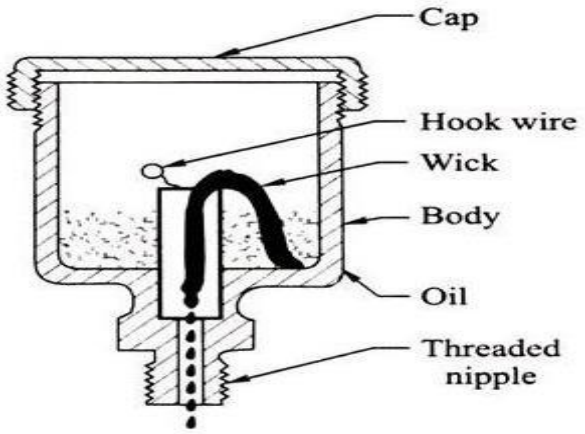
(xiv) Accelerated service tests.

(xv) Corrosion,

Lubrication System

Wick feed lubricator

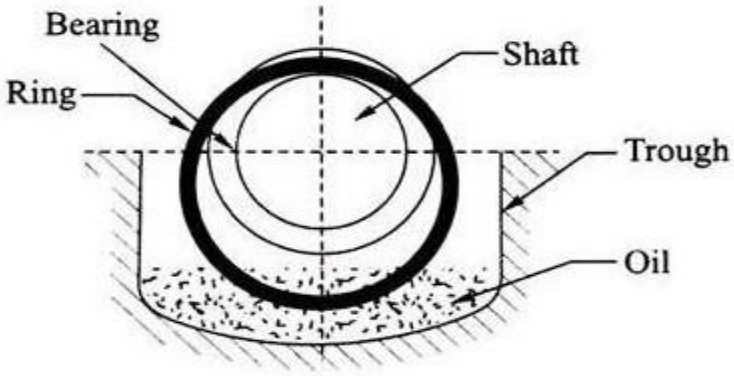
- Figure shows the assembled drawing of wick feed lubricator.
- The working of this lubricator is based on the siphon principle.
- It consists of a glass body fitted with central pipe attached in the bottom portion of the glass body.
- The lower portion of the body has the provision to fix the threaded nipple to the machine components and the machinery to be lubricated.
- The threaded nipple will have an oil hole through which the oil drops down.
- A cotton wick hangs about 40 mm below the oil level. The cotton wick gets soaked in the oil.
- The oil is dripped off by gravity and vibration caused by the motion of the machine components.
- The flow rate depends on the type and twist of the rope.
- A wire hook is provided to take out the wick when machine is in idle conditions.
- Wick feed lubricators are used for the lubrication of slides, guides, spindles, and plain bearings.



Ring Oil Lubricator

- Ring oil lubricator is shown in Fig.
- It consists of an oil trough to keep sufficient oil in it.
- The trough acts as storage of oil and is placed below the shaft to be lubricated.
- A metallic ring hangs over the shaft and the bottom portion of the ring hangs in oil.
- When the journal rotates, the ring also rotates and it carries oil from the oil bath and spreads the oil.
- The oil is placed on top of the bearing.
- The oil is further distributed to the bearing through the oil grooves.

- The excess oil spread drops down in the oil trough.
- The system is found suitable for slow-speed horizontal shaft.
- For high-speed engine shaft, the ring slips due to excess centrifugal force developed due to high rotation.
- In place of ring, steel chains can also be used. The sheet chains carry more lubricating oil.



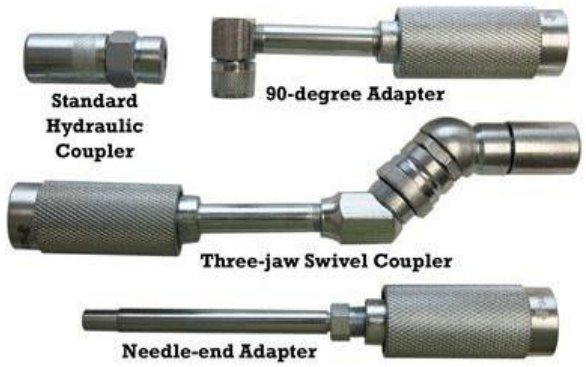
Pressure Grease Guns

- Grease guns are handy tools used for applying lubricants and greases to various mechanical or moving parts.
- They are widely used by mechanics, engineers, and hobbyists alike.
- Grease guns are designed to deliver lubrication under pressure, forcing it into areas of a rotary bearing which may otherwise be very tricky to reach without disassembly
- A grease gun is a common workshop and garage tool used for lubrication.
- The purpose of the grease gun is to apply lubricant through an aperture to a specific point, usually from a grease cartridge to a grease fitting .
- The channels behind the grease nipple lead to where the lubrication is needed.
- The aperture may be of a type that fits closely with a receiving aperture on any number of mechanical devices.
- The close fitting of the apertures ensures that lubricant is applied only where needed.
- There are four types of grease gun:

1. Hand-powered, where the grease is forced from the aperture by back-pressure built up by hand-cranking the trigger mechanism of the gun, which applies pressure to a spring mechanism behind the lubricant, thus forcing grease through the aperture.
2. Hand-powered, where there is no trigger mechanism, and the grease is forced through the aperture by the back-pressure built up by pushing on the butt of the grease gun, which slides a piston through the body of the tool, pumping grease out of the aperture.

3. Air-powered (pneumatic), where compressed air is directed to the gun by hoses, the air pressure serving to force the grease through the aperture. Russell Gray, inventor of the air-powered grease gun, founded Graco based on this invention.[citation needed]
4. Electric, where an electric motor drives a high pressure grease pump. These are often battery-powered for portability.

Connectors, Adapters and Couplers



Flexible Hose vs. Fixed Tube

- The decision to use a flexible hose or a fixed tube depends on the machine's grease-fitting type and ease of location, as well as the type of grease gun used.
- For example, a hard-to-reach location would benefit from a flexible tube.
- On the other hand, lever-style grease guns require both hands to pump the grease and would favour the fixed-tube alternative.

Accessories

- Grease gun meters can be retrofitted onto a grease gun to help optimize lubricant consumption. Plastic caps provide benefits such as preventing corrosion and debris.
- They also can be color-coded so that cross-contamination does not occur. Other accessories such as sonic/ultrasonic devices are also available.

Grease Fittings.

- Grease fittings have several names such as a Zerk fitting, grease nipple or Alemite fitting.
- This is the lubrication point where the grease connector is attached.
- The standard hydraulic grease fitting is most commonly used for standard applications. It can be either upright or angled.
- The button-head fitting is ideal for good coupler engagement when large volumes of grease are being added.
- A flush-type grease fitting is preferred when space is limited for standard protruding fittings, while the pressure-relief vent fitting helps prevent higher pressures that could lead to damaged seals.

Working of Pressure Grease Gun

Step 1 – Begin by pulling the plunger back. You will have to rest it in the tool body's catch.

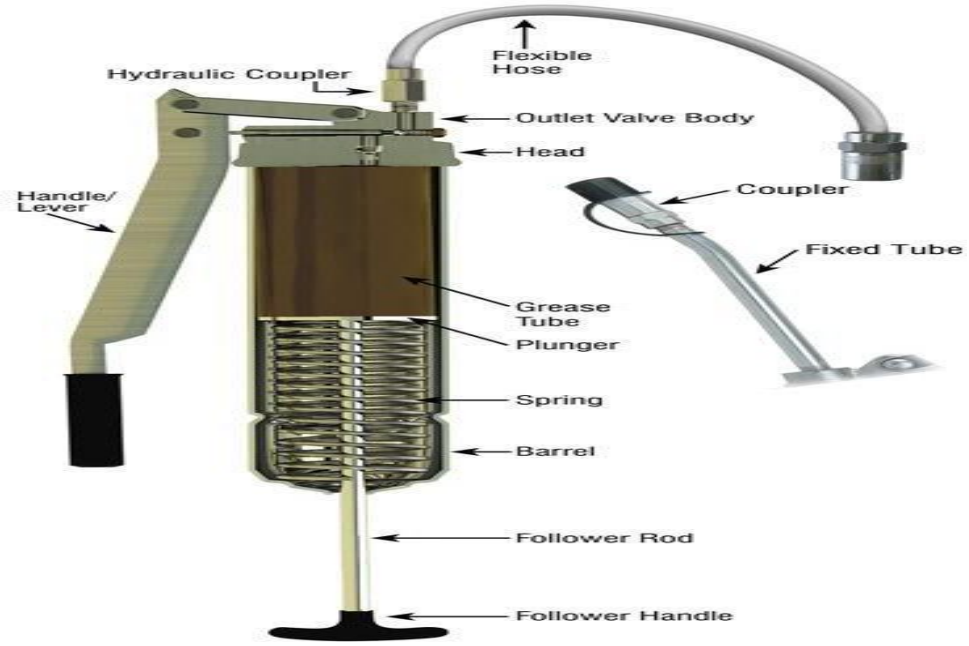
Step 2 – Now you need to unscrew the body from the head. In some cases, it can have an old grease tube which you will have to remove.

Step 3 – Remove the existing grease cartridge and open a latest lubricant cartridge. You will have to insert the new lubricant cartridge into the tube. Before doing, it is important to check the manufacturer guidelines.

Step 4 – In the next step, you will have to screw refilled tube tightly. Follow it by giving one full turn.

Step 5 – Re-tighten the cylinder to the grease gun's body by pushing the plunger back.

Step 6 – Check the nozzle by pumping a small quantity of lubricant. This is in case you happen to replace old grease with new grease.



High Grease Gun Pressure

- A high-pressure manual grease gun is designed to deliver from 2,000 to 15,000 psi.
- Applying too much pressure while greasing will damage the bearing seals, which rarely handle more than 500 psi. Symptoms of high grease gun pressure include collapsed bearing shields, damaged bearing seals, grease driven into electric motor windings, and safety and environmental issues.

Output is Measured

- It is common for maintenance departments to have a wide variety of grease gun types, makes and models.
- This can cause grease-related disorders due to cross-contamination and inaccurate knowledge of each grease gun's output per stroke.
- Grease guns are known to vary in the amount of grease that is output from 0.5 grams to more than 3 grams.
- This inconsistency depends on factors such as the type, model and age of the grease gun.

Screw down Grease Cup

- Single-point automatic grease lubricators are refinements of the old compression grease cup
- Grease cups are small containers filled with grease that are fitted to the bearing.

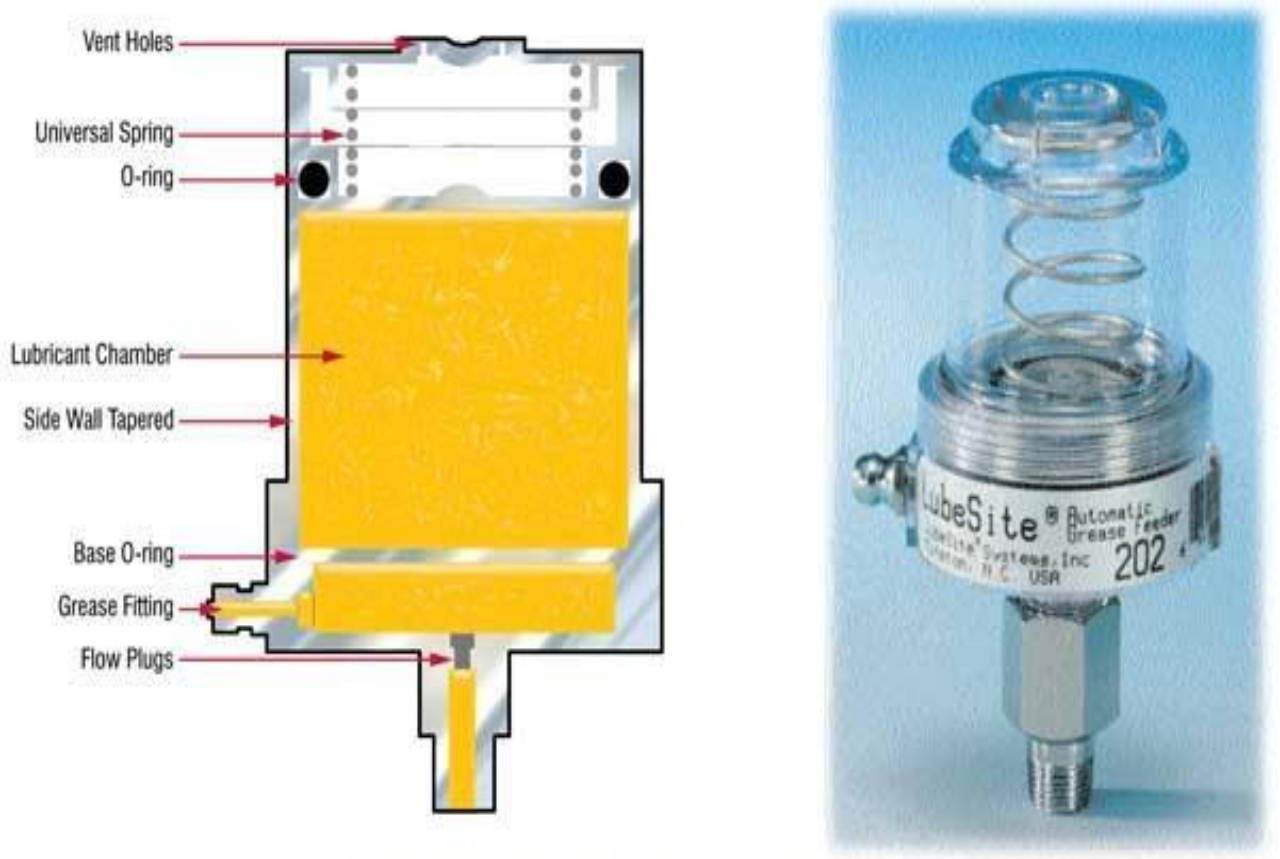


Figure 1. Original Single-Point Lubricator[2]

- The principle of operation is to force the grease into the bearing by turning down the cap or piston covering the grease charge.
- The next development in this line of products is the spring-loaded grease cup. The spring-loaded lubricator, a simple refinement of the compression cup, is accomplished by replacing the screw-down cap or piston with a spring-activated, leather-packed plunger.
- This plunger, when engaged by the spring pressure, slowly forces grease into the bearing.
- Neither of the two types of grease cups is recommended for use under conditions of wide temperature variation, where the consistency of the grease may be affected.
- Single-point lubricators differ from the traditional grease cup by employing either a spring or an expanding gas pressure to exert a force on the cap, piston or diaphragm in contact with the grease volume.
- These continuous forced grease injection devices are screwed into the threaded grease port.
- They range in size from 2 to 18 oz. (60 to 250 cc) of grease capacity and can develop pressures as high as 65 psi (4 bar).

Working

- The pressure generator is a rubber bladder containing an electrolytic solution and a sealed plastic tube containing a galvanic strip of specially treated metal.
- After the injector is installed, the activating screw is used to break the plastic tube.
- This exposes the galvanic strip to the electrolytic solution, resulting in an electrochemical reaction within the bladder which produces a gas.
- As the bladder pushes against the piston, the piston pushes the lubricant out of the injector and into the bearing.
- When all of the lubricant has been expelled into the bearing, the unit expires and is thrown away, and a similar unit is installed.
- The rate of lubricant ejection is a function of the gas production, which in turn depends on time and rate of reaction.
- Consequently, the rate of lubricant discharge can be predesigned into this device to accommodate the user's discharge rate specifications.
- An assembly comprised of a small metal cup with internal threads that could be screwed dow n over a threaded base plate that was screwed into the housing of the mechanism to be grease d (usually a bearing).
- The cup was packed with grease. When screwed down it forced the grease through a hole in t he base plate and into the mechanism to be greased.

The Purpose of Grease Lubrication

- A lubricating grease is a semi-fluid to solid lubricant containing a thickening agent and additives
- There are three core principles of grease lubrication: the grease works its way into the cavities around a bearing; the thickener holds the oil in the lubricating zone; and the grease shears, delivering a slow release of oil into the path of the rolling elements.
- The purpose of grease in industrial applications is to lubricate moving parts while retaining its performance properties under extreme temperatures and pressures.
- Industrial applications where grease may be used include roller bearings, open gears, enclosed gears, centralised systems, wire ropes, slides and seals.
- In most applications, the original manufacturer will recommend a grease or an oil for its machinery.
- If a bearing needs both cooling and cleaning, an oil may be recommended.
- However, if the location is difficult to access and cooling is not needed, a grease can be used.

Pressure Lubrication Systems

- Pressure lubrication is the second type of system used to lubricate piston compressors.
- It is a more technically advanced and usually more costly method, but it results in longer life for a compressor.
- Pressure lubrication is a process where an oil pump precisely distributes oil to key areas of the pump.
- Typically, the oil is pumped through an oil filter and into the pump where it is then recycled and reused; using a replaceable oil filter can further improve the life of the oil. The oil is transported to the key area by use of an oil pump.
- Therefore, the viscosity of the oil is not as critical as with a splash tube system.
- Either method has been used extensively in many various pump and engine applications, and both are suitable for piston compressor applications.
- When purchasing a new piston compressor, decide what's important for you.
- If upfront cost is important, a splash lubricated compressor may be the way to go.
- But if you are willing to invest more in a pressure lubricated piston compressor, you'll be rewarded with added longevity and reliability
- The Pressure Lubrication system is universally used in modern car engines.
- The Pressure Lubrication system has come into picture because the Splash Lubrication system is not suitable for automobile engines due to the absence of positive lubrication.

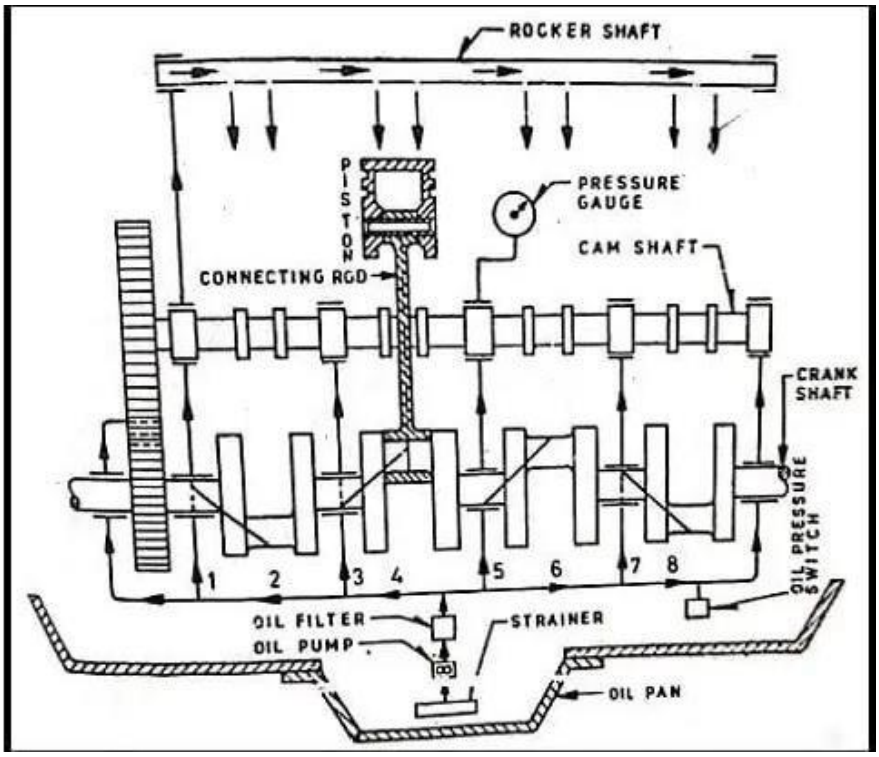
Components of Pressure Lubrication System:

1. Crankcase (for oil storage)
2. Oil Strainer
3. Oil Pump
4. Oil Troughs
5. Crankshaft
6. Oil Galleries
7. Piston
8. Cam Shaft
9. Oil Pressure Gauge.

Working of Pressure Lubrication System

- In this system, Oil is taken from the wet sump through the strainer by the pump and delivers it at a pressure of 200 to 400 Kpa to the main oil gallery.

- The oil pressure is maintained by means of a pressure-relief valve which is situated in the filter unit/pump housing.
- An oil pressure regulator ensures that the oil pressure level is maintained properly.



- For inline engines, one main gallery is used whereas for V-Engines one/two main galleries are used.
- The oil filter removes all the dust particles present in the oil and supplies clean oil to all the oil lines.
- The pressurised oil flows through the oil lines and galleries so as to lubricate the moving engine parts.
- Oil from the main gallery flows through the holes drilled inside the crankshaft and main bearing to lubricate them.
- The oil sprout connected with the gallery, forces the oil upwards to lubricate the piston and all the parts of it from inside.
- Oil flows through the oil rings to lubricate and form a thin film around the cylinder walls.
- After all the parts are lubricated in first gallery, the oil will be pumped to the second gallery which can lubricate all the parts connected with camshaft.
- The sprouts connected to the gallery helps in lubricating camshaft, valves and valve springs.
- After lubricating the engine parts, oil begins to flow downwards through a separate passage to the sump

- A pressure gauge calculates the oil pressure in the system and displays it on the dial.

Advantages of Pressure Lubrication System

- Due to the presence of oil galleries, the oil will be passed through them to reach all the components of engine cylinder and thereby there will be no wear and tear takes place among the mating parts.

Disadvantages of Pressure Lubrication System

- In this system also, if oil was not poured properly into the engine for every servicing then despite of the pressure system also, the parts will wear.

Splash Lubrication Systems

- In splash lubrication systems, oil is applied to the cylinders and pistons by rotating dippers on the connecting-rod bearing caps.
- Each time they rotate, the dippers pass through an oil-filled trough.
- After running through the oil trough, the dippers splash oil onto the cylinders and pistons to lubricate them.

The Components of Splash Lubrication System Are Follows:

1. Crankcase
2. Oil Strainer
3. Oil Pump
4. Oil Troughs
5. Crankshaft
6. Scoop
7. Piston
8. Cam Shaft
9. Oil Pressure Gauge

Explanation for the Parts of Splash Lubrication System:

Crankcase

It is used to store the oil which is passed through the oil galleries for the proper lubrication.

Oil Strainer

It is used to filter the impurities present in the oil such there should not be any blockage at any part.

Oil Pump

It is the major part of the lubrication system because it is used to transport the fluid from the crankcase to all the parts of the engine.

Oil Troughs

These are provided just below the scoop of piston such that when the piston is in its reciprocating motion, the scoop of piston lifts the oil from the oil troughs such that the oil reach to all the parts of the piston for the lubrication.

Crankshaft

The reciprocation motion of piston is converted into the rotary motion of crankshaft in the engine cylinder. The power obtained from the crankshaft will be transmitted to all the parts of the vehicle.

Scoop

It is connected at the end of the piston and the scoop of piston lifts the oil from the oil troughs such that the oil reach to all the parts of the piston for proper lubrication.

Piston

It plays an important role in IC engines. It is present in the engine cylinder and it converts the reciprocation motion into rotary motion of the crankshaft.

Camshaft

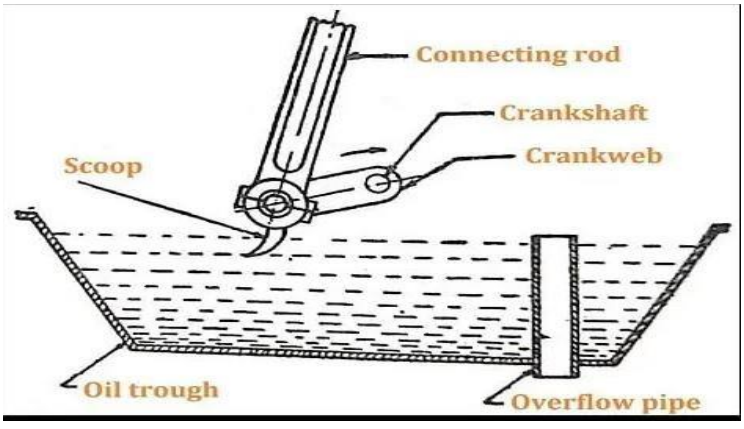
This camshaft consists of cams which are used for operating the valves in the internal combustion engines.

Oil Pressure Gauge

It is used to measure the pressure of oil in the engine cylinder.

Working of Splash Lubrication System

- Firstly oil is filled in the Crankcase.
- Oil strainer will remove any impurities present in the oil and the oil pump will supply it to all the parts including oil troughs.
- In the splash lubrication system, oil is splashed up from the oil trough or oil trays in the lower part of the crankcase with each revolution of the crankshaft to produce the oil splash.
- The oil is thrown upward either as droplets or fine mist and provides adequate lubrication to piston pins, piston rings, valve mechanisms, cylinder walls etc.
- Oil flows through the holes drilled inside the crankshaft and main bearing to lubricate them his system is too uncertain for automotive applications.



Advantages of Splash Lubrication System

- In some of the automobiles also, the splash lubrication system is used where the machine can do little effort compared to the IC engines.

Disadvantages of Splash Lubrication System

- Due to the presence of scoop at the end of piston, it does not serves the proper lubrication throughout the engine cylinder. It will just spill the lubricant on to the piston parts.
- Due to this, wear and tear of the components takes place.
- To avoid the incomplete lubrication, Pressure Lubrication System has come into picture.

Uses of Splash Lubrication System

- Splash lubrication is commonly used in smaller engines.
- More specifically, this technique is used in lawnmower and outboard boat engines or motors that have sufficient amounts of oil in the trough to fully lubricate the machine.
- Due to the benefits of splash lubrication, many of our lines of positive displacement blowers and vacuum pumps also utilize this process including our Duro Flow and Sutor belt blowers.
- These PD blowers are manufactured with an oil slinger that dips into a reservoir filled with oil.
- As the gears rotate in the blower, the oil is then splashed upon them, hence the term, splash lubrication.
- It is common for blowers to utilize splash lubrication in both the gear and drive ends of the machine.
- This method is called dual-splash lubrication and gives the machine an even longer product life.

7. Explain In Detail About Corrosion.

- Corrosion is when a refined metal is naturally converted to a more stable form such as its oxide, hydroxide or sulphide state this leads to deterioration of the material.
- It is basically defined as a natural process that causes the transformation of pure metals into undesirable substances when they react with substances like water or air.
- This reaction causes damage and disintegration of the metal, starting from the portion of the metal exposed to the environment and spreading to the entire bulk of the metal.
- Corrosion is usually an undesirable phenomenon since it negatively affects the desirable properties of the metal.
- For example, iron is known to have good tensile strength and rigidity (especially alloyed with a few other elements).
- However, when subjected to rusting, iron objects become brittle, flaky, and structurally unsound.

Principle

- The basic theory of electrochemical corrosion requires an anode, a cathode, an electrolyte and a flow of electricity between the anode and the cathode.
- The anode always corrodes in preference to the cathode.
- The smaller the anode area in relation to the cathode area, the faster the corrosion rate.
- An electrolyte is a solution containing ions which are particles bearing an electric charge.
- Ions are present in solutions of acids, alkali's and salts.
- Anodes and cathodes exist on all iron and steel metals.
- They are caused by surface imperfections, grain orientation, lack of homogeneity of the metal, variation in environment, localized stresses, mill scale, and existing red iron oxide rust.

8. What are the Factors Affecting Corrosion?

1. Exposure of the metals to air containing gases like CO2, SO2, SO3 etc.
2. Exposure of metals to moisture, especially salt water (which increases the rate of corrosion).
3. Presence of impurities like salt (For example, NaCl).
4. Temperature: An increase in temperature increases corrosion.
5. Nature of the first layer of oxide formed: Some oxides like Al2O3 form an insoluble protecting layer that can prevent further corrosion. Others, like rust, easily crumble and expose the rest of the metal.
6. Presence of acid in the atmosphere: Acids can easily accelerate the process of corrosion.

9. What are the Types of Corrosion?

Some of the corrosion types include the following:

(i) Crevice Corrosion

- Whenever there is a difference in ionic concentration between any two local areas of a metal, a localised form of corrosion known as crevice corrosion can occur.
- For instance, this form of corrosion mostly occurs in confined spaces (crevices). Examples of areas where crevice corrosion can occur are gaskets, the under surface of washers, and bolt heads.
- All grades of aluminium alloys and stainless steels also undergo crevice corrosion.
- This is mainly because of the formation of a differential aeration cell that leads to the formation of corrosion inside the crevices.

(ii) Stress Corrosion Cracking

- Stress corrosion cracking can be abbreviated to 'SCC' and refers to the cracking of the metal as a result of the corrosive environment and the tensile stress placed on the metal.

- It often occurs at high temperatures.
- For example, stress corrosion cracking of austenitic stainless steel in chloride solution.

(iii) Intergranular Corrosion

- Intergranular corrosion occurs due to the presence of impurities in the grain boundaries that separate the grain formed during the solidification of the metal alloy.
- It can also occur via the depletion or enrichment of the alloy at these grain boundaries.
- For example, Aluminium-base alloys are affected by IGC.

(iv) Galvanic Corrosion

- When there exists an electric contact between two metals that are electrochemically dissimilar and are in an electrolytic environment, galvanic corrosion can arise.
- It refers to the degradation of one of these metals at a joint or at a junction.
- A good example of this type of corrosion would be the degradation that occurs when copper, in a salt-water environment, comes in contact with steel.
- For example, when aluminium and carbon steel are connected and immersed in seawater, aluminium corrodes faster, and steel is protected.

(v) Pitting Corrosion

- Pitting Corrosion is very unpredictable and, therefore, is difficult to detect.
- It is considered one of the most dangerous types of corrosion.
- It occurs at a local point and proceeds with the formation of a corrosion cell surrounded by the normal metallic surface.
- Once this 'pit' is formed, it continues to grow and can take various shapes.
- The pit slowly penetrates metal from the surface in a vertical direction, eventually leading to structural failure if left unchecked.
- For example, consider a droplet of water on a steel surface, pitting will initiate at the centre of the water droplet (anodic site).

(vi) Uniform Corrosion

- This is considered the most common form of corrosion wherein an attack on the surface of the metal is executed by the atmosphere.
- The extent of the corrosion is easily discernible.
- This type of corrosion has a relatively low impact on the performance of the material.
- For example, a piece of zinc and steel immersed in diluted sulphuric acid would usually dissolve over its entire surface at a constant rate.

(vii) Hydrogen Grooving

- This is a corrosion of the piping by grooves that are formed due to the interaction of a corrosive agent, corroded pipe constituents, and hydrogen gas bubbles.

- The bubbles usually remove the protective coating once it comes in contact with the material.

(viii) Metal Dusting

- Metal dusting is a damaging form of corrosion that occurs when vulnerable materials are exposed to certain environments with high carbon activities, including synthesis gas.
- The corrosion results in the break-up of bulk metal to metal powder.
- Corrosion occurs as a graphite layer is deposited on the surface of the metals from carbon monoxide (CO) in the vapour phase.
- This graphite layer then goes on to form meta-stable M3C species (where M is a metal) that usually move away from the metal surface.
- In some cases, no M3C species may be observed.
- This means that the metal atoms have been directly transferred into the graphite layer.

(ix) Microbial Corrosion

- Microbial corrosion, which is also known as microbiologically influenced corrosion (MIC), is a type of corrosion that is caused by microorganisms.
- The most common one is chemoautotrophs. Both metallic and non-metallic materials, either in the presence or absence of oxygen, can be affected by this corrosion.

(x) High-Temperature Corrosion

- High-temperature corrosion, as the name suggests, is a type of corrosion of materials (mostly metals) due to heating.
- Chemical deterioration of metal can occur due to a hot atmosphere that contains gases such as oxygen, sulphur, or other compounds.
- These compounds are capable of oxidising the materials (metals in this case) easily. For example, materials used in car engines have to resist sustained periods at high temperatures, during which they can be affected by an atmosphere containing corrosive products of combustion.

10. What are The Prevention Methods of Corrosion?

- Preventing corrosion is of utmost importance in order to avoid huge losses.
- The majority of the structures that we see and use are made out of metals. This includes bridges, automobiles, machinery, household goods like window grills, doors, railway lines, etc.
- While this is a concerning issue, several treatments are used to slow or prevent corrosion damage to metallic objects.
- This is especially done to those materials that are frequently exposed to the weather, saltwater, acids, or other hostile environments.
- Some of the popular methods to prevent corrosion include,
    - Electroplating

- Galvanization
- Anodization
- Passivation
- Biofilm Coatings
- Anti-Corrosion Protective Coatings
- Painting and Greasing
- Use of Corrosion Inhibitor or Drying Agents
- Periodic Cleaning of Metal Surface

Electroplating

The main purpose of electroplating is to improve:

- Appearance
- Protection against corrosion
- Special surface properties
- Engineering or mechanical properties
- In the process of electroplating the anode is connected to the positive terminal, and the cathode (metal to be plated) is connected to the negative terminal. Both are immersed in a solution that contains an electrolyte and then connected to an external supply of direct current.
- When DC power is applied, the anode is oxidized—its metal atoms dissolve in the electrolyte solution.
- These dissolved metal ions are reduced at the cathode and form a coating. The current through the circuit is adjusted so that the rate at which the anode is dissolved equals the rate at which the cathode is plated.
- Different metals can be coated using the electroplating process

Passivation

- It involves applying an outer layer to a material to protect it from harmful reactions such as corrosion reactions.
- The layer may occur spontaneously in nature through a process called self-passivating, or it can be introduced to the material as a micro-coating.
- In this case, a light coat of material, for instance a metal oxide is used to form a shield against corrosion.
- In microelectronics, passivation is useful in the enhancement of silicon.
- The great practical significance of passivation is that it protects structural metals from rapid corrosion that occurs in fresh water, moist atmosphere and aggressive chemical mediums.

Biofilm

- A protective biofilm, which secretes a poly anionic chemical composition is positioned on the exterior surface that reduces corrosion of the exterior surface.
- In one embodiment, the metal is aluminum, aluminum alloy, copper, a copper alloy, titanium, a titanium alloy, nickel or a nickel alloy.
- In another embodiment, the metal is steel. In a preferred embodiment, the steel is mild steel-1010.

Anti-Corrosion Protective Coatings

- Some coating types that are particularly useful on steel are inorganic zinc and epoxy Inorganic zinc coatings are extremely good for preventing rust on steel. They are also excellent for providing protection from environmental factors like saltwater and harsh weather conditions.
- As a result, chemical plants and refineries often use such coatings to shield their equipment from deterioration.
- Additionally, zinc-rich primers can be coupled with super-durable polyester coatings in a vast array of colors—resulting in a finish that is both highly corrosion resistant and aesthetically.

Anodizing

- Anodizing is achieved by submerging aluminum in an acid bath and delivering an electric current throughout the environment.
- A cathode is incorporated inside the anodizing tank and the aluminum in this setting serves as the anode. In this process, the oxygen ions are freed by the electrolyte to join the atoms of aluminum at the point that is anodizing.
- Therefore, anodizing is the process of extremely controlled oxidation or the enhancement of a natural or existing phenomenon.

Galvanic Corrosion

- Galvanic corrosion (also called ' dissimilar metal corrosion' or wrongly 'electrolysis') refers to corrosion damage induced when two dissimilar materials are coupled in a corrosive electrolyte.
- It occurs when two (or more) dissimilar metals are brought into electrical contact under water.
- When a galvanic couple forms, one of the metals in the couple becomes the anode and corrodes faster than it would all by itself, while the other becomes the cathode and corrodes slower than it would alone.

- Either (or both) metal in the couple may or may not corrode by itself (themselves). When contact with a dissimilar metal is made, however, the self-corrosion rates will change:
- Corrosion of the anode will accelerate Corrosion of the cathode will decelerate or even stop.
- Galvanic coupling is the foundation of many corrosion monitoring techniques

Use of Inhibitors

- Inhibitors are chemical substances used to reduce or eliminate corrosion.
- Inhibitors are used widely in the oil industry to prevent corrosion of steel by crude oils.
- Inhibitors based on chromates, phosphates, silicates, etc. are used to decrease corrosion of steel in aqueous media.
- Inhibitors have to be replenished at regular intervals in stagnate environments and added continuously to solutions that are in motion, such as a pipeline.
- Adding inhibitors to a solution does not normally prevent corrosion by its vapours.

Use of Cathodic Protection

- As mentioned earlier cathodic protection is used to reduce or eliminate corrosion by electrically connecting a more active metal to the metal that must be protected.
- For example, zinc and magnesium anodes are used to protect steel in marine environments.
- Cathodic protection is also achieved with the utilization of an impressed current (dc) and using a relatively inert anode.
- An electrolyte is, of course, needed for proper electron flow.

Use of Protective Coatings

Inhibitive Coatings –

- Inhibitive coating systems are based on a prime coat containing a pigment known to chemically react at the surface of the metal.
- Red lead primers are probably the oldest, followed by the chromates, molybdates, lead suboxide and barium metaborate.
- Many of these are losing their position in corrosion control due to the personal and environmental concerns being raised over the last decade.
- Inhibitive pigments release soluble ions into the water that penetrate the coating film.
- These ionic species are carried to the metal surface and increase the polarization of the anode or the cathode.
- This process encourages the development of microscopic protective surface layers.

Sacrificial Coatings –

- Sacrificial coatings, usually limited to zinc rich coatings, rely on the incorporation of metallic zinc that will preferentially corrode or sacrifice itself to protect the steel substrate.
- These coatings take advantage of galvanic (dissimilar metal) corrosion as previously discussed.
- When in contact with the steel substrate, the zinc film serves as the anode of a large corrosion cell, minimizing any small electrical differences on the steel surface.
- The steel thus becomes totally cathodic to the zinc and is protected.

Barrier Coatings –

- The barrier concept of corrosion protection is not based on the action of a particular pigment in the prime coat engaging in a reaction with the metal substrate.
- Barrier coatings function as primers, intermediates, topcoats or in thick-film formulations, as single coat "systems".
- Barrier coatings produce a tighter, more cohesive film, with lower permeability to water, oxygen and ions than inhibitive or sacrificial films.
- This properly insures corrosion control even under the most demanding conditions including immersion in both fresh and salt water, burial in soils and highly corrosive chemical environments.
- Examples are coal tars, epoxies, multi-coat vinyls and aliphatic urethanes.

Protective Barrier Coatings

- Protective barrier coatings vary considerably in composition, performance and cost.
- The corrosion engineer has a wide choice of materials for most all applications and his selection will depend on the important requirements of the job.
- Many leading companies emphasize the importance of obtaining protection based on the lowest cost per square foot per year of service.
- In some cases, where short-term protection is needed, a barrier that would provide good performance for only that period may be quite adequate.

UNIT IV

PART A

1. **What is meant by fault tracing?**

- Fault tree analysis (FTA) is a type of failure analysis in which an undesired state of a system is examined.
- This analysis method is mainly used in safety engineering and reliability engineering to understan how systems can fail, to identify the best ways to reduce risk and to determine (or get a feeling fo event rates of a safety accident or a particular system level (functional) failure.

2. **What are the importance of fault tracing?**

- Understand the logic leading to the top event / undesired state.
- Show compliance with the (input) system safety / reliability requirements.
- Prioritize the contributors leading to the top event- creating the critical equipment/parts/events lists for different importance measures.

3. **What is meant by a decision tree?**

- A decision tree is a tree-like model that acts as a decision support tool, visually displaying decisions and their potential outcomes, consequences, and costs.
- From there, the "branches" can easily be evaluated and compared in order to select the best courses of action

4. **What are the applications of decision tree?**

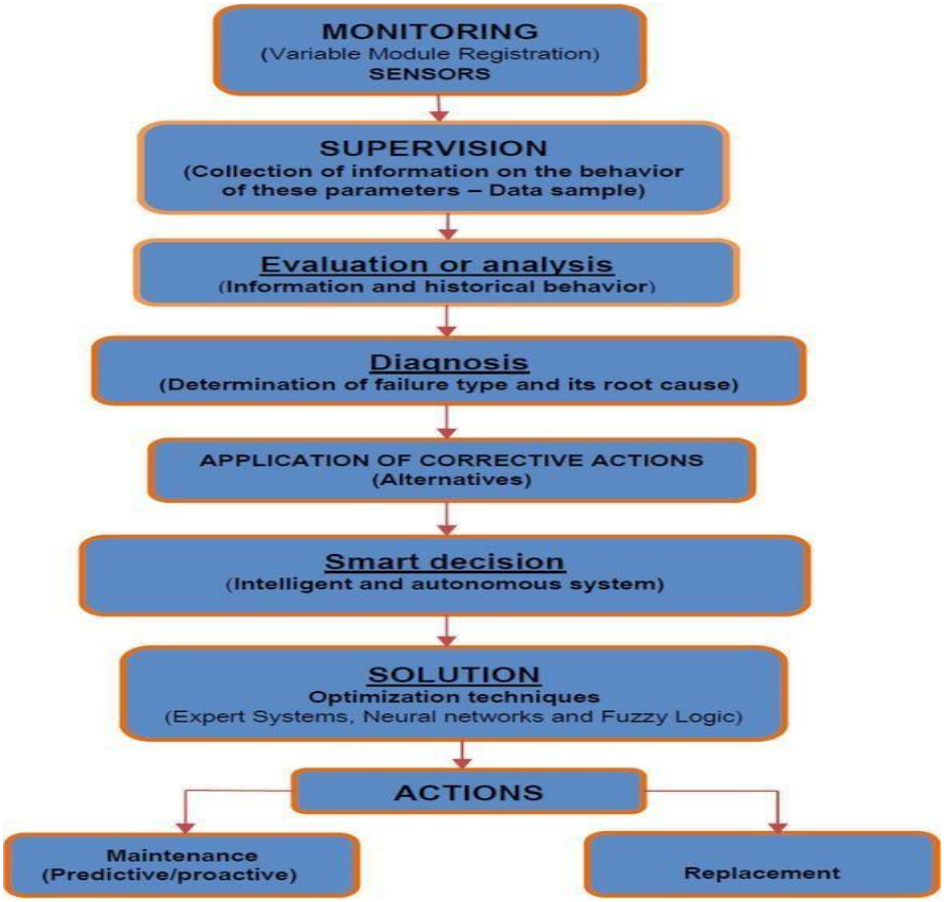
- decision tree analysis in risk management,
- decision tree analysis in healthcare,
- decision tree analysis in capital budgeting,
- decision tree business analysis, and
- decision tree analysis in finance.

5. **What are the types of machine tool faults?**

- Bearing Overheating
- Machine tool vibration
- Noise

- Oil leak

6. What is the fault finding sequence.



PART B & C

1. Explain in detail about the fault tracing analysis and its importance.

Fault Tracing

- Fault tree analysis (FTA) is a type of failure analysis in which an undesired state of a system is examined.
- This analysis method is mainly used in safety engineering and reliability engineering to understand how systems can fail, to identify the best ways to reduce risk and to determine (or get a feeling for) event rates of a safety accident or a particular system level (functional) failure.
- FTA is used in the aerospace, nuclear power, chemical and process, pharmaceutical, petrochemical and other high-hazard industries; but is also used in fields as diverse as risk factor identification relating to social service system failure.
- FTA is also used in software engineering for debugging purposes and is closely related to cause-elimination technique used to detect bugs.

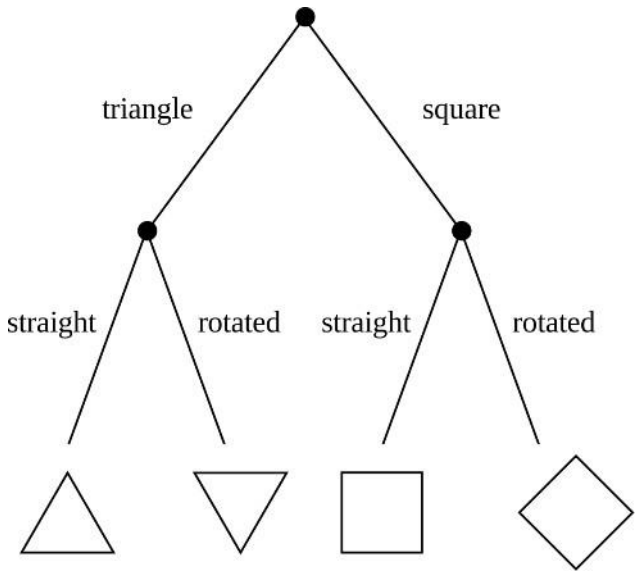
Importance

- Understand the logic leading to the top event / undesired state.
- Show compliance with the (input) system safety / reliability requirements.
- Prioritize the contributors leading to the top event- creating the critical equipment/parts/events lists for different importance measures.

2. What is meant by decision tree and explain the steps involved in it with suitable sketch.

Decision Tree

- A decision tree is a tree-like model that acts as a decision support tool, visually displaying decisions and their potential outcomes, consequences, and costs.
- From there, the "branches" can easily be evaluated and compared in order to select the best courses of action.
- Decision tree analysis is helpful for solving problems, revealing potential opportunities, and making complex decisions regarding cost management, operations management, organization strategies, project selection, and production methods.
- Drawing a decision tree diagram starts from left to right and consists of "burst" nodes that split into different paths.
- Nodes are categorized as Root nodes, which compiles the whole sample and is then split into multiple sets; Decision nodes, typically represented by squares, are sub-nodes that diverge into further possibilities; and the Terminal node, typically represented by triangles, is the final node that shows the final outcome that cannot be further categorized.



The steps in decision tree analysis consist of:

1. Define the problem area for which decision making is necessary.
2. Draw a decision tree with all possible solutions and their consequences.
3. Input relevant variables with their respective probability values.
4. Determine and allocate payoffs for each possible outcome.
5. Calculate the Expected Monetary Value for every chance node in order to determine which solution is expected to provide the most value.

APPLICATIONS

- Decision tree analysis in risk management,
- Decision tree analysis in healthcare,
- Decision tree analysis in capital budgeting,
- Decision tree business analysis, and
- Decision tree analysis in finance.

3. Explain the sequence involved in fault finding activities with suitable flow chart.

1. Collect the Evidence

- All the evidence collected must be relevant to the problem at hand.
- If one is in doubt as to whether anything is relevant, then include it.
- Reject it afterwards at the first opportunity if it clearly is not relevant.
- The quantity of information collected is unimportant, what matters is that all information collected is relevant.
- Observe the system running, if you consider it safe to do so. Use all your senses: smell (burning), hearing (vibration), touch (temperature), sight (for unusual conditions).
- Refer to any relevant documentation.

2. Analyse the Evidence

- Consider all the evidence collected and, if possible, reject any which after further careful consideration is not relevant.
- Study the hardcore of relevant evidence and – through the process of careful, logical thinking – diagnose the likely fault or at least the area or region of the fault.

3. Locate the Fault

- In a sense, this is a continuation of the process of 'analysis.

- The areas or regions are systematically reduced in size until a specific part can be identified as being faulty.
- For example, if a doorbell does not ring when it should, it is only by means of a systematic approach that one determines that the bell itself is faulty.

4. Determination and Removal of the Cause

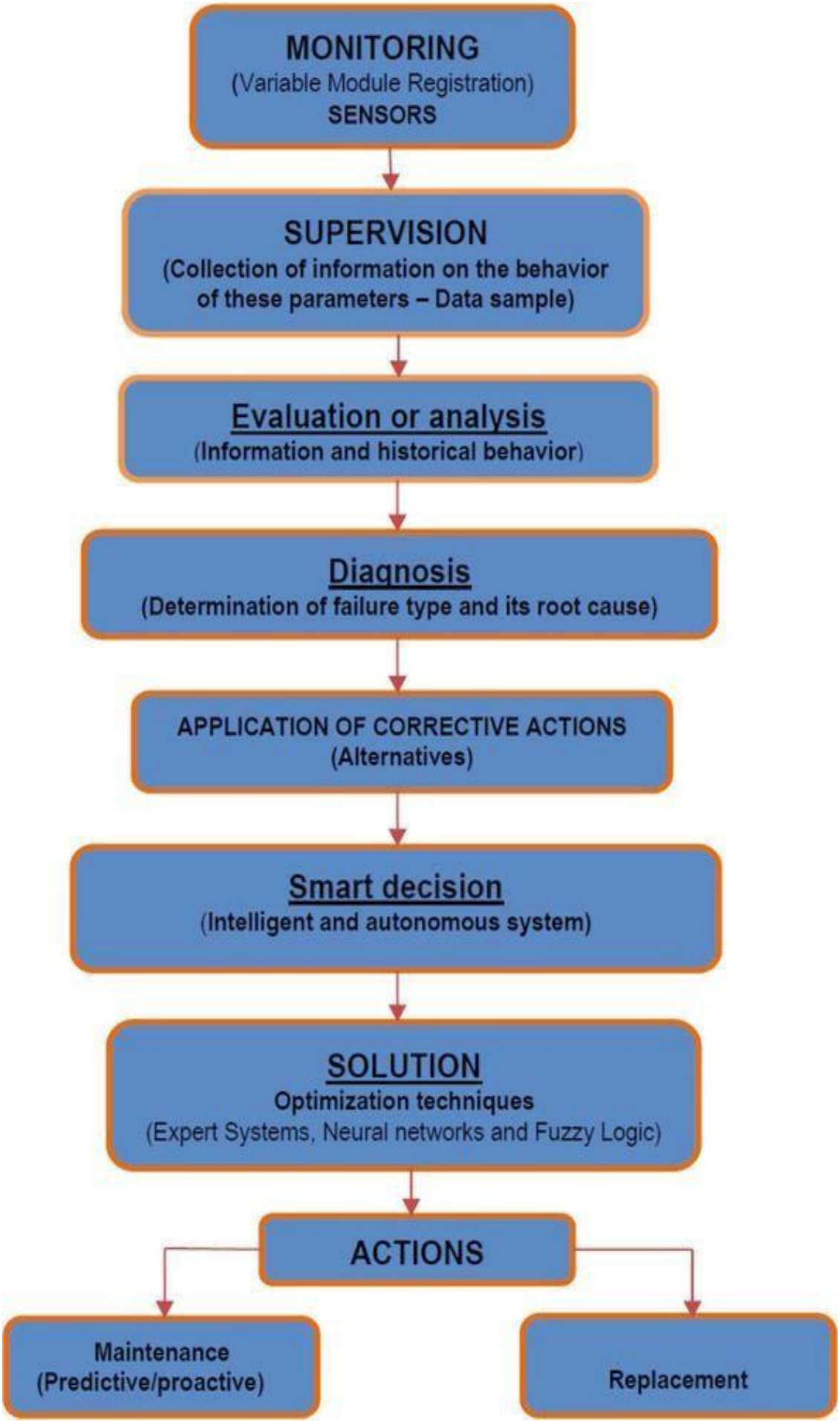
- If the cause of a fault is not removed, the fault will recur even though the fault has been rectified.
- For instance, a flat bicycle tyre might be the result of a puncture (the fault) in the inner tube.
- If the puncture is repaired (i.e. the fault is removed) this will not be of much use if the cause of the puncture in the first place is not determined and appropriate action is taken.
- The cause of the puncture may be a nail that has penetrated the outer cover. This must be removed.

5. Rectification of the Fault

- This may be a simple task, as in the case referred to above, or it may be a much bigger one. Whatever is the case, it is a specific task based on earlier findings.

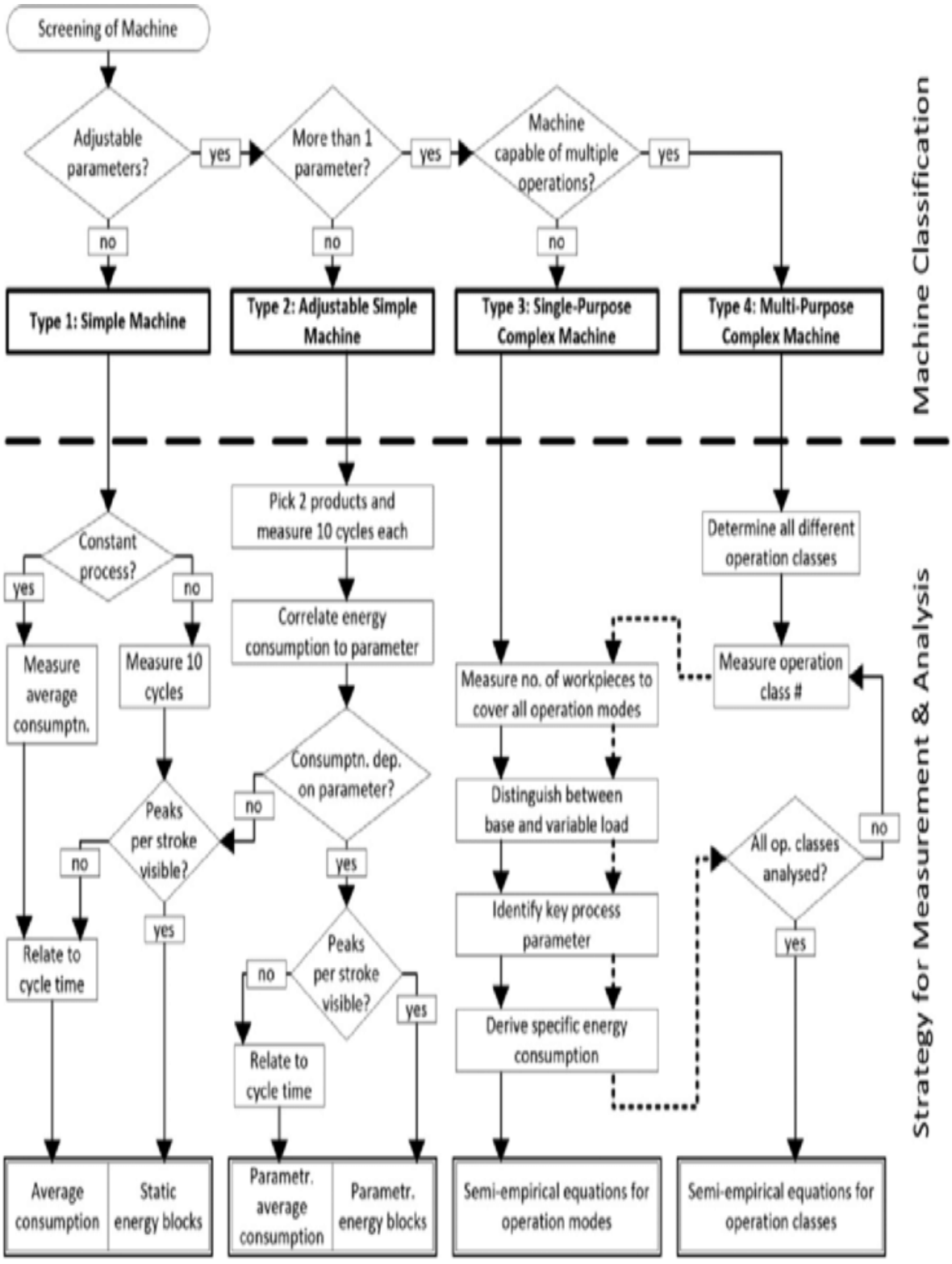
6. Check the System

- It is important to ensure that the machine, equipment or system is functioning normally after the cause of the fault and the fault itself has been dealt with. In the case of the puncture, it is easy to confirm that the cause of the fault – and the fault itself – has indeed been dealt with satisfactorily, assuming that the tyre remains inflated.
- With more sophisticated equipment or systems, it may necessary to 'fine-tune' the system in order to return it to optimum working conditions.


MONITORING
(Variable Module Registration)
SENSORS
SUPERVISION
(Collection of information on the behavior of these parameters – Data sample)
Evaluation or analysis
(Information and historical behavior)
Diagnosis
(Determination of failure type and its root cause)
APPLICATION OF CORRECTIVE ACTIONS
(Alternatives)
Smart decision
(Intelligent and autonomous system)
SOLUTION
Optimization techniques
(Expert Systems, Neural networks and Fuzzy Logic)
ACTIONS
Maintenance
(Predictive/proactive)
Replacement

4. **Construct the decision tree for problem identification in any one of the machine tool.**

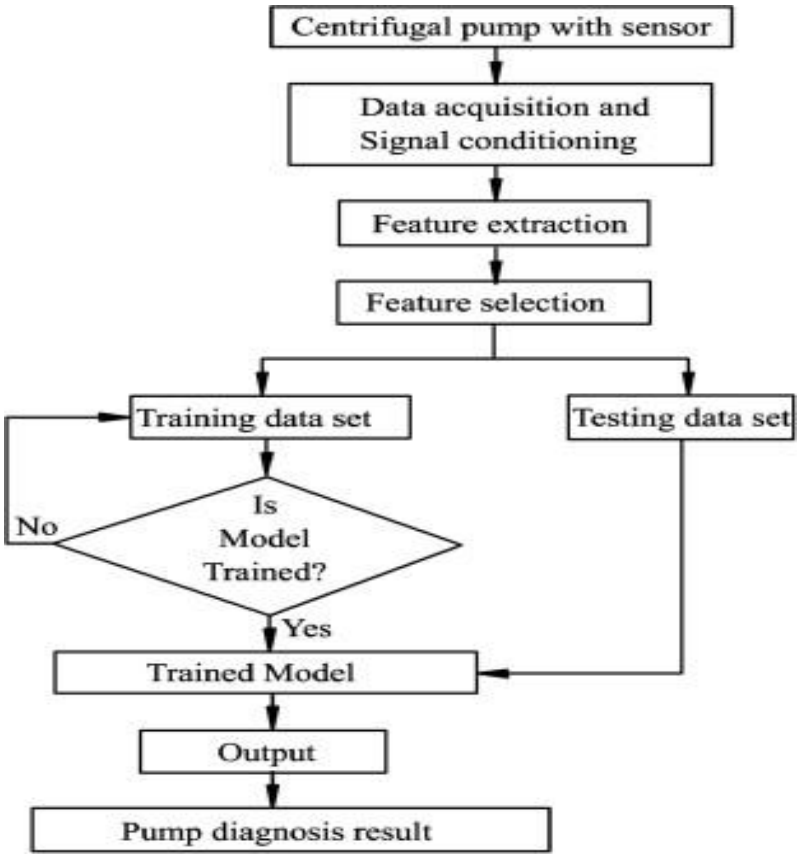
Decision Tree for Problem in Machine Tool (Milling)



5. Construct the decision tree for fault tracing in pump.

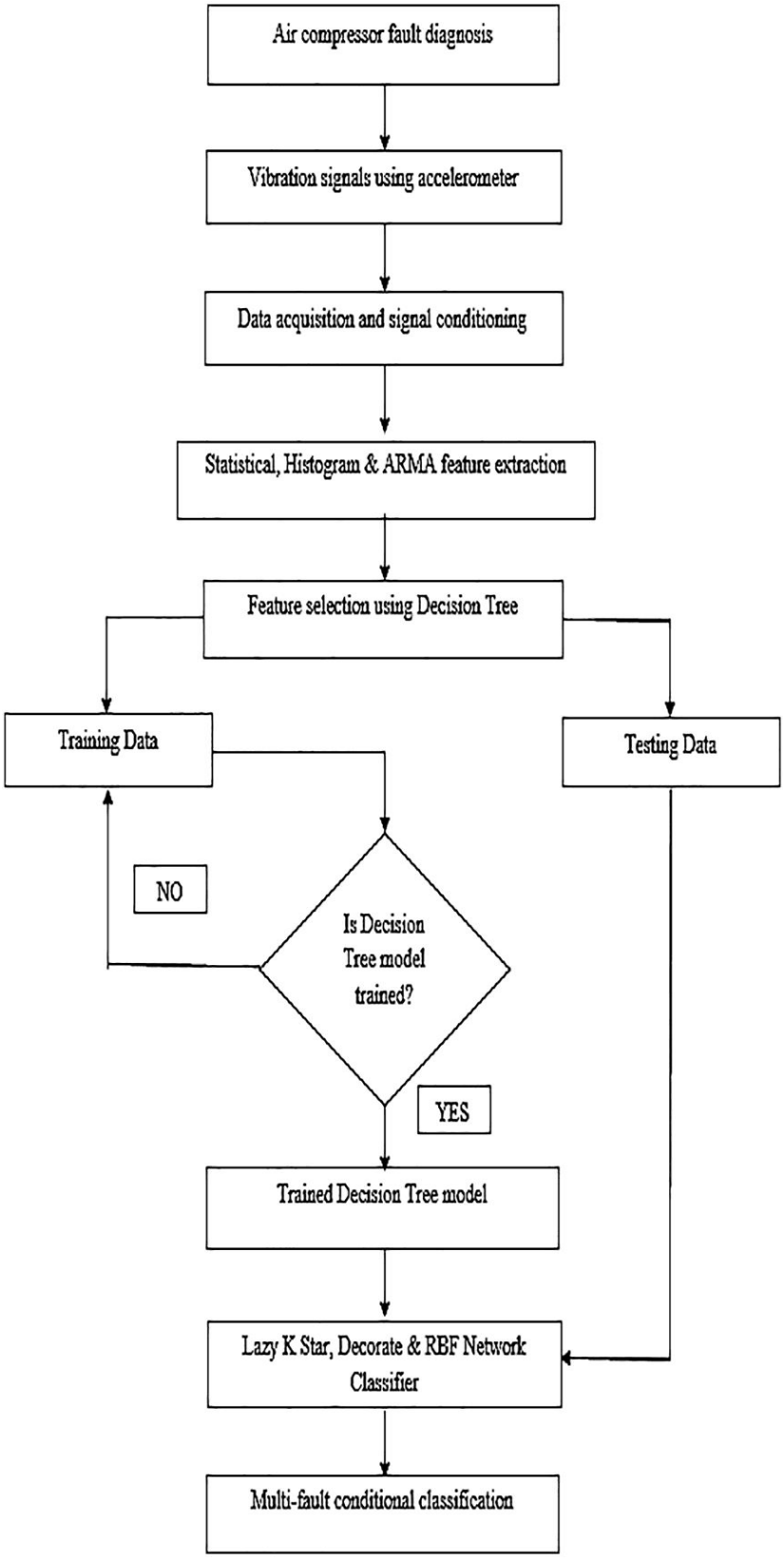
Decision Tree for Fault In Pump

- A pump coupled with an electric motor is one of the most significant pieces of equipment within any industrial setting and is considered a high priority asset for failure analysis.
- Similar to an FMEA on pumps, FTA would also require the realization of interconnected subsystems that constitute a pump assembly.
- For example, any standard centrifugal pump would constitute the pump impeller, seal, suction and discharge nozzles, bearings, etc. Similarly, a coupled electric motor and its associated instrumentation and controls are also part of the pump-motor assembly and can trigger pump failure.
- Any single or combination of failures within each of these components can impact the pump operation and therefore need to be considered in the analysis.
- Due to a large number of components with various inter-dependencies, the pump FTA can become fairly complicated if the team is missing credible failure data or lacks experience on how to interpret fault trees correctly.
- The starting point to construct a fault tree for the pump would always be to define the top failure event and branch out further events that caused the top event.
    - The top event can be as simple as the pump failing to operate.



6. Construct the decision tree for fault tracing in air compressor.

Decision Tree for Fault in Air Compressor



- Considering the fact that compressors work at high cycles, generated vibrations and fatigues are factors contributing to fracture and failure of these sets.

- In normal operating conditions, compressor has an allowed range of vibrations. If these vibrations exceed a definite limit, it suggests that compressor is no longer operating in normal conditions.

- On the other hand, each part or element of compressor runs at a certain frequency. If a failure occurs in this set, it is represented at a distinct frequency and range of vibrations.

- Therefore, the present study uses vibration signals for condition monitoring of compressors.

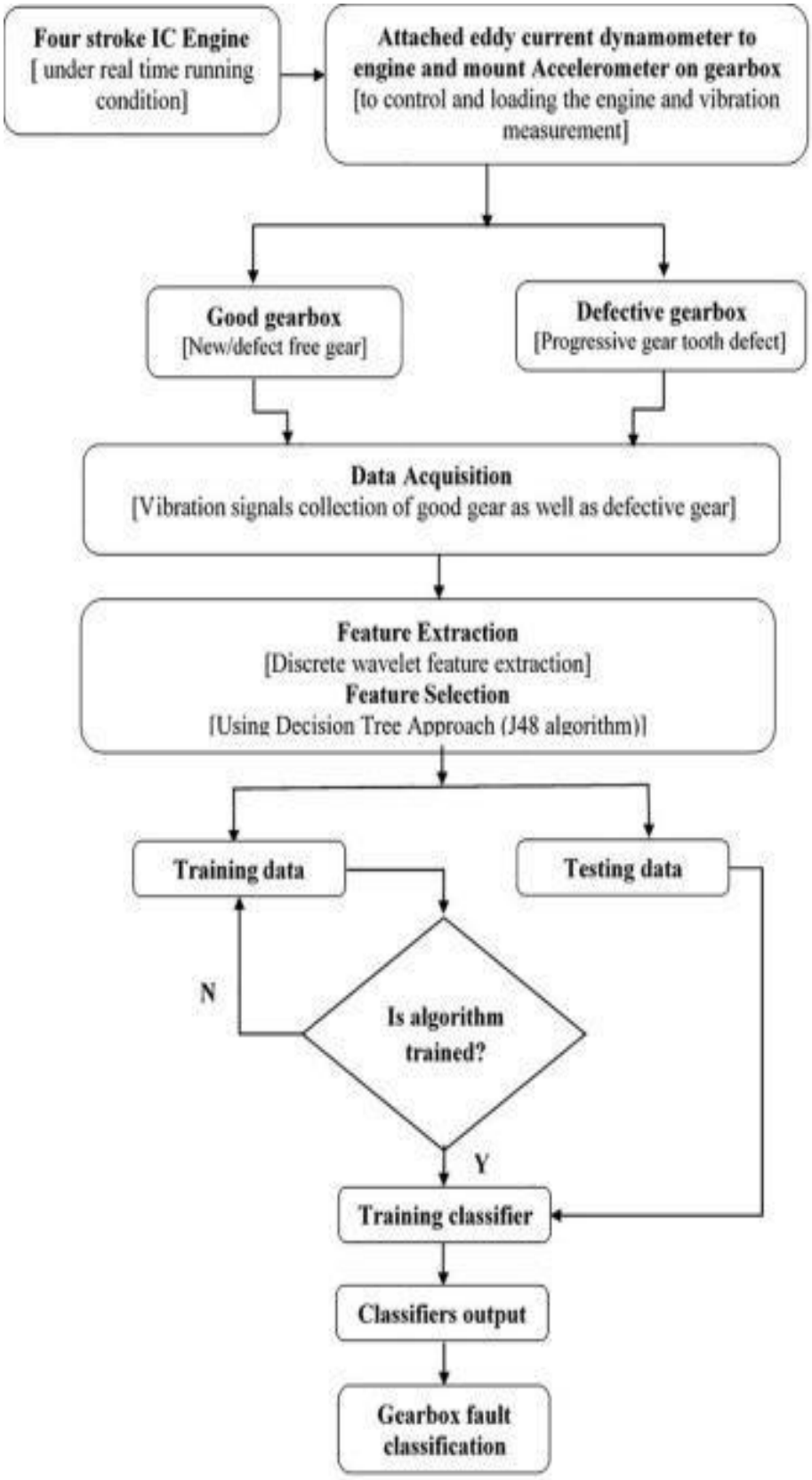
- Before analysis of signals in pre-processing step, samples were imported into MATLAB Software and wavelet transform of each sample which represents distinctive states of compressor was done.

- Signals collected by sensors in the first step were wholly at time domain. Although vibration data offers valuable information on condition of the machine, but such data does not include failure signal and there are numerous noises in them.

- The noises in time-domain signals problematize direct detection of failures.

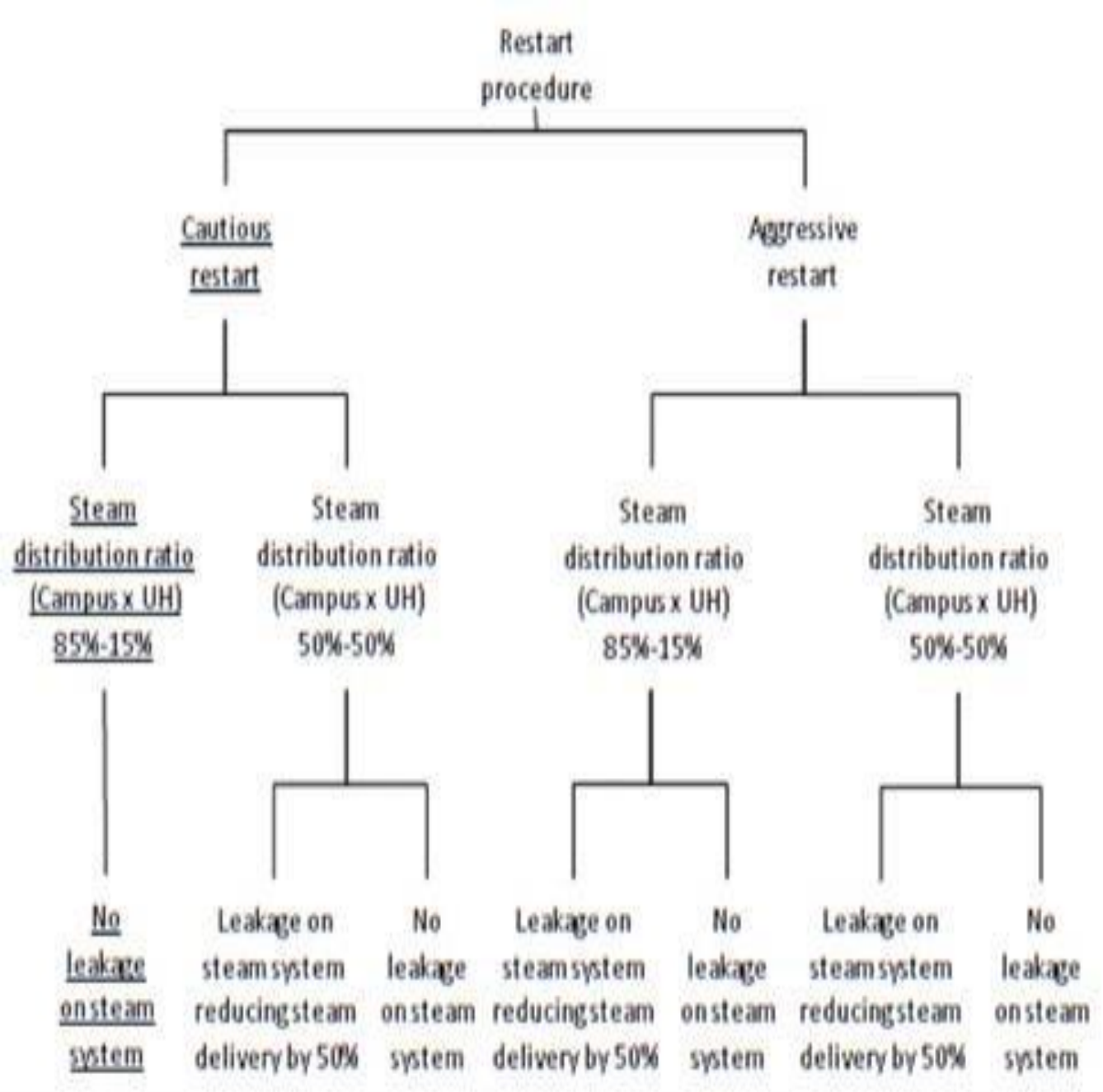
7. Draw the decision tree for fault tracing in internal combustion engine.

Decision Tree for Fault in an IC Engine.

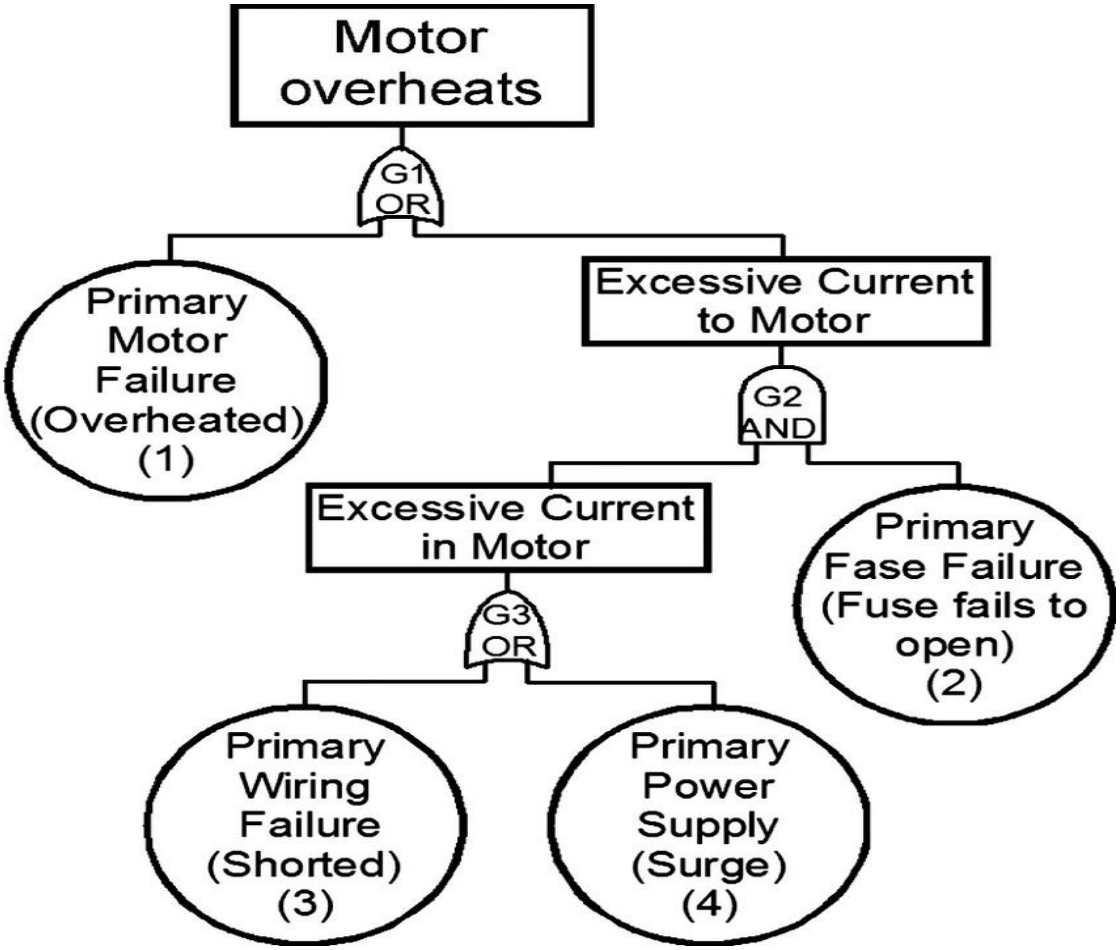

Four stroke IC Engine
[under real time running condition]
Attached eddy current dynamometer to engine and mount Accelerometer on gearbox
[to control and loading the engine and vibration measurement]
Good gearbox
[New/defect free gear]
Defective gearbox
[Progressive gear tooth defect]
Data Acquisition
[Vibration signals collection of good gear as well as defective gear]
Feature Extraction
[Discrete wavelet feature extraction]
Feature Selection
[Using Decision Tree Approach (J48 algorithm)]
Training data
Testing data
N
Is algorithm trained?
Y
Training classifier
Classifiers output
Gearbox fault classification

8. Construct the decision tree to identify fault in a boiler and electric motor.

Decision Tree for Fault in a Boiler.



DECISION TREE FOR FAULT IN A MOTOR.



9. List out the types of fault associated with machine tools.

Types of Machine Tool Faults.

- Machine tools in the process of use, there are often some faults, such as not timely elimination, will directly affect the production, and will make the precision of the machine tool rapidly decline.

- Therefore, it is very important to summarize and analyze the fault causes of machine tools and explore the methods of troubleshooting.

Generally speaking, there are the following causes of failure:

- The machine itself of the mechanical parts, electrical components, hydraulic equipment and other work failure, or some parts wear badly, accuracy is out of tolerance and even damage.
- The machine tool is inaccurately installed.
- Improper daily maintenance.
- Unreasonable usage. The original design of the machine tool is imperfect or unreasonable.

1. Bearing Overheating

- The shaft parts of machine tools, especially the spindle, are generally assembled into a rolling bearing or sliding bearing, and rotating at a very high speed sometimes will produce a high amount of heat.

- This phenomenon, if not eliminated in a timely manner, will lead to overheating of the bearing, and the corresponding part of the machine tool temperature and thermal deformation, which not only affects the accuracy of the machine tool itself and machining accuracy, and will burn out the bearing.

2. Machine tool vibration

- Machine tool vibration in machining process, it is inevitable, but when the vibration will not only reduce the machining accuracy of work piece, affect productivity, aggravate wear of the machine tool friction pair, and the tool life, especially for cemented carbide, ceramics, such as brittleness tool material is particularly significant, cause vibration of the machine tool.

3. Noise

- After the machine is started, due to the rotation between the motion pairs or reciprocating linear sliding, periodic contact and separation, between them due to mutual motion and produce a certain vibration.
- In addition, the entire transmission system of the machine will resonate.
- Therefore, no matter how reasonable the structure of any machine, how accurate assembly, how appropriate operation, once started will produce noise.
- If the sound is rhythmic and harmonious, it is normal; if the sound is too loud and harsh, it is abnormal.
- Noise is the forerunner of machine failure, so if abnormal phenomenon should be stopped immediately, troubleshooting before production.

4. Oil leak

- Oil leakage of machine tools is a common fault in the daily work of machine tools.
- It not only wastes oil, directly causes economic losses, but also affects the working performance of the machine tool.
- Meanwhile, long-term oil leakage will also bring adverse consequences to the installation foundation of the machine tool.
- Therefore, we should attach importance to the "leakage control" work of machine tools.
- To carry out investigation and research, find out the oil leakage site, analyze the causes of oil leakage, and take measures to solve.

UNIT V

PART A

1. **Define periodic maintenance**

   - Periodic maintenance is a process that ensures company assets remain in good condition throughout their useful life.
   - It is based on the fixed maintenance schedule for assets like equipment, machinery, and vehicles.

2. **What is the need for periodic maintenance**
   - Periodic maintenance service is important because it helps ensure that assets are long-lasting, stable, and reliable.
   - Unlike other types of maintenance, periodic maintenance is nonselective.

3. **What is degreasing.**
   - Degreasing is the process of removing grease, oil, and other types of contaminants from surfaces or parts.
   - The process typically involves the use of a degreaser, which is a specialized cleaning agent designed to dissolve and remove these types of substances.

4. **What is overhauling in machine.**
   - Overhauling of a machine is defined as a process of general maintenance performed on a machine or other industrial equipment.
   - The goal of overhauling is to keep the system in serviceable condition.
   - Regular checks can prevent all kinds of critical damage.

5. **What are the benefits of overhauling**
   - Cost-effective
   - Extended life length
   - Increased performance
   - Reduced labor costs

6. **What are the common troubles in electric motor?**
   - Overheating
   - Low resistance
   - Electrical overload
   - Vibration
   - Contamination

7. What is meant by preventive maintenance?

- The care and servicing by personnel for the purpose of maintaining equipment and facilities in satisfactory operating condition by providing for systematic inspection, detection and correction of incipient failures either before they occur or before they develop into major defects.
- Maintenance, including tests, measurements, adjustments, and parts replacement, performed specifically to prevent faults from occurring.

8. Write any 4 daily checks of pumps

- Check pump exterior for any leaks
- Clean pump and nearby region to remove any debris
- Check for excessive pump vibration or unusual noises
- Check for foaming or oil discoloration

9. What is meant by repair cycle

- The repeated performance of all/some of the above mentioned activities in sequence between the successive overhauling is termed as "Repair cycle".
- The repair cycle embraces the following activities.
    1. Inspection
    2. Repair
    3. Overhauling.

PART B & C

1. Explain in detail about concept, needs and repairing schemes of periodic maintenance.

Periodic Maintenance

- Periodic maintenance is a process that ensures company assets remain in good condition throughout their useful life.
- It is based on the fixed maintenance schedule for assets like equipment, machinery, and vehicles.
- This type of maintenance heavily relies on the time interval given to the specific model of the asset.

Need

- Periodic maintenance service is important because it helps ensure that assets are long-lasting, stable, and reliable.
- Unlike other types of maintenance, periodic maintenance is nonselective.

- It aims to inspect, clean, repair, and maintain every component of the equipment or machine which lessens the possibility of missing any factor that could become a problem.

Degreasing

- Degreasing is the process of removing grease, oil, and other types of contaminants from surfaces or parts.
- The process typically involves the use of a degreaser, which is a specialized cleaning agent designed to dissolve and remove these types of substances.
- Degreasers can be formulated with a variety of different chemicals, depending on the specific application and the type of contaminants that need to be removed.

Common chemicals used in degreasers include:

- Solvents like acetone or isopropyl alcohol
- Alkaline cleaners like sodium hydroxide
- Surfactants like detergents

2. Explain in detail about any one of the mechanical components.

Overhauling of Machine

- Overhauling of a machine is defined as a process of general maintenance performed on a machine or other industrial equipment.
- The goal of overhauling is to keep the system in serviceable condition.
- Regular checks can prevent all kinds of critical damage.
- Machinery overhaul is usually performed by companies offering maintenance services.
- The frequency of overhauling can be agreed upon, routine maintenance is usually scheduled for once a year.
- A more frequent equipment check is recommended for older machines and especially larger machines involving complex mechanisms.

Benefits

- Cost-effective
- Extended life length
- Increased performance
- Reduced labor costs

Overhauling of a Machine in Stages

Overhauling usually involves the following stages:

- **Inspection**

1. First of all, the machine will be thoroughly inspected.
2. Experienced maintenance crews perform an inspection on the overhauled machine under production conditions.

3. It means, the machine's performance is monitored while the machine is in use.
4. Such a procedure allows to allocate any issues and perform the troubleshooting more effectively.

- **Disassembly**

1. After the initial inspection, the piece of equipment should be taken apart.
2. Disassembly is crucial for further check and the next steps of the overhauling process, such as repair.
3. A skilled maintenance worker is capable of putting the machine down efficiently, indicating which parts of the equipment need to be replaced or repaired.

- **Repair**

1. Depending on the issue, the machine is either repaired or certain damaged parts are replaced.
2. This step once again proves how effective overhauling is as opposed to replacing the whole piece of equipment at once.
3. Replacement of parts might take longer than a simple repair, as the spare parts might need to be ordered from a manufacturer.

- **Reassembly**

1. Following the successful replacement of spare parts, reassembly of the whole mechanism is performed.
2. Being one of the final steps, the reassembly is crucial for the functioning of the equipment.
3. Certain skill is surely needed to perform reassembly, so it's best handled by professionals.

- **Testing**

1. The final step that concludes the overhauling process.
2. Without testing it is naturally impossible to identify if the performed repair was effective.
3. During testing the retrofit is either proclaimed successful or – less frequently – the process goes back to the starting point (inspection).

4. Discuss about the overhauling of electric motor and common troubles involved in it with remedies.

Overhauling of Electric Motor

A standard electric motor overhaul includes an initial equipment inspection and diagnosis, bearings replacement, a test run and report.

A sample motor overhaul work scope includes –

- Collection from site
- Inspect and record all relevant data from the nameplate

- Carry out electrical and mechanical check tests to verify motor condition and any reported faults, where possible
- Dismantle motor
- Clean and inspect all component parts
- Datum checks, including bearing journals and seatings, shaft extensions, shaft extension run out, shaft seal fits, commutator diameter, and brush surface length
- Repair or replacement of defect components and parts
- Steam cleaning, stove drying and varnishing of stator and rotor windings as specified in IEEE 1068
- Rotating parts dynamically balanced to ISO grade 2.5 or better
- Up to date motor plate fitted before dispatch
- Delivery service to customer site and recommissioning.

Common Troubles and Remedies of Electric Motor.

- Electric motors play a central role in machinery in every industry.
- A failure in this critical piece of machinery could be catastrophic to the business, with the potential for high costs and a long period of downtime.
- Understanding the common problems that can occur with electric motors can allow you to put measures in place to avoid failure and give your electric motor the best possible chance of achieving its maximum possible service life.

1. Low Resistance

- Low resistance is the most common cause of failure in electric motors. It is also often the most difficult to overcome.
- Under conditions such as overheating, corrosion or physical damage, degradation of the insulation of the internal windings of the motor may occur.
- This then causes insufficient isolation between the motor windings or conductors, leading to short circuits, leakages and eventually motor failure.
- Regularly inspect the insulation of the windings for signs of wear and replace before low resistance leads to failure. If you are unsure, consult an expert.

2. Overheating

- Overheating is generally caused by either a high temperature in the operating environment or poor power quality.
- It is responsible for around 55% of insulating failures in electric motors. For every 10 degrees Celsius that the temperature of a motor rises, the insulation life is reduced by half.
- To avoid overheating, ensure that electric motors are kept as cool as possible.

- This can be done by maintaining as cool an operating environment as possible and regularly checking the temperature of the motor.

3. Electrical Overload

- Electrical overload is also commonly referred to as over current.
- It is caused by an excessive flow of current within the windings of the motor, which exceeds the design current that the motor is able to carry efficiently and safely.
- Over current is often the result of a low supply voltage, which results in the motor drawing in more current in an attempt to maintain torque.
- Electrical overload can also be caused by short-circuited conductors, or an excessive voltage supply.
- It is important to install effective over current protection which is able to detect overcurrent and interrupt supply to protect the motor.

4. Vibration

- Vibration can be extremely damaging to electric motors, frequently causing premature failure. It is often caused by the motor being positioned on an uneven or unstable surface.
- However, vibration can also be a result of an underlying issue with the motor, such as misalignment or corrosion.
- Electric motors should be regularly inspected for vibration using a motor analyzing tool.
- Ensure that electric motors are positioned on a flat and stable surface.
- If vibration still occurs, check for signs of wear, as well as misalignment or loose bearings.
- Consider contacting a specialist if the source of vibration cannot be easily identified.

5. Contamination

- Electric motors frequently operate in environments where dust, dirt and chemicals are present, which may find their way inside the motor, leading to contamination and motor failure.
- These contaminants can dent bearing raceways and balls, leading to high levels of vibration and wear.
- They may also block the cooling fan, limiting the motor's ability to regulate its temperature and increasing the chances of overheating.
- As contamination is one of the leading causes of failure in electric motors, it is essential to prevent it from entering the motor. Luckily, this is relatively easy.
- Ensure that work areas, tools and fixtures are kept as clean as possible at all times to help eliminate the chances of contamination entering the motor.
- When laying out the workspace, try to position motors away from applications such as grinding machines which product large quantities of harmful contamination.

- Electric motors are the driving component of a vast range of applications across every industry, and regular inspection is essential to reduce the risk of premature failure.
- If you are in doubt about the condition of your motor, it is always advised to contact a specialist for further investigation.

5. Explain the concept of preventive maintenance and its advantages.

Preventive Maintenance

- The care and servicing by personnel for the purpose of maintaining equipment and facilities in satisfactory operating condition by providing for systematic inspection, detection and correction of incipient failures either before they occur or before they develop into major defects.
- Maintenance, including tests, measurements, adjustments, and parts replacement, performed specifically to prevent faults from occurring.
- The primary goal of maintenance is to avoid or mitigate the consequences of failure of equipment. This may be by preventing the failure before it actually occurs which Planned Maintenance and Condition Based Maintenance help to achieve.
- It is designed to preserve and restore equipment reliability by replacing worn components before they actually fail. Preventive maintenance activities include partial or complete overhauls at specified periods, oil changes, lubrication and so on.
- In addition, workers can record equipment deterioration so they know to replace or repair worn parts before they cause system failure. The ideal preventive maintenance program would prevent all equipment failure before it occurs.
- Preventive maintenance can be described as maintenance of equipment or systems before fault occurs. It can be divided into two subgroups:
- Planned maintenance and
- Condition-based maintenance.
- The main difference of subgroups is determination of maintenance time, or determination of moment when maintenance should be performed.
- While preventive maintenance is generally considered to be worthwhile, there are risks such as equipment failure or human error involved when performing preventive maintenance, just as in any maintenance operation.
- Preventive maintenance as scheduled overhaul or scheduled replacement provides two of the three proactive failure management policies available to the maintenance engineer.
- Common methods of determining what Preventive (or other) failure management policies should be applied are; OEM recommendations, requirements of codes and legislation within a

jurisdiction, what an "expert" thinks ought to be done, or the maintenance that's already done to similar equipment, and most important measured values and performance indications.

- Preventive maintenance is conducted to keep equipment working and/or extend the life of the equipment.
- Corrective maintenance, sometimes called "repair," is conducted to get equipment working again.

Examples in Some organization

- An individual bought an incandescent light bulb. The manufacturing company mentioned that the life span of the bulb is 3 years. Just before the 3 years, the individual decided to replace the bulb with a new one. This is called preventive maintenance.
- On the other hand, the individual has the opportunity to observe the bulb operation daily. After two years, the bulb starts flickering. The individual predicts at that time that the bulb is going to fail very soon and decides to change it for a new one. This is called predictive maintenance.
- The individual ignores the flickering bulb and only goes out to buy another replacement light bulb when the current one fails. This is called corrective maintenance

6. Explain the steps and procedure for periodic& preventive maintenance of machine tool, pump, air compressor and diesel generator.

Procedure for Periodic& Preventive Maintenance

1. Machine Tools

- 5 Preventive Maintenance Tips for Machine Tools
- Preventive maintenance of machine tools can be easily performed with a few basic tips, including the need to keep these tools:
- Dry by storing them in non-moisturized locations and safeguarding them from industrial rust and pollutants.
- Lubricated including the moving parts, internal, and fixed components without which, your machine tools are likely to break down due to wear and tear.
- Sharpened, particularly those tools that are used for cutting, sharpening, or slicing without which, these machine tools are likely to have a shorter operating life due to constant wear and tear.
- Clean to get rid of industrial hazard materials and grime that can prevent your tools from working at optimum efficiency.

- In good shape by performing maintenance on smaller machine accessories such as the tool screws and bolts.
- With a digitized Front Line Worker Platform, manufacturers can optimize the preventive maintenance work of their machines and equipment. Let's look at how this can be accomplished.
- How Front Line Worker Platforms Improve Preventive Maintenance of Tools & Equipment
- For effective preventive maintenance of tools and equipment in your manufacturing facility, front line operators must incorporate several actions as part of their daily tasks, including the following:
- Regular inspection of machine tools for any defects or wear or tear
- Complete cleaning of manufacturing assets including the factory premise and ventilation
- Periodic lubrication of all moving parts in machinery to prevent damage
- Repair or replacement of defective machine tools and equipment
- A Connected Worker Platform improves preventive maintenance operations by empowering front line workers to:
- Automate repetitive task assignment such as tool cleaning
- Integrate the maintenance-related tips into their daily workflows and check off if they have been followed at the end of every working day.
- Improve the quality of their maintenance work by streamlining best practices through an integrated platform and removing any redundant or inefficient steps from the process of cleaning their tools and equipment.
- Implement daily inspection routines using a guided maintenance workflow as part of the PM guidelines.
- Have procedures in place to make sure tools are properly collected at the end of jobs and that any issues without equipment is reported.

2. Pumps

- The strength and effectiveness of your pump preventive maintenance plan depending on how robust your checklist is.
- While you would want to include all possible checks in the plan, it is impractical and inadvisable for all routine checks.
- Therefore the checklist is divided based on the frequency of checks making it more sustainable and effective:

Daily Check:

- Check pump exterior for any leaks
- Clean pump and nearby region to remove any debris

- Check for excessive pump vibration or unusual noises
- Check for foaming or oil discoloration
- Check bearing temperature for overheating
- Inspect all gaskets to ensure there are no oil leaks
- Inspect self flush pumps is applicable
- Clean bearing covers if needed
- Check pump cooling system

Monthly Check:

- Top up oil to bearing reservoirs if needed
- Clean oil bulbs and level windows
- Check the pump guards and replace them if needed
- Clear out dirt and debris from bearings and grease them
- If applicable, check that the hydraulic governors are working properly
- Check overall pump systems for leaks and clean the pumping system surroundings

3. Air Compressor

- Below is a checklist of things that you should check every time you maintain your air compressor.
- Typically, this relies on operating hours, so consult your owner's manual to see specific maintenance schedules.

1. Check the Oil

- This is very important for any engine (large or small).
- If your air compressor takes oil, make sure you check it before you start it up each time. If the oil is low, you could find yourself doing serious damage to the compressor. Whenever the oil is low, top it off.

2. Remove Moisture and Contaminants

- Filters, dryers, oil separators, and even the air tanks collect water, oil, and other contaminants from the air.
- The only way these components can operate efficiently is if you drain the waste from them.
- It should be done every time you've finished using the air compressor but needs to be inspected closely during maintenance.

3. Replace the Air Filter(s)—

- Frequently check all of your filters, and change them if there's heavy build-up. If you rarely use your air compressor, change the air filter every 3-6 months for optimal performance.
- If your air filter is dirty, your air compressor will work much harder to do its job. And even worse, you'll run the risk of contaminating the compressor.

4. **Replace the Separator Element**—

- The separator element prevents excessive use of oil.
- You may not want to pay for a replacement separator, but it's honestly cheaper than the rise in energy costs over time due to a drop in separator pressure.
- For every 2 PSI the separator pressure drops, your energy costs can increase by 1 percent.
- Periodically replacing your separator element will keep your compressor healthy and reduce how much you're spending on energy costs.

5. **Clean the Fuel Tank**—

- If you've got an oiled compressor, you'll need to clean the fuel tank during servicing to ensure it remains clear of gunk and contaminants to continue running effectively.

6. **Test Safety Shutdown Features**—

- At a minimum, this should be done each time a compressor is fully serviced.
- Run through your company's safety procedure and follow protocol to ensure the compressor will operate correctly according to the plan.

4. DIESEL GENERATOR

Lubrication Service

- The Engine oil must be checked while powering off the generator at regular intervals using a dipstick.
- Allow the oil in the upper portion of the engine to drain back into the crankcase and follow the engine manufacturer's recommendations for API oil classification and oil viscosity.
- Keep watching the oil level as near as possible to the full mark on the dipstick by adding the same quality and brand of oil.

Cooling System

- Check the coolant oil level during shutdown periods at the specified interval.
- Must be noted these points "remove the radiator cap after allowing the engine to cool, and, if necessary, add coolant until the level is about 3/4 in" And a More critical role in balancing diesel engines require a balanced coolant mixture of water, antifreeze, and coolant additives.
- Examine the exterior of the radiator for obstructions, and remove all dirt, grimy or foreign material with a soft brush or cloth with caution to avoid damaging the fins.
- If available means, use the low-pressure compressed air or a stream of water in the opposite direction of normal airflow to clean the radiator.

Fuel System

- This is the important point when it comes to the maintenance of diesel generators.

- Diesel is subject to contamination and corrosion within a period of time is one year, and therefore regular generator set exercise is highly recommended to use up stored fuel before it degrades.
- The fuel filters should be drained at the designated intervals due to the water vapour that accumulates and condenses in the fuel tank.
- Better check regularly testing and fuel polishing may be required if the fuel is not used and replaced in three to six months.

Testing Batteries

- If the battery's charges reach the dead-end level is a common cause of standby power system failures.
- The battery must be kept fully charged and well-maintained at an all-time 40% to 100% to avoid regular testing and inspection to know the current status of the battery and avoid low battery levels.

Routine Engine Exercise

- Regular exercising keeps the engine parts lubricated and thwarts oxidation of electrical contacts, uses up the fuel before it deteriorates, and helps to provide diesel generator maintenance to reliable engine starting.
- Engine exercise is recommended to be executed 15 days once or 25 days once for a minimum of 30 min

Keep your Diesel Generator Clean

- Maintain your engine all-time nice and clean because it will be taken care of Oil drips and other issues.
- Check day-by-day hoses and belts that are in good condition or not.
- Frequent checks can keep better conditions and other nuisances from nesting in your equipment.

Exhaust system inspection

- In case of any leaks along the exhaust line which usually occur at the connection points, the welds, and the gaskets.
- Find the place of leakages and repair them immediately by a technician.

5. Explain the programming and scheduling concept of preventive maintenance.

Program and Schedule of Preventive Maintenance of

1. Mechanical Equipment.

- Every PM program is developed to increase the equipment life and reduce unscheduled downtime.
- However, you should list all other objectives of developing a PM plan.
- That can include lowering costs, increasing savings, achieving minimal unplanned downtime, and minimal lost production opportunity time.
- Other things can include reducing spare parts usage, reducing manufacturing interruptions, reducing labor costs, increase machine life spans, improving the quality of products, and maximizing manufacturing time per machine.

PM Schedule

- Once you're done listing the proper PM procedures, you would upload them in your Computerized Maintenance Management System (CMMS).
- At this point, you have to develop a maintenance schedule, with each PM procedure scheduled to efficiently make use of the people and resources available.
- Preventive maintenance scheduling is done daily, weekly, monthly, quarterly, semi-annual, and annual PM events.
- Not all machines require daily or even weekly checks; however, they do need monthly, quarterly, and annual checks. Your preventive maintenance software keeps track of the maintenance checks for you.

Machine Lubrication Engineering in PM

- Almost all of the manufacturer recommendations include the importance of lubricating rotating and reciprocating machine parts.
- Many maintenance professionals misunderstand the importance of lubrication in preventive maintenance; they consider the PM plan as a means of ensuring a lubrication program.
- However, the reality is more complicated, and lubrication tasks require much more effort than is traditionally thought.
- You need to visually and physically inspect the machine and its components to write the appropriate PM procedures for the lubrication, for starters.

Preventive Maintenance Training

- It's crucial for each team member to understand all the steps for preventive maintenance in machines.

- It’s very much possible that individuals are either not utilizing the right tools for maintenance or doing it completely wrong.
- In the short-term, that won’t matter much, but in the long term, it can lead to multiple equipment failures.

PM Program Management Plan

- It’s crucial to have a proper preventive maintenance management system in place.
- The best way to go around that is to have a complete work order system in place that captures labor hours, materials, and task details.

Communication and Collaboration

- The last step of any successful preventive maintenance plan for machines is to develop proper communication channels.
- Communicating the past success of PM programs is essential for reaffirming your PM team and developing two-way feedback channels.

2. Electrical Equipment

Residential location checklist

- Residential areas (also known as dwellings) usually have a smaller electric supply requirement.
- This means fewer circuit panels and less wiring.
- However, a preventive maintenance plan is just as important in a residence as it is in large facilities.
- Check cable assemblies and other wiring methods in rooms, hallways, stairways, and attics.
- Check cable installations and circuit boxes for general suitability.
- Examine boxes for warning lights and other irregularities.

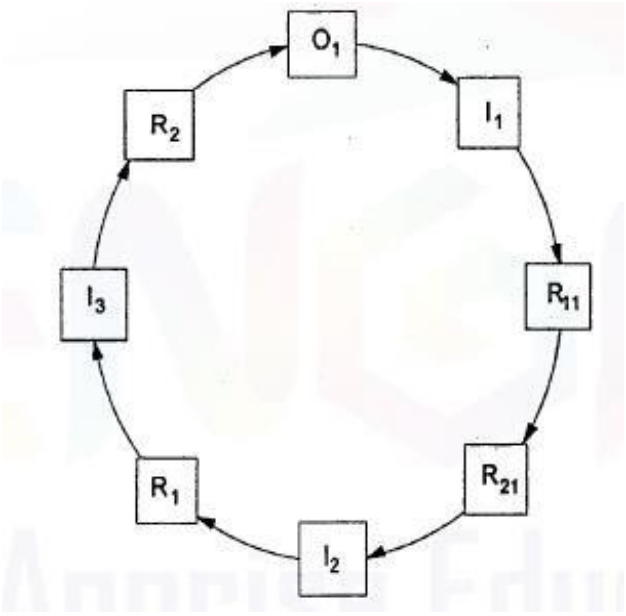
Industrial and commercial establishment checklist

- Check all power meters for regular function before shutting them down for maintenance.
- Confirm that indicators, sensors, and warning lights are functioning correctly.
- Torque test and inspect bolted electrical connections to specified levels whenever needed.
- Visually inspect primary control points for signs of deterioration and overheating.
- Disassemble battery tripping packs and check for signs of general battery integrity and any signs of corrosion or heat damage.
- Perform thermal imaging surveys using precise thermography equipment.
- Check for signs of persistent overheating and single out specific areas for repair or part replacement.

6. Explain about the concept of repair cycle.

Repair Cycle Concept and Importance

- The repeated performance of all/some of the above mentioned activities in sequence between the successive overhauling is termed as "Repair cycle". The repair cycle embraces the following activities. 1. Inspection 2. Repair 3. Overhauling.



- It is clear from that first an inspection activity is scheduled followed by minor/major activities. Then an inspection takes place followed by a minor repair. Ageing a second inspection is followed by a major repair.

- Second inspection is followed by a major repair. Like this it goes and completes one repair cycle.

- The set of these activities between two consecutive overhauling is considered. More the complexity number more will be the activities involved and in turn more staffing requires to complete the repair cycle