MODULE III
OPERATIONS MANAGEMENT
MAINTENANCE MANAGEMENT

INTRODUCTION

Maintenance activities are related with repair, replacement and service of components or some identifiable group of components in a manufacturing plant so that it may continue to operate at a specified 'availability' for a specified period. Thus maintenance management is associated with the direction and organisation of various resources so as to control the availability and performance of the industrial unit to some specified level. Thus maintenance management may be treated as a restorative function of production management which is entrusted with the task of keeping equipment/machines and plant services ever available in proper operating condition.

The minimization of machine breakdowns and down time has been the main objective of maintenance but the strategies adopted by maintenance management to achieve this aim have undergone great changes in the past. Maintenance has been considered just to repair the faulty equipment and put them back in order in minimum possible time. In view of the utilization of mostly general purpose/conventional machines with low production output, the demands on maintenance function were not very high. But with fast developments in the design, development and mechanisms of control such as electronic, NC and CNC in machine tools the manufacturing scenario has changed a lot.

The stringent control of dimensional tolerances and surface finish of the product have increased the tendency to adopt standardization and interchange-ability of parts/components of machines. In the current production setups even a minor down time leads to serious production problems both technological as well as economical. All this is due to tough competition in the industrial market. Under the present circumstances effective and objectively designed efforts to update maintenance management has become a necessity.

Objectives of Maintenance Management:

The purpose of maintenance management is to optimize the performance of productive facilities of an organization by ensuring that these facilities function regularly and efficiently. This can be achieved by preventing the failures or breakdowns if any, as far as possible and by minimizing the production loss due to failures.

The main objectives of maintenance management are as follows:

(1) Minimizing the loss of productive time because of equipment failure to maximize the availability of plant, equipment and machinery for productive utilization through planned maintenance.

(2) To extend the useful life of the plant, machinery and other facilities by minimizing their wear and tear.

(3) Minimizing the loss due to production stoppages.

(4) To ensure operational readiness of all equipment's needed for emergency purposes at all times such as fire-fighting equipment.

(5) Efficient use of maintenance equipment's and personnel.

(6) To ensure safety of personnel through regular inspection and maintenance of facilities such as boilers, compressors and material handling equipment etc.

(7) To maximize efficiency and economy in production through optimum utilization of available facilities.

(8) To improve the quality of products and to improve the productivity of the plant.

(9) To minimize the total maintenance cost which may consist of cost of repairs, cost of preventive maintenance and inventory costs associated with spare parts/materials required for maintenance.

Importance of Maintenance Management:

- Maintenance management is responsible for the smooth and efficient working of the industrial plant and helps in improving the productivity.

- It also helps to keep the machines/equipment in their optimum operating conditions. Thus plant maintenance is an important and inevitable service function of an efficient production system.
- It also helps in maintaining and improving the operational efficiency of the plant facilities and hence contributes towards revenue by decreasing the operating cost and improving the quality and quantity of the product being manufactured.
- As a service function it is related with the incurrence of certain costs. The important component of such costs are — employment of maintenance staff, other minor administrative expenses, investment in maintenance equipment and inventory of repair components/ parts and maintenance materials.
- Absence of plant maintenance may lead to frequent machine breakdown and failure of certain productive centers/services which in turn would result in stoppages of production activities, idle man and machine time, dislocation of the subsequent operations, poor quality of production, failure to meet delivery dates of product supply, industrial accidents endangering the life of workers/ operators and allied costs etc.

TYPES OF MAINTENANCE

The type of maintenance cannot be equated for each equipment, which depends on the method, cost and critical level. The following types of maintenance methods are commonly used in several industries.

1. Preventive Maintenance
2. Predictive Maintenance
3. Corrective Maintenance
4. Breakdown Maintenance

1. Preventive Maintenance: It is a method for preventing damage to equipment by periodically replacing parts based on time of use and carrying out minor maintenance and inspections to find out the current state of the equipment / machinery. Example: Cleaning, checking, lubricating, bolt tightening Periodic inspection Periodic and small over haul restorations

Advantages

1. Cost effective in many capital intensive processes.
2. Flexibility allows for the adjustment of maintenance periodicity.
3. Increased component life cycle.
4. Energy savings.
5. Reduced equipment or process failure.
6. Estimated 12% to 18% cost savings over reactive maintenance program.

Disadvantages

1. Catastrophic failures still likely to occur.
2. Labor intensive.
3. Includes performance of unneeded maintenance.
4. Potential for incidental damage to components in conducting unneeded maintenance.

2. Predictive Maintenance: Predictive maintenance is a method for doing maintenance by replacing parts based on predictions using a tool. The point is if the preventive method is only based on the schedule, then the predictive method is based on the results of the measurement. This method can also use the five senses, for example in bearing inspection can be distinguished from the sound produced. Or checking temperature, by touching it we can feel the difference or abnormality of the equipment.

Examples: Tachometer, to measure the rotation of the Thermometer, to measure the temperature of the Ampermeter, to measure amperage

Advantages

1. Increased component operational life/ availability.

2. Allows for pre-emptive corrective actions.
3. Decrease in equipment or process downtime.
4. Decrease in costs for parts and labor.
5. Better product quality.
6. Improved worker and environmental safety.
7. Improved worker moral.
8. Energy savings.
9. Estimated 8% to 12% cost savings over preventive maintenance program.

Disadvantages

1. Increased investment in diagnostic equipment.
2. Increased investment in staff training.
3. Savings potential not readily seen by management

3. Corrective Maintenance: It is a method intended to improve the reliability of equipment/machines by improvising. In addition to equipment, it is also intended for parts that have a short life cycle (reduce the frequency of damage) and speed up repair time. In other words, this method is to extend MTBF (Mean Time Between Failure) and accelerate MTTR (Mean Time To Repair) because of its reliability (activity to prevent recurrence of damage) and maintainability (activity to speed up repair time).

Example: The operator has difficulty checking the oil volume of the generator engine, so improvisation is done by making a measuring cup equipped with a scale.

4. Breakdown Maintenance: It is a method where inspection and replacement of parts are not carried out, so with this method we leave the equipment damaged and then we fix it or replace it

Usually this method is applied to equipment / machines with consideration:

- Equipment is only optional (additional) so that if it is damaged it does not interfere with production
- The cost of repairing / replacing cheap parts
- Insignificant damage
- Easy and fast repair

Advantages

1. Involves low cost investment for maintenance.
2. Less staff is required.

Disadvantages

1. Increased cost due to unplanned downtime of equipment.
2. Increased labor cost, especially if overtime is needed.
3. Cost involved with repair or replacement of equipment.
4. Possible secondary equipment or process damage from equipment failure.
5. Inefficient use of staff resources.

MAINENANCE COST

Maintenance costs include the expenses your plant incurs that are tied to the upkeep and repair of machinery and components present throughout your operation. This KPI measures the levels of maintenance expenses and is useful for tracking machinery's effectiveness over time.

Steps to reduce Maintenance Management Costs

1. Safety first!

Reducing maintenance costs and downtime is often associated with decreasing safety or service; in fact, it's the other way around! Reducing Maintenance Costs is all about managing your maintenance strategy and planning more efficiently. Meaning that you would spend a little bit of extra time on scheduling work orders which will highly increase safety in the work environment.

2. Failure Data Analysis

A big part of implementing a successful preventative maintenance program in your business is understanding maintenance failure data, and effectively using them as KPI's. This article will discuss 5 key metrics & failure data collection procedures that you need to consider how to calculate them, and what benefits they offer for cost reduction and optimized efficiency.

3. Reactive maintenance

Reactive maintenance also often referred to breakdown maintenance means that equipment repairs are done after the equipment failure. While reactive

maintenance might make sense from the first sight (repairing only when failures occur) read this article to find out why it shouldn't be your main strategy.

4. Measuring KPI's for maintenance

In order to achieve your goals, you have to focus on specific objective in order to be able to measure your effort and results afterwards and see if you have achieved the goal in the first place.

Especially for maintenance managers, tracking the goals and results has become so much easier in the past years due to technology and EAM systems. Most of the EAM solutions allow creating custom dashboard based on your needs and data you are gathering. However, most maintenance departments still find it challenging to do reporting. The most obvious reason for that is... DATA. We gather too much information, where people get lost pretty fast and start analyzing data that is actually not important or relevant.

In this article you will find most useful 5 Key Performance Indicators for Maintenance Department to follow in order to reduce Maintenance Costs and Increase Productivity!

5. Maintenance Data Tracking

Many companies still rely on old school techniques for reporting, including pen and paper ledgers and Excel spreadsheets. These might have worked well in the past when there were fewer data available, but they're time-consuming and are prone to human error. By using ancient techniques of analyzing data, you risk overlooking many vital processes and critical data.
Maintenance software that allows you to automate reporting and target specific data is a much more efficient way to track your assets.
Learn how you can improve your decision making with better maintenance data.

OEE (OPERATIONAL EQUIPMENT EFFICIENCY)

Overall equipment effectiveness (OEE) is a measure of how well a manufacturing operation is utilized (facilities, time and material) compared to its full potential, during the periods when it is scheduled to run. It identifies the percentage of manufacturing time that is truly productive. An OEE of 100% means

that only good parts are produced (100% quality), at the maximum speed (100% performance), and without interruption (100% availability).

Measuring OEE is a manufacturing best practice. By measuring OEE and the underlying losses, important insights can be gained on how to systematically improve the manufacturing process. OEE is an effective metric for identifying losses, bench-marking progress, and improving the productivity of manufacturing equipment (i.e., eliminating waste)

OEE provides one of the quickest ways to assess operational efficiency. It can also help you pinpoint performance issues. If a particular machine has a high rate of downtime, you likely have a maintenance issue, a part that needs to be replaced, or operator error. Surprisingly, many companies fail to track this important key performance indicator (KPI).
The basic definition of OEE is the percentage of time your equipment is actually productive and generating revenue for your company.

OEE Calculation

The preferred OEE calculation is based on the three OEE Factors: Availability, Performance, and Quality.

Availability: Availability takes into account all events that stop planned production long enough where it makes sense to track a reason for being down (typically several minutes). Availability is calculated as the ratio of Run Time to Planned Production Time:

Availability = Run Time / Planned Production Time

Run Time is simply Planned Production Time less Stop Time, where Stop Time is defined as all time where the manufacturing process was intended to be running but was not due to Unplanned Stops (e.g., Breakdowns) or Planned Stops (e.g., Changeovers).

Run Time = Planned Production Time − Stop Time

Performance: Performance takes into account anything that causes the manufacturing process to run at less than the maximum possible speed when it is

running (including both Slow Cycles and Small Stops). Performance is the ratio of Net Run Time to Run Time. It is calculated as:

Performance = (Ideal Cycle Time × Total Count) / Run Time

Ideal Cycle Time is the fastest cycle time that your process can achieve in optimal circumstances. Therefore, when it is multiplied by Total Count the result is Net Run Time (the fastest possible time to manufacture the parts). Since rate is the reciprocal of time, Performance can also be calculated as:

Performance = (Total Count / Run Time) / Ideal Run Rate

Performance should never be greater than 100%. If it is, that usually indicates that Ideal Cycle Time is set incorrectly (it is too high).

Quality

Quality takes into account manufactured parts that do not meet quality standards, including parts that need rework. Remember, OEE Quality is similar to First Pass Yield, in that it defines Good Parts as parts that successfully pass through the manufacturing process the first time without needing any rework.

Quality is calculated as:

Quality = Good Count / Total Count

This is the same as taking the ratio of Fully Productive Time (only Good Parts manufactured as fast as possible with no Stop Time) to Net Run Time (all parts manufactured as fast as possible with no stop time).

OEE

OEE takes into account all losses, resulting in a measure of truly productive manufacturing time. It is calculated as:

OEE = Availability × Performance × Quality

MATERIAL HANDLING

There is no hard and fast definition of materials handling, however attempts have been made to define this term. Materials handling is the science and art both involving the moving, packing and storing of substance in any form, and includes the preparation, placing and positioning the material to facilitate their movement or storage

Materials handling occurs whenever a material is moved may be in a manufacturing, distribution (warehouse), or office environment. Materials handling also occur during preparation for shipment, transportation may be by sea, air or land, and moving material in and out of carriers.

International Material Management Society has defined the Materials Handling as "Materials handling is an art and science involving the movements, packaging and storing of substances in any form".

Objectives of Materials Handling:

As we know that with the rise of factory system, men continued to develop handling equipment to perform jobs where human or animal muscles were insufficient in either capacity or speed. Later on it becomes important to reduce materials handling labour in order to reduce production cost.

Therefore main objective of materials handling engineer is to reduce product cost the one overall goal. Materials handling equipment is not production machinery, but is auxiliary equipment that improves the flow of material which in turn reduces stoppages in production machines and thus increases their production.

Objectives of a proper materials handling system are:

1. Reduced costs,

2. Increased capacity,

3. Improved working conditions,

4. Improved customer service, and

5. Improved productivity.

PRINCIPLES OF MATERIALS HANDLING:

Since it is not possible to acquire experience by a materials handling engineer himself on all types of problems, he has to take advantage of others' experience. On the basis of-experience gained by himself and also by others he should try to solve the handling problems.

On the basis of these experiences facts, systematic approach and other ideas, certain principles have been developed. These principles have been implemented, practiced and perfected during several years. These principles of material handling are useful in all the fields may it be engineering, office or elsewhere.

The word 'principle' can be defined as a prescribed guide to accepted procedures established through past practice and is accepted as authoritative by practitioners, and without which a system would be less effective. Therefore, when these principles of materials handling are applied by materials handling engineer, even if he is not much experienced, he can find correct solution faster.

These principles are general guides, and can be put to use by means of different activities. In the table below, principles of materials handling are given, and against each of them activities necessary for implementing the principle are indicated.

A. Principles Related to Planning:

1. Planning Principle:

All material handling activities should be planned.

(i) Material should be placed on pallet or any other support and not on the floor directly.

(ii) One container should be used throughout and avoid frequent changes.

(iii) Utilise truss capacities and ceiling heights.

(iv) Provide sufficient storage space at the work-place.

(v) Each operator must be instructed/trained to follow correct method.

(vi) Plan for scrap removal means.

(vii) Efforts are made to combine operations like inspection during productive operation.

(viii) Minimise movement of men and material.

2. Systems Principle:
Handling activities be integrated and coordinated. Handling activities are receiving, storage, in-process handling, inspection, packaging, warehousing, shipping and transportation.

(i) Consider all the handling activities while giving a detailed consideration to an activity.

(ii) Material flow between work areas is planned.

(iii) Integrated activities into the handling system.

3. Simplification Principle:
Reduce, combine or eliminate unnecessary movements and/or equipment.

(i) Motion Economy principles by applied.

(ii) Reduce or eliminate, long and complicated movements.

(iii) Deliver the material at correct spot in first instance.

(iv) Eliminate rehandling.

(v) Reduce variety of equipment.

4. Material Flow Principle:
Material flow pattern must be determined by operation sequence and pattern of equipment arrangement.,

(i) Avoid overcrowding.

(ii) Eliminate obstacles in the flow.

(iii) Move in a direct path and avoid back tracking.

(iv) Move greatest weight and/or bulk for least distance.

(v) Minimize movements between floors, and buildings.

(vi) Plan proper locations of sub-assemblies.

(vii) Plan related work areas close together.

(viii) Avoid traffic jams and take necessary precautions for cross traffic.

5. Gravity Principle:
Utilize gravity where possible.,

(i) Use slides, chutes, hoppers etc. where possible

6. Unit Size Principle:
Increase size, quantity, weight of the load handled. Since larger the load, lesser will be the cost per unit handled.

(i) Handle unit loads. Unit loads described separately.

(ii) Use containers.

(iii) Containers should be standardised.

(iv) Use standardised pallets.

(v) Optimise unit loads.

7. Space Utilisation Principle:
Optimum utilisation of building space. As space means money.

(i) Equipment or work area may be kept in reasonably close position.

(ii) Inventory at temporary stores must not be kept too much.

(iii) Utilise height of building and use rack to permit higher stocking.

(iv) Use concept of economic order quantities and economic lot sizes.

(v) Dispose obsolete or scrap items in time.

(vi) Use handling equipment requiring minimum aisles.

(vii) Use mobile or overhead equipment.

(viii) Use collapsible containers to save space required by empty ones.

8. Safety Principle:

Safe handling methods and equipment for better working conditions and to avoid unsafe conditions.,

(i) Provide adequate guards and other safety devices.

(ii) Handling equipment is kept in good operating conditions.

(iii) Highlight handling hazards, moving vehicles or danger areas.

(iv) Make arrangement for removal of undesirable fire, dust, smoke etc.

(v) Emergency switches or controls be provided.

(vi) Proper instructions and training for safe operation to the operators.

(vii) Keep floor clean.

(viii) Provide good housekeeping.

(ix) Keep aisles clear.

(x) Do not overload handling equipment or devices.

B. Principles Related to Equipment:

1. Mechanisation Principle:

For increasing efficiency use mechanised handling equipment but to the desired extent only.

(i) Mechanisation is useful for large quantities, long, frequent, high effort or hazardous moves.

(ii) Replace excess manual handling or where large numbers of persons are engaged on handling jobs.

(iii) Moving heavy containers.

(iv) Design containers suitable for mechanical handling.

(v) Use mechanised communication where required.

2. Flexibility Principle:

Equipment's capable of handling variety of tasks be used.,

(i) Buy versatile and flexible equipment.

(ii) Buy adjustable racks.

(iii) Utilise accessories and attachments.

3. Equipment Selection Principle:

Select equipment very carefully considering all aspects of materials, movements, and the method.

(i) Select versatile equipment.

(ii) Cost per unit to be handled should be compared.

(iii) Consider standardization aspects.

(iv) Equipment should be economical on long term basis.

4. Standardisation Principle:
Standardise equipment as well as methods.

(i) Standardise the equipment, containers and pallets.

(ii) Standardise methods.

(iii) Train employees on standardised equipment and methods.

5. Light Weight Principle:
Reduce weight of equipment.

(i) Equipment should have less dead weight to pay load ratio.

(ii) Use light weight pallets, skids and containers.

6. Motion Principle:
The handling equipment should be kept in motion i.e., minimum period for loading, unloading or other idleness.

(i) Reduce loading/unloading time.

(ii) Use mechanical means or other means for quick loading and unloading.

(iii) Use tractor trailers, so that tractor can be used for other work while the trailer is being loaded /unloaded.

(iv) Minimize downtime.

7. Idle-time Principle:
Reduce idle and unproductive time.

(i) To avoid idle manpower, deliver material at a desired rate.

(ii) Do not use productive labour for handling.

(iii) In order to utilise manpower fully, more than one machine can also be allotted to one man.

(iv) Equipment should be fully utilized.

8. Obsolescence Principle:
Obsolete methods and equipment be replaced by efficient methods and equipment.

(i) Obsolete equipment be identified and replaced by new equipment.

(ii) Beware of new technological developments and remain in constant touch through books, journals, attending, conferences etc.

9. Maintenance Principle:
Preventive maintenance practices are adopted for handling equipment.

(i) Preventive maintenance is carried out to avoid breakdowns.

(ii) Carry out schedule maintenance and daily inspections and take remedial measures.

(iii) Set up regular maintenance schedule.

(iv) Train operators for proper operation and maintenance.

(v) Maintain adequate spare supplies.

C. Principles Related to Operation:
1. Control Principle:
Control production and inventory through materials handling equipment.

(i) Provide direct mechanical paths for materials movement.

(ii) Materials be moved in lots, batches, containers of a predetermine quantity or size.

(iii) Materials handling system should have built in features of controlling production, inventory, and accounting.

(iv) Material is moved as per schedule.

2. Capacity Principle:
Production capacity should be fully achieved.

(i) Ensure uniform desired rate of flow.

(ii) Equipment is operated at optimum rate.

(iii) Plan to utilise forward as well as return runs of the equipment.

(iv) Vehicles, conveyors, containers etc. should be loaded to full capacity.

(v) Utilise overhead space.

(vi) Aisles should be obstacle free and wide enough for speedy movement.

(vii) Store items not affected by weather.

3. Performance Principle:
Performance of handling is measured in terms of cost per unit handled, safe working condition, and increase in production rate or reduced manpower for handling.

MATERIAL HANDLING EQUIPMENTS

Material handling equipment (**MHE**) is mechanical equipment used for the movement, storage, control and protection of materials, goods and products throughout the process of manufacturing, distribution, consumption and disposal. The different types of handling equipment can be classified into four major categories: transport equipment, positioning equipment, unit load formation equipment, and storage equipment

Types of Material Handling Equipment

The four main categories of material handling equipment include storage, engineered systems, industrial trucks, and bulk material handling.

1. Storage and Handling Equipment

Storage equipment is usually limited to non-automated examples, which are grouped in with engineered systems. Storage equipment is used to hold or buffer materials during "downtimes," or times when they are not being transported. These periods could refer to temporary pauses during long-term transportation or long-term storage designed to allow the buildup of stock. The majority of storage equipment refers to pallets, shelves or racks onto which materials may be stacked in an orderly manner to await transportation or consumption. Many companies have investigated increased efficiency possibilities in storage equipment by designing proprietary packaging that allows materials or products of a certain type to conserve space while in inventory.

Examples of storage and handling equipment include:

- **Racks**, such as pallet racks, drive-through or drive-in racks, push-back racks, and sliding racks, are a basic but important method of storage, saving floor space while keeping their contents accessible.
- **Stacking frames** are stackable like blocks, as their name implies. They allow crushable pallets of inventory, such as containers of liquid, to be stacked to save space without damage.
- **Shelves, bins, and drawers.** Shelves, another basic storage method, are less open than racks. Used with bins and drawers, they're more able to keep smaller and more difficult to manage materials and products stored and organized. Shelving types can include boltless, cantilever, revolving, and tie-down.
- **Mezzanines**, a type of indoor platform, help to create more floor space in a warehouse or other storage building for offices or more storage. Typical types include modular, movable, rack supported, building supported, and free-standing versions.
- **Work assist tooling** enables safe and efficient product handling across numerous industries in applications that require the movement of products, enhancing the efficiency of assembly and manufacturing operations.

2. Engineered Systems

Engineered systems cover a variety of units that work cohesively to enable storage and transportation. They are often automated. A good example of an engineered system is an Automated Storage and Retrieval System, often abbreviated AS/RS, which is a large automated organizational structure involving racks, aisles and shelves accessible by a "shuttle" system of retrieval. The shuttle system is a mechanized cherry picker that can be used by a worker or can perform fully automated functions to quickly locate a storage item's location and quickly retrieve it for other uses.

Other types of engineered systems include:

- **Conveyor systems** come in a variety of types, depending on what they are meant to transport, including vibrating, overhead, chain, vertical, and apron conveyors.
- **Automatic Guided Vehicles (AGV)** are independent computer-operated trucks that transport loads along a predetermined path, with sensors and detectors to avoid bumping into anything.

3. Industrial Material Handling Trucks

Industrial trucks (material handling trucks) refer to the different kinds of transportation items and vehicles used to move materials and products in materials handling. These transportation devices can include small hand-operated trucks, pallet jacks, and various kinds of forklifts. These trucks have a variety of characteristics to make them suitable for different operations. Some trucks have forks, as in a forklift, or a flat surface with which to lift items, while some trucks require a separate piece of equipment for loading. Trucks can also be manual or powered lift and operation can be walk or ride, requiring a user to manually push them or to ride along on the truck. A stack truck can be used to stack items, while a non-stack truck is typically used for transportation and not for loading.

There are many types of industrial trucks:

- **Hand trucks**, one of the most basic pieces of material handling equipment, feature a small platform to set the edge of a heavy object on, and a long handle to use for leverage. Whatever is being moved must be tipped so that it rests on the handle, and is carried at a tilt to its destination.

- **Pallet Trucks,** also known as pallet jacks, are a type of truck specifically for pallets. They slide into a pallet and lift it up to move it. Pallet trucks come in both manual and electrical types.
- **Walkie Stackers** transport and lift pallets like a forklift, though they don't include a place for the operator to ride in. They come in both powered or manual versions.
- **Platform trucks** are hand trucks low to the ground, with a wide platform for transporting goods.
- **Order pickers** lift the operator several feet above the ground on a platform so they can retrieve or store goods on high shelves.
- **Sideloaders**, also known as VNA (Very Narrow Aisle) trucks, are meant to fit in narrow warehouse aisles, as they can load objects from different directions. They're also good for long, awkward products that need moving.
- **Many types of AGV**, or automatic guided vehicles, as discussed above, shuttle products along a route automatically, without human guidance.

See more on trucks and carts in our other Thomas' Buying Guide: Types of Trucks and Carts.

4. Bulk Material Handling Equipment

Bulk material handling refers to the storing, transportation and control of materials in loose bulk form. These materials can include food, liquid, or minerals, among others. Generally, these pieces of equipment deal with the items in loose form, such as conveyor belts or elevators designed to move large quantities of material, or in packaged form, through the use of drums and hoppers.

- **Conveyors**, as mentioned above, come in a wide variety of types for different types of bulk material.
- **Stackers**, which are usually automated, pile bulk material onto stockpiles, moving between two points along rails in a yard.
- **Reclaimers** are the opposite of stackers, retrieving materials from stockpiles, some using bucket wheels to carry the material while others are scraper or portal style.
- **Bucket elevators**, also known as grain legs, use buckets attached to a rotating chain or belt to carry material vertically.
- **Grain elevators** are tall buildings specifically for storing grain. They include equipment to convey the grain to the top of the elevator, where it is sent out for processing.

- **Hoppers** are funnel-shaped containers that allow material to be poured or dumped from one container to another. Unlike a funnel, though, hoppers can hold material until it's needed, then release it.
- **Silos** are generally large storage structures for bulk materials, though they don't necessarily include equipment to convey the material to the top of the structure like grain elevators. Different varieties include tower, bunker, and bag silos.
- **Elevated lift tables** are available in hydraulic, pneumatic, and scissor lift versions, and are designed to slowly lift and lower heavy loads for easier transference to other handling equipment like forklifts. Lift tables are simple devices that can enhance productivity and ensure employee safety when used correctly.

INDUSTRIAL SAFETY

Industrial safety refers to the management of all operations and events within an industry in order to protect its employees and assets by minimizing hazards, risks, accidents, and near misses. Industrial safety is overseen by federal, state, and local laws and regulations. The Occupational Safety and Health Association (OSHA) is the primary regulatory body in the United States dedicated to ensuring industrial safety

"An industrial safety system is a countermeasure crucial in any hazardous plants such as oil and gas plants and nuclear plants. They are used to protect humans, industrial plants, and the environment in case of the process going beyond the allowed control margins."

In simple words: "The management of all operations and procedures in an industry in order to protect its employees and assets by minimizing hazards, risks, accidents, and near misses" called the Industrial Safety." Industrial safety covers a number of issues and topics affecting safety of personnel and the integrity of equipment in a particular industry.

The following topics are generally discussed:

General Safety – General aspects of safety which are common to all industries

Occupational Safety and Health – Particularly associated with the occupation

Process and Production Safety

Material Safety

Workplace Safety – Safety issues directly related to the workplace setting

Fire Safety

Electrical Safety – Arising from the equipment used

Building and Structural Safety – Including installations as per existing building code

Environmental Safety – Concerns the direct and indirect environmental impact of the industry

Objectives of Industrial Safety

A practical goal of industrial safety is to lighten the environmental impact on the manufacturing unit and each person and the role of the industrial safety professionals is to find leverage or opportunities for considerable improvement using practical effort. The objectives of industrial safety systems are as follows:

- Industrial safety is needed to check all the possible chances of accidents for preventing loss of life and permanent disability of any industrial employee, any damage to machine and material.
- It is needed to eliminate accidents causing work stoppage and production loss.
- It is needed to reduce workman's compensation, insurance rate, and all the cost of accidents.
- It is needed to achieve better morale among industrial employees.
- It is needed to increase production means to a higher standard of living.
- It is needed to prevent accidents in the industry by reducing any hazards.

Planning of Industrial Safety

In industries, the no. of fire hazards, accidents, industrial disasters may be reduced through careful safety planning. All those unfortunate events can be avoided by

effective planning for safety. Some important considerations for industrial safety are the following:

- Proper Plant Layout
- Proper Fire Prevention system
- Health & Hygiene
- Proper Safety Training
- Proper Alarms And warning systems
- Appropriate sensors and safety gears for employees
- Sufficient lighting in the work area as well as the pathways
- Cleanliness & dryness of shop floor
- Proper pressure gauges and other safety equipment Electrically insulation
- Proper signboards for safety instructions

Safety Programmes

A safety programme intends to identify when where and why accidents occur. On the same lines a safety programme aims at reducing accidents and associated losses. A safety programme is initiated with the assumption that it is possible to prevent most work connected accidents. A safety programme is a continuous process and tries to be decrease the influence of personal and environmental factors which cause accidents. Normally a safety programme consists of providing safety equipment's and special training to workmen or employees.

Indian standards Institute has done commendable job in this context and lays down as follows:

(i) Safety precautions to be taken during manifesting operations.

(ii) Standards for proper lighting, ventilation and proper layout of the industrial unit.

(iii) Standards and specifications of safe industrial operations and practices etc.

(iv) Requirements for effective maintenance of tools and equipment's

(v) Guidance on safe cutting and welding processes.

(vi) Guidance on use of powered industrial trucks, belt conveyors and fire protection equipment's.

(vii) Safety requirements for personal protective equipment's.

(viii) Classification of hazardous chemicals and provision of accident provision tags.

(ix) Markings for handling and labeling of dangerous items/ goods.

ERGONOMICS

Ergonomics is the science which deals with the relationship between man and his working environments. It takes care of factors governing the physical and mental strains. Ergonomics consists of words 'Ergo' (which means work), and 'Nomos' (which means 'Natural Laws'). This can also be termed as 'Human Engineering'. Ergonomics (or Human Engineering) is defined by I.L.O. (International Labour Organisation) as "the application of human biological sciences in conjunction with engineering sciences to the worker and his working environment so as to obtain maximum satisfaction for the worker which, at the same time, enhances productivity".

Thus ergonomics is a multi-disciplinary science comprising subjects like anatomy, psychology, physiology, sociology, engineering, anthropology, physics, and medicine. The task of ergonomics is to develop such conditions for workers, which are necessary to reduce physical workload, to improve working postures, facilitate instrument handling, and thus improves the quality of working life, reduce fatigue, maximise efficiency of production operators and to minimise human errors.

Ergonomics helps to study the effect of working environment on health and safety and in turn on productivity. The workers' interest in the job to a greater extent depends on how comfortable and safe is the workplace.

Objectives of Ergonomics:

1. To optimise the integration of man and machine in order to increase productivity with accuracy.

It involves in the design of:

(a) A work place suitable for the worker,

(b) Machinery and controls, so as to minimise mental and physical strain on the worker to enable the improvement in efficiency,

(c) A, favourable environment for performing the task most effectively,

(d) Task and work organisation,

2. To take care of the factors governing the physical and mental strain (i.e. fatigue) so as to get maximum satisfaction for the worker which at the same time enhances the productivity.

3. Attempts to minimize the risk of injury, illness, accidents and errors without compromising productivity.

4. To improve the design of machine at the initial design stage or later whenever the existing product or process is modified.

Ergonomics helps in:

(a) Developing most comfortable conditions related to climate, lighting, ventilation and noise level;

(b) Reducing the physical work load;

(c) Improving working postures and reducing efforts of certain movements;

(d) Making the handling of machine levers and controls easy;

(e) Increasing safety.

Design of Workplace:

Backaches, necaches, and other muscular strains due to bad seating and incorrect working posture are common in industry, where most of the jobs are performed by the operators either in sitting or standing in a fixed posture for a long duration.

The interaction of the operator with the immediate workspace around him is influenced by many factors such as seat design, the working desk and adjacent machine. These factors are responsible for the position and postures of the users and, hence their efficiency.

(a) Location of Tools and Materials:

All tools and materials required must be located within the normal grasp area and as far as possible in front of the worker. This will enable him to travel lesser distances to pick up and put these tools and materials frequently at desired place so as to save time and energy.

For the assembly work, it is advisable to provide such arrangement so that the components can slide along the smooth surface and the worker picks them up. It will greatly reduce the time and effort.

(b) Proper Chairs:

Chairs permitting proper posture for the workers must be provided. This is possible when the worker is working on the work bench (e.g. assembly, fitting and inspection etc.). Performing a job on floor in sitting position or on table in standing position requires more energy.

The height of chair and the work bench must be arranged in such a way so that the worker may not feel any difficulty while working. Their height must be such that the top of bench remains at the height of the elbow of the worker. If possible the height of the bench must be such that worker can work both in sitting and standing positions. Chairs must be provided with foot rests.

(c) Working desk:

All the tools and materials must be located within the normal grasp area and as close in front of the operator as possible. Experiment have shown that a semi-circular table having a radius of 20″ or 50 cm from a point at 4″ or 10 cm back (4″ or 10 cm gives approximately centre line of the operator shoulders and elbow) as shown in Fig. 53.1., allows a most comfortable position.

Working desk must be so designed so that use of both hands can be taken simultaneously. In the end, "work place layout" helps the analyst in determining the required body and eye motions of operators, safety measures and operational difficulties that may occur at working place.

d) Work Posture:

The posture that a workman needs to adopt to perform the task is an important consideration in the design of workplace. Incorrect posture can cause strain in back, waist, legs and hands. Ergonomic design of the seats include type of seat, seat height, back support, arm support, foot rests etc.

Ergonomics and Health:

Ergonomics is helpful in both the prevention of occupational diseases and promotion of health. Studies have suggested that many of the occupational diseases are connected to poor design of tools, machines, work place and work environment. To prevent cumulative/repetitive strain injuries, variety of health problems including visual fatigue, ergonomics play an important role to increase work efficiency and productivity.

Poor workplace layout and design are major factors contributing to workplace injuries as well as increasing the risk of sprain and strain injuries and occupational overuse injuries. It also make it difficult to deal with emergency situations. If poor workplace design means you have to work near noisy equipment or in areas where you may be exposed to hazardous substances, this can increase the risk of hearing loss and of chemical related health problems.

Ergonomic Principles in the Design of Work Systems:

The work system comprises a combination of people and work equipment acting together in the work process to perform the work task at the workplace in the work environment under the conditions imposed by the work task.

Various ergonomic principles which should be considered during design of various work systems are given here-under:

1. Design of Workspace and Work Equipment in Relation to Body Dimensions:

(a) Working height should be adopted to the body dimensions of the operator and to the kind of work performed.

(b) Seat and working desk should be designed as a unit to achieve the preferred body posture.

(c) Sufficient space should be provided for body movements.

(d) Controls should be within functional reach

(e) Grips and handles should suit the structure of the hand

2. Design in Relation to the Body Posture:

(a) Design of work should be such that it avoid unnecessary or excessive strain in muscles, joints and respiratory and circulatory systems.

(b) The operator should be able to alternate between sitting and standing.

(c) If high muscle is to be exerted, the chain of force through the body should be kept short and simple by allowing suitable body posture and providing appropriate body support.

(d) Body postures should not cause work fatigue from prolonged static muscular tension.

3. Design in Relation to the Muscular Strength:

(a) Strength requirements should be within physiological desirable limits.

(b) Maintenance of prolonged static tension in the same muscle should be avoided.

4. Design in Relation to Body Movement:

(a) Body movements should be in harmony with each other.

(b) A good balance should be established among body movement. Motion should be preferred to prolonged immobility.

(c) Movements with great accuracy requirements should not entail exertion of considerable muscular strength.

(d) Execution and sequencing of movements should be facilitated by guiding devices.

5. Design of Signals, Displays and Controls:

(a) Signals and displays should be selected, designed and laid out in a manner compatible with the characteristics of human perception.

(b) Controls shall be selected, designed and laid out in such a way as to be compatible with the movement of that part of the body by which they are operated.

(c) Control movement, equipment response and display information should be mutually compatible.

(d) Where controls are numerous they should be laid out so as to ensure safe, unambiguous and quick operation.

(e) Critical control should be safeguarded against inadvertent operations.

6. Design of the Work Environment:

(a) The work environment should be designed and maintained so that physical, chemical, biological conditions have no adverse effect on people, but serve to ensure their health, as well as their capacity and readiness to work.

Work environment should include adequate work space, air renewable, emission of pollutants, appliances consuming oxygen, thermal conditions, air temperature, air humidity, air velocity, thermal radiation, intensity of physical work involved, illumination, absence of glare and undesirable reflections, noise, distribution of working hours, vibrations, exposure to dangerous materials.

7. Design of the Work Process:

(a) The design of the work process should safe guard workers' health and safety, promote their well-being, and facilitate task performance, in particular by avoiding

overloading and under loading. Overloading produce fatigue, while under loading results in monotony which diminishes vigilance.

(b) The physical and psychological stresses exerted depend not only on factors considered above but also on the content and repetitiveness of operations and on the workers control over the work process.