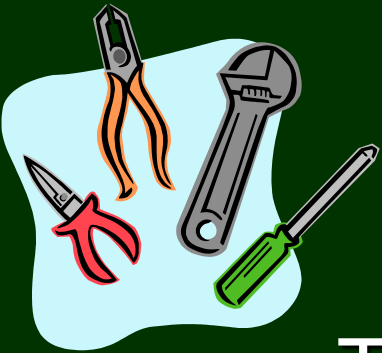


Chapter two: Types of maintenance



By: Belay A.

Different types of maintenance



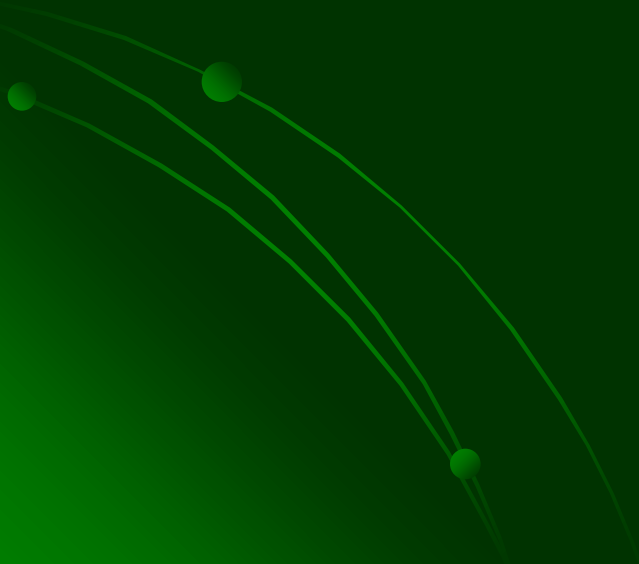
Types of maintenance can be

- Preventive
- Productive
- Predictive
 - Break down
 - Corrective



Productive maintenance

- The goal of the PM program is **to markedly increase production** while, at the same time, increasing employee morale and job satisfaction.



Preventive maintenance

- It is a daily maintenance (cleaning, inspection, oiling and re-tightening), design **to keep the healthy condition of equipment and prevent failure through the prevention of deterioration**, periodic inspection or equipment condition diagnosis, to measure deterioration. It is further divided into **periodic maintenance** and **predictive maintenance**.
- Just like human life is extended by preventive medicine, the equipment service life can be prolonged by doing preventive maintenance.

Predictive maintenance

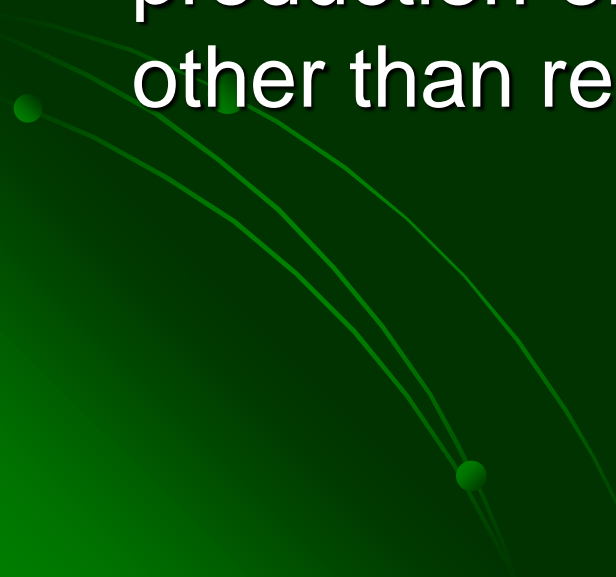
This is a method in which the service life of important part **is predicted based on inspection or diagnosis**, in order to use the parts to the limit of their service life. Compared to periodic maintenance, predictive maintenance is condition based maintenance. It manages trend values, by measuring and analyzing data about deterioration and employs a surveillance system, designed to monitor conditions through an on-line system.

Corrective maintenance

- It improves equipment and its components so that preventive maintenance can be carried out reliably. **Equipment with design weakness must be redesigned** to improve reliability or improving maintainability

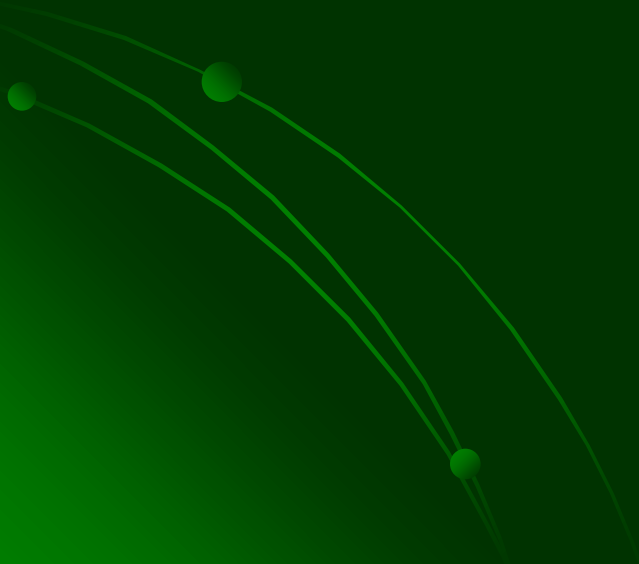


Breakdown maintenance

- It means that people waits until equipment fails and repair it. Such a thing could be used when the equipment failure does not significantly affect the operation or production or generate any significant loss other than repair cost.
- 


The maintenance function is performed mainly in two ways

- By prevention of break down.
- By the repair of break down.



Prevention of break down

Successful preventive maintenance can be achieved through two ways.


- Routine servicing between scheduled works
 - Periodic scheduled repair.
- 

Generally the action included in prevention can be :

- ❖ Preparation of plan for preventive maintenance adjusted to the specific requirements of the respective plant or installation.
- ❖ Preparation for execution (every thing required for the implementation
- ❖ Execution
- ❖ Feed back

Cont...

- Preventive maintenance covers all programmed maintenance which is **carried out in order to prevent the occurrence of failures or to detect failures before** they develop to a break-down or other disturbances in production.



Note: If a job will be classified as a preventive maintenance it should be programmed. That means that the maintenance will be decided in advance.


Routine servicing

Basic preventive activities taking place on a routine bases are :-

- Lubrication
- Adjustment
- Cleaning
- Inspection
- Routine work must be done by the **maintenance service** and as well as the **operator** of the machine.



Inspection

 Action to assess and determine the actual state of the technical means of a system.

- Actions included are :-
- Plan the inspection work knowing specific requirements of the respective plant.

This plan shall contain details like

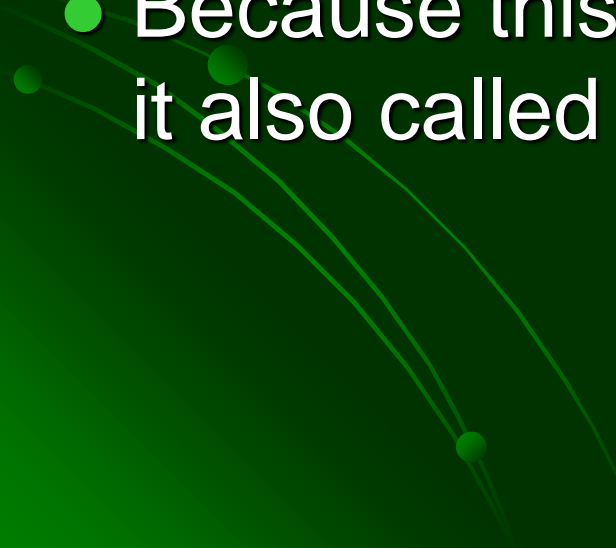
- ❑ Place
 - ❑ Date
 - ❑ Equipment
 - ❑ Method of inspection.
 - ❑ Characteristics to be considered. e.t.c
-
- Perform the work according to the plan
 - Reporting

Direct and indirect preventive maintenance.

Direct PM:

- The part where we are concentrated to prevent the occurrence of failure is called direct preventive maintenance because the condition will be influenced directly. Examples Lubrication, cleaning, etc

Cont...

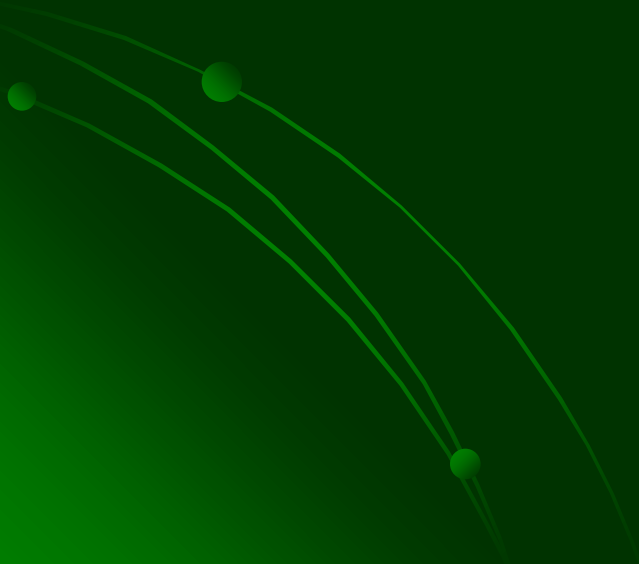
- The direct preventive maintenance activities are controlled by the **time** which can be calendar time, operation time, etc
 - Because this maintenance is fixed in time it also called **Fixed Time** Maintenance.
- 

Indirect PM

- Is done to find the failures in an early stage of their development by measuring or inspection and control the condition level.
- Indirect preventive maintenance is also called condition monitoring.
- Predictive,
- Condition based maintenance

Condition monitoring

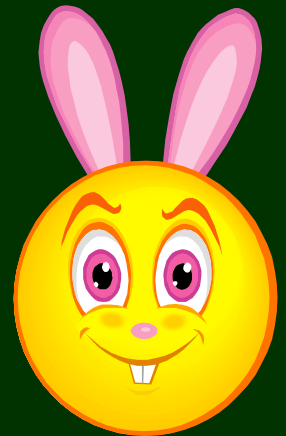
- Subjective condition monitoring
- Objective condition monitoring
- Continuous monitoring

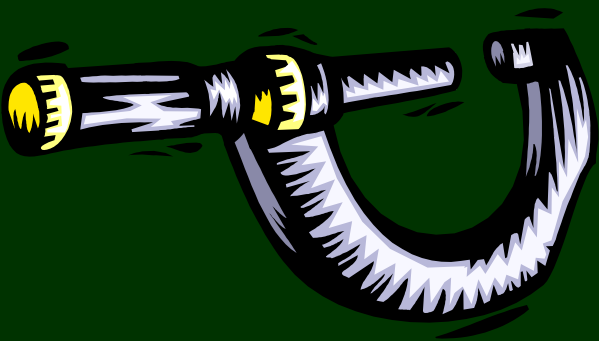




Subjective CM

- Subjective condition monitoring is when the monitoring is done by the man's senses such as listen, look, touch, taste and smell and out of that estimate the condition.





Objective CM

- Objective condition monitoring is when the condition of equipment is measured in some way instead of using the man's senses.
- E.g. using instruments
- **Continuous monitoring** also belongs to objective condition monitoring



- In a preventive maintenance system based on condition monitoring normally 70% is subjective and 30% objective condition monitoring.
- Why?




Periodic scheduled repair (planned preventive maintenance)

This planned preventive maintenance can be divided in to three main parts depending on the **volume of work** and the **duration between repairs**

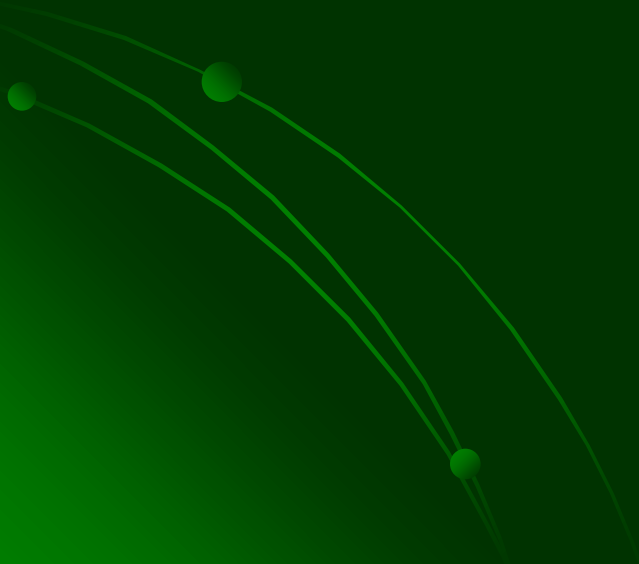
- Minor repair
- Medium repair
- Major overhaul.

Break down

- Break down can be understood as a condition of a plant or installation which does not fulfill the factors of evaluation.
 - It covers all failure of parts from minor adjustment to total machine collapse.
- 

Failure Modes

- Preventable but not prevented
- Preventable but not predicted
- Predicted but not acted upon
- Not preventable or predictable



After break down took place

Preventive solution

- Treatment of the cause but not effect:
- If the real cause of the problem is not corrected then further breakdowns are likely to occur.
- Preventive solution: - Restoration of equipment to its original condition is not necessarily the best solution to a break down problems, rather corrective maintenance can be a better solution.



Corrective maintenance (indirect preventive)

Actions to establish the required state of plants or installations.

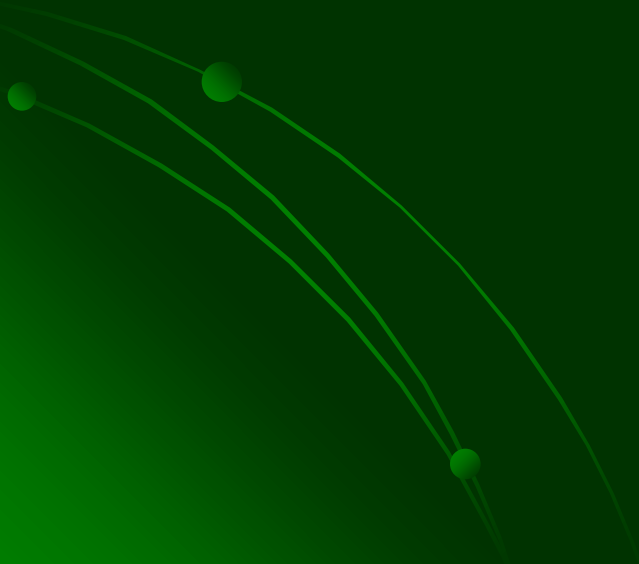
- Establish wear potential required for further utilization
- Improvement of components and elimination of weak points.

Actions in corrective maintenance comprise:

- Order documentation and analysis of content
- Indication and evaluation of alternative solution
- Decision for a solution
- Preparation of the execution including calculation, scheduling, coordination, provision of personnel, means and materials, preparation of working plans.
- Execution
- Functional test and acceptance.
- Completion report
- Evaluation

Regular planned preventive maintenance:

- Minor repair (small repair)
- Medium repair
- Major over hauls



Minor repair:

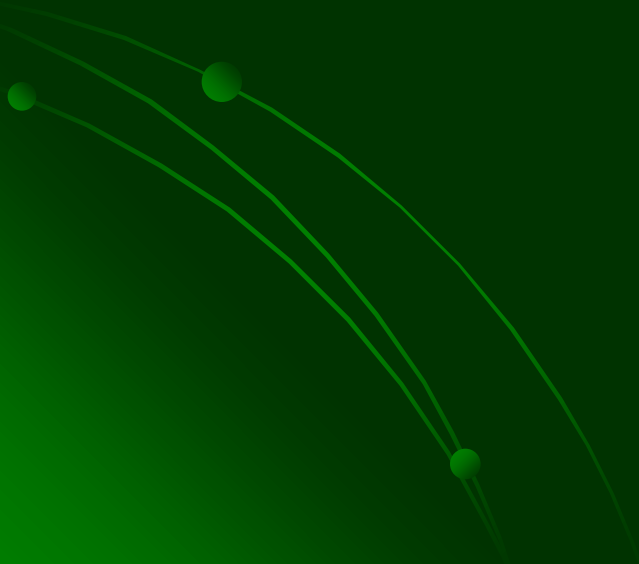
- Current repair under taken to restore **individual parts and assemblies** to working order.
- The scale of the work is comparatively small and is carried out on the spot at the machine.
- Workers: - shop or departmental maintenance fitters or shop mechanic.
- Time: - not longer than the time a machine is expected to be idle and is laid down in the maintenance schedule.
- If it is necessary to shut the equipment down the time for repair should never exceed that established for it.

Work to be done during minor repair:

- Replacement of damaged bolts, keys and worn parts;
- Cleaning and truing of key ways
- Filing of burrs(rough edges) from journals, bushes, and gear teeth;
- Mending or repairing of guards and protection devices;
- Welding of cracks.
- And all other minor maintenance activities mentioned under routine work.

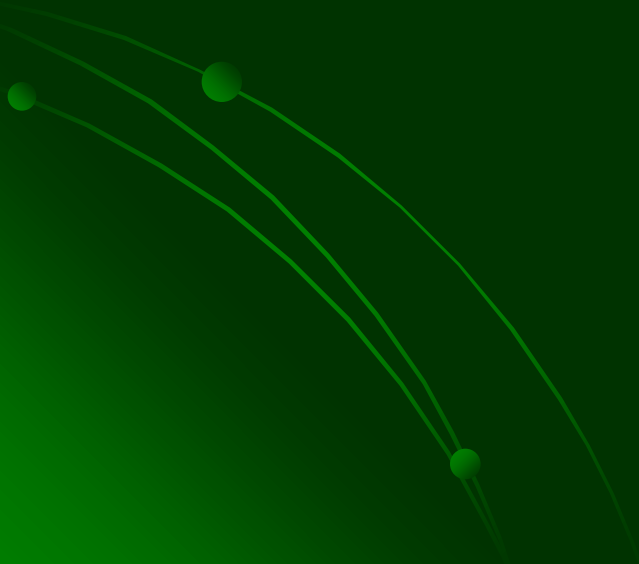
Cont...

- The total volume of minor repair in any period is about 20% of the volume of work of planned major over hauls.



The scale of work is determined from facts:

- Inspection report
- Manufacturers recommendation
- Experience
- Design modification



Medium repair:

- Medium repairs are minor over hauls and are carried out as planned in the maintenance schedule by the maintenance men.
- Medium repair include all maintenance activities which takes place during routine work and minor repair.

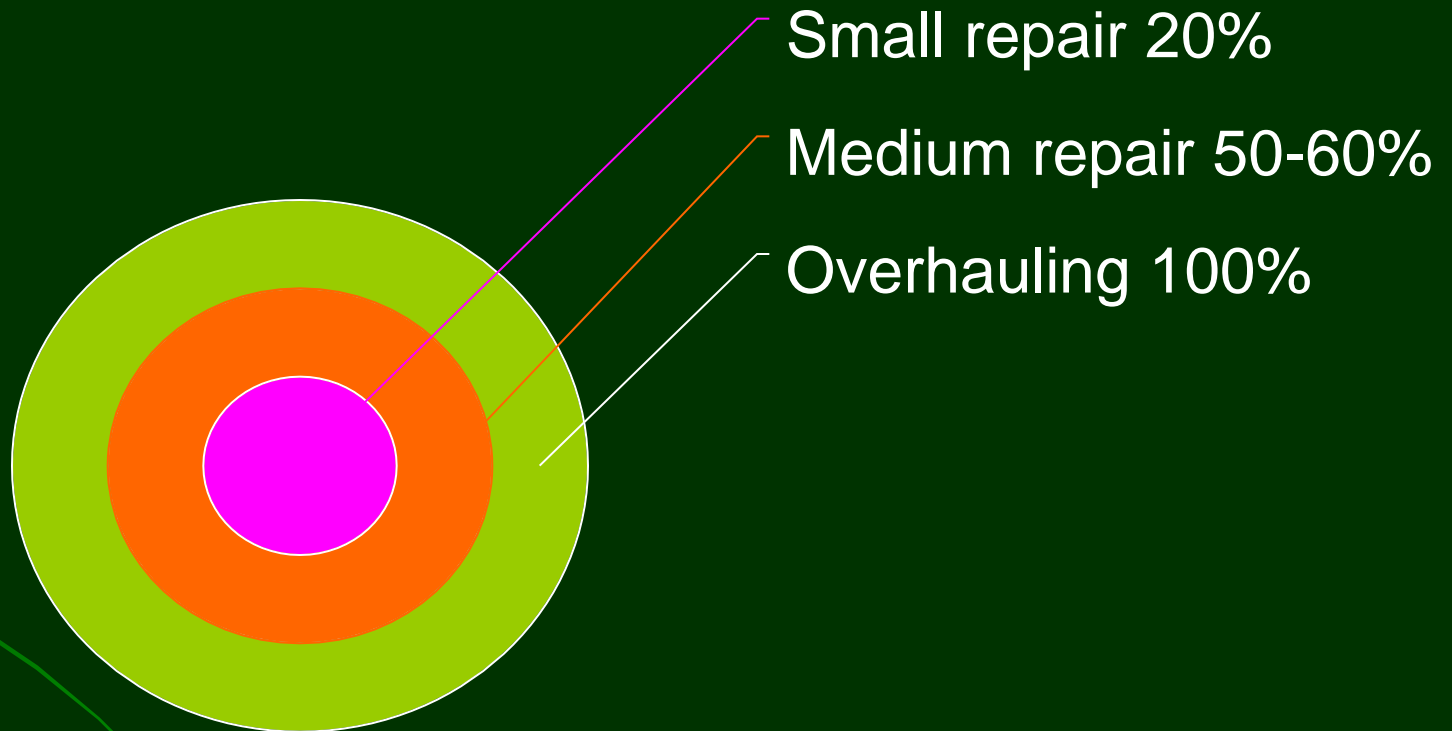
Work to be done

- Involves partial dismantling of the machine, but **not the foundation and frames**.
- Worn parts are replaced or repaired.
- **Mechanisms** are adjusted, and the accuracy is checked

Who?

- The work is supervised by the shop mechanic.
- Down time should not exceed the time laid down on the schedule
- The volume of work is about 50 to 60% of that of major over hauls.

Volume of work



Major over haul:


This is the largest scheduled repair work.

- It involves complete dismantling of the equipment
- Replacement or reconditioning of worn parts and assemblies including base plates.
- Units frequently have to be taken off their foundations.
- Over hauling is often combined with work to modify and modernize.

Cont...

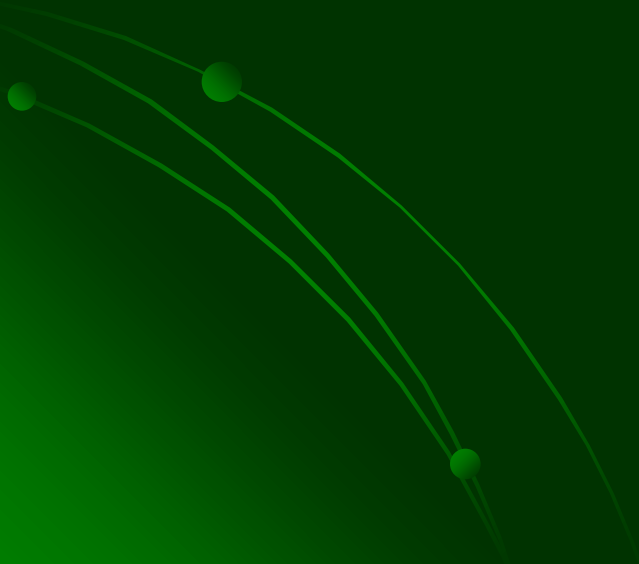
- All levels are checked and fixed
- All precision units are gauged and fixed.
- Reassemble and testing. dry running...
- Accuracy, power and capacity of the machine is checked.
- Delivered to normal operation.
- Down time, should not exceed the scheduled period.

The scale of work is determined from facts:

- Inspection report
 - Manufacturers recommendation
 - Experience
 - Design modification
 - **Statutory regulations** (equipments which may cause total shut down)
- 

Chapter three

- **Principles and horizons of Maintenance Management**



III Acceptance and procedure of equipment repair system

1. Acceptance of machines for repair



2. Disassembling the machine into units

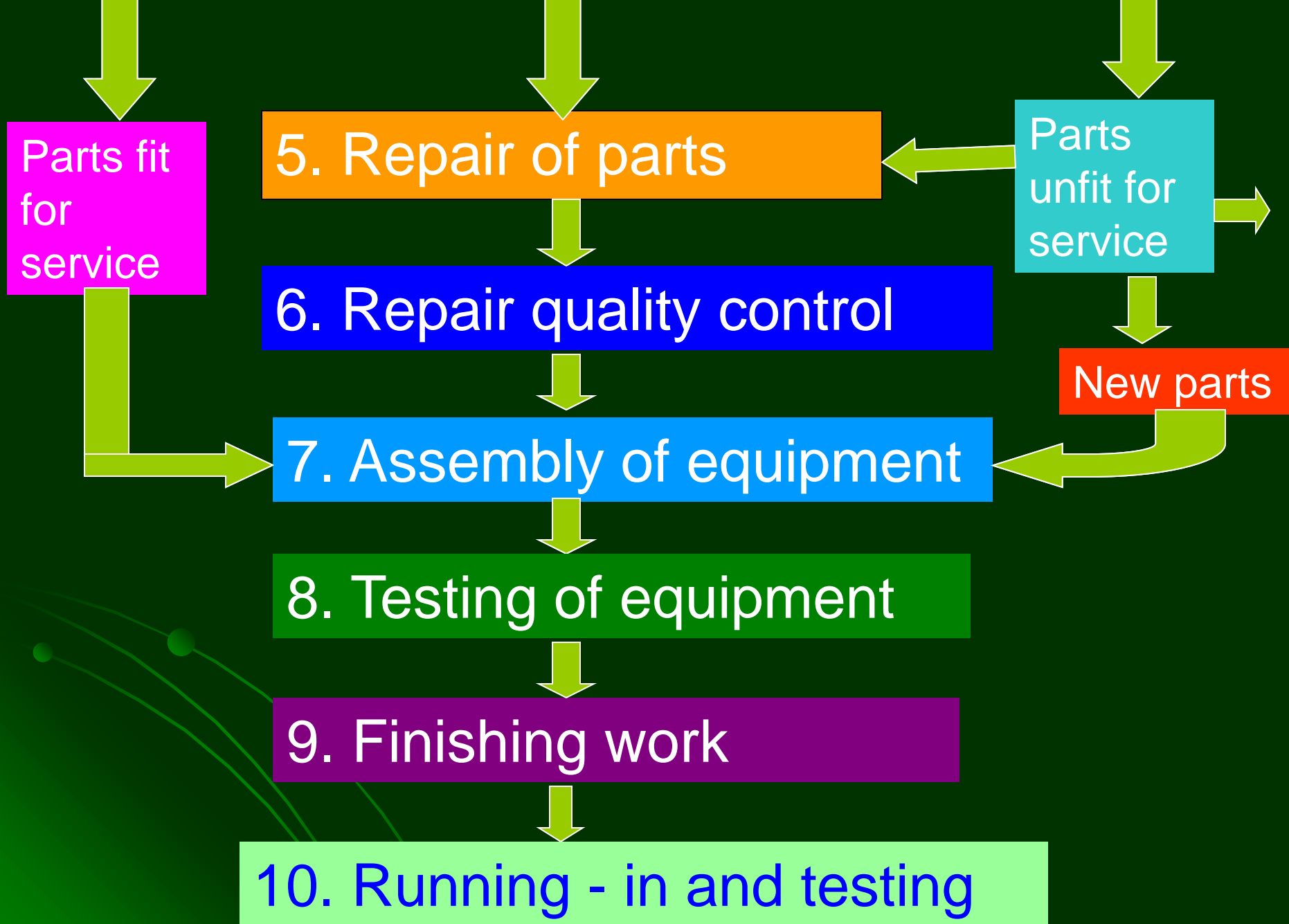


3. Cleaning and washing of parts



4. Inspection and sorting of parts





1. Acceptance of machines for repair

- All machines are accepted for major over haul or medium repair in **strict conformity** with the adopted schedule.
- If machine has to be accepted for medium repair, the maintenance head or responsible personnel makes out a **list of defects not latter than five days before the repair start.**
- For over hauling the list of defects must be written during the last medium repair. The list is specified and checked **10 days before** the beginning of the major over haul.

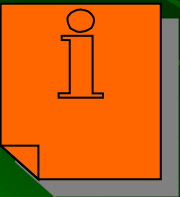
- This is done to determine the maintenance capacity for carrying-out the repair.

Maintenance capacity:

- Manpower (engineers- technicians - crafts men)
- Material (Spare parts- other consumable materials)
- Facilities (shop equipments, transporting equipments, air compressor)

The list of defects should contain:

- The enumeration of machines, mechanisms, and units, to be repaired.
- Parts to be replaced or restored
- Assessment of operational capability of the machine

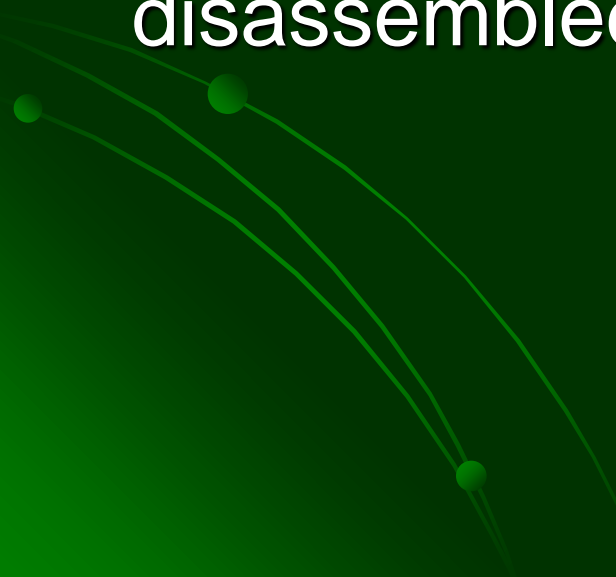


The list of defects is specified in the course of repairs.

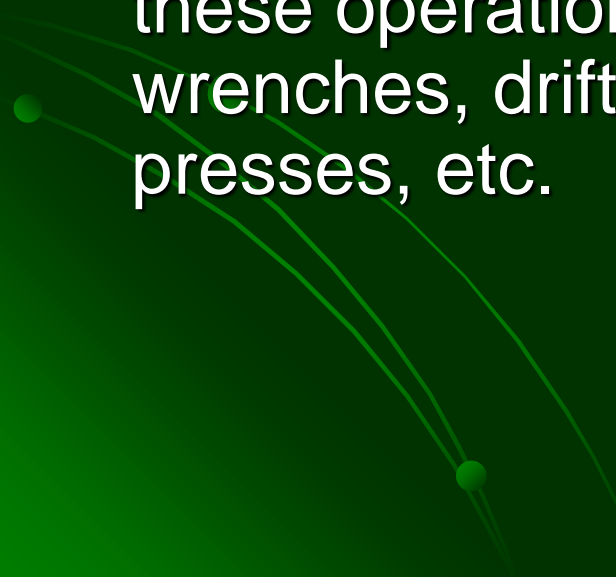
2. Disassembling the machine into units

- Disassembling is carried-out in reverse order as compared to the assembly. i.e. parts which are the last ones to be assembled are the first to be removed.
- Depending on the kind of the repair to be carried out, the disassembly may be **complete** (major over haul) or **partial** (medium repair).

Order of disassembling

- The machine is dismantled in to assembly units (groups)
 - The assembly units (Groups) are disassembled in to parts (elements).
- 

Different kinds of work carried out

- Nuts, bolts, pins and screws are screwed-in and out
 - Bushes, bearings and axles are un pressed .
 - Pulleys, gears and cams are removed.
 - Different kinds of tools and devices are used for these operations, such as:- mallets, hammers, wrenches, drifts, screw drivers, strippers, presses, etc.
- 

3.Cleaning and washing of parts.

- After they have been disassembled the parts are cleaned and if required washed.

The purpose:

prepare the surfaces of parts for inspection.



Materials and equipments used

- hand and mechanized brushes
- blowing with compressed air or by means of an industrial type vacuum cleaner.
- wire bent as a loop with loose pointed ends.
- metal brushes of low carbon steel wire.
- Brushes of fiber cord or other synthetic materials

- electric polishing machine

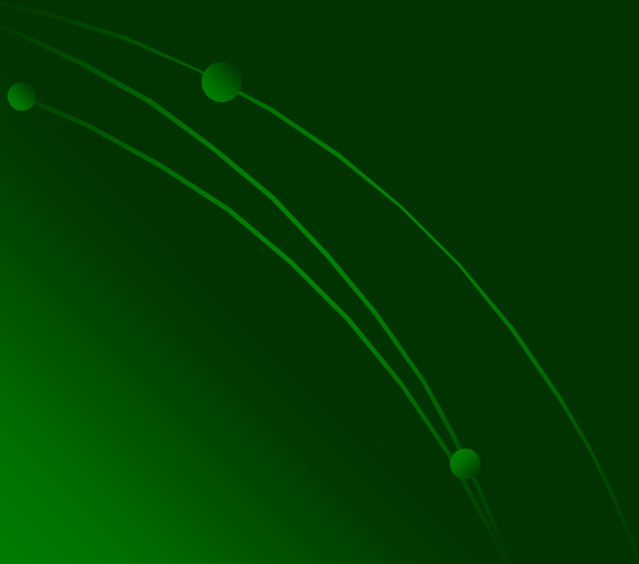
Washing procedure



For Reading

4. Inspection and sorting of parts

- The parts are sorted in three groups:
 - Fit for further use with out repair
 - Needing repair
 - Unserviceable

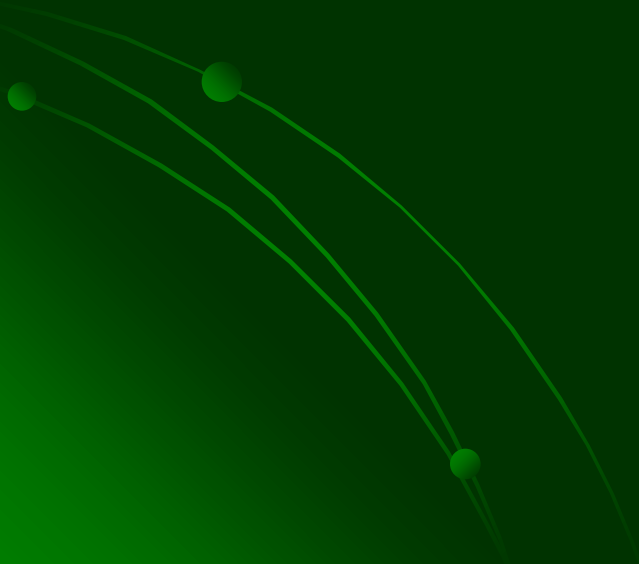


↪ **In the first one**:- the out ward appearance satisfies the specifications (there is no crack and other defects) , dimensions and degree of wear is allowable.

↪ **In the second group** :- parts with changed structural or repair dimensions due to wear having cracks and other defects which may be repaired.

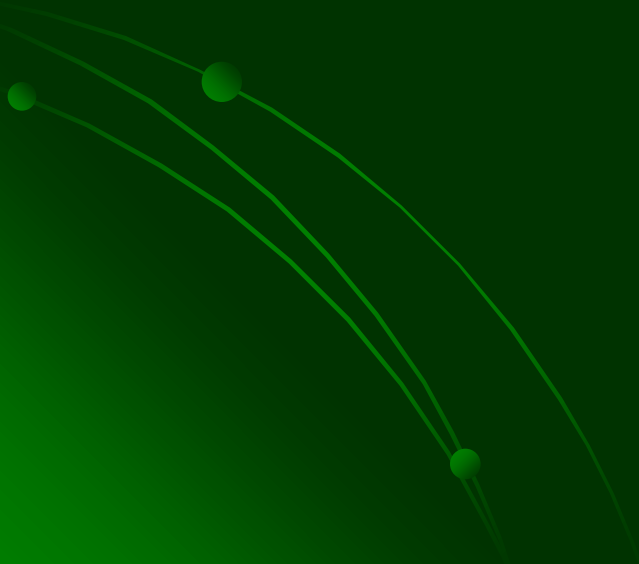
↪ **In the third group** :- parts which are badly worn, broken or cracked, very difficult to repair and **not worth** to be restored.

- Sorting of parts makes it possible to specify defects in the list which was established before disassembly of the machine.



The kinds of inspection and sorting of parts depends on the following classification.

- Movable important
- Stationary important
- Non important



5. Repair of parts

- 1. Shafts :
 - ↗ Bent shafts
 - ↗ Cracked and broken shafts
 - ↗ Worn out shafts
- 2. Gears :
 - ↗ Wear
 - ↗ Breakage of the teeth
 - ↗ Cracks in the rims and spokes
 - ↗ Crushing butt faces and hubs

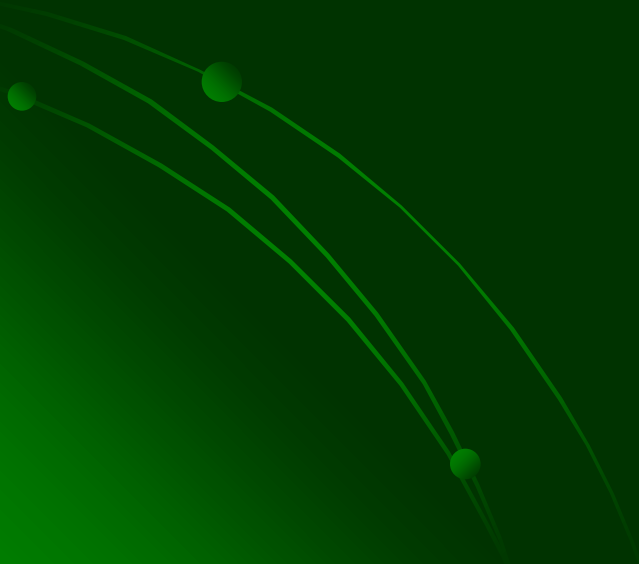
6. Repair quality control

- The quality of the repair work performed must be controlled.
- In the process of controlling the repair engineers are using the
standard machine – repair check – up sheet.

**THE PARTS AFTER REPAIR SHOULD
FIT THE REQUIRED SPECIFICATIONS!**

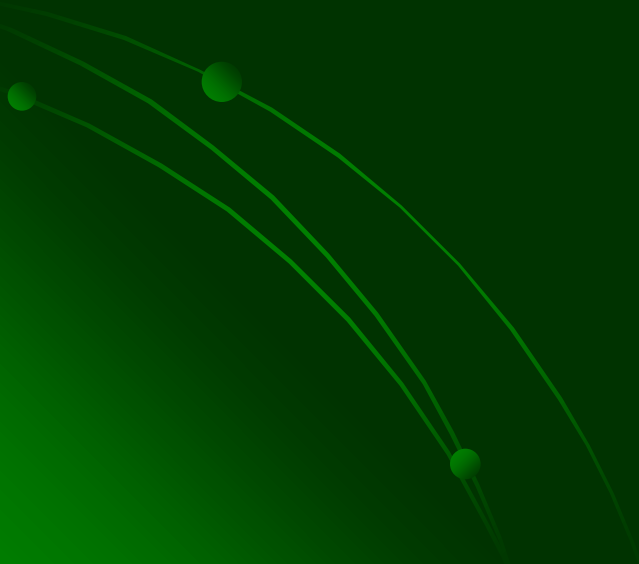
Assembly of equipment

- The proper operation of equipment depends on its correct assembly.
- After the parts pass through quality control they are received for assembly.



- Before assembly :
- ⌚ cleaned from dust , chips , scale , dirt , the contacting surfaces must be clean and with out impressions, scratches , indentations, etc
- ⌚ All joints and seals must be tight so as to avoid leakages.
- ⌚ Ball and roller bearings must be cleaned from oil and dirt, washed in an anti corrosion solvent and dried.

- The machine under repair should be assembled in full conformity with the requirements of assembly drawings.
- The order of assembly of a mechanism is opposite of disassembly



- The assembly of mechanisms can be divided in to classes of accuracy, depending upon the precision requirements.

- Standard (S)
- Improved (I)
- High (H)
- Supper high..... (SH)
- Ultra high – precision (U)

8. Testing of equipment

- After the machine assembly , it will be subjected to fitness tests.
- The technical condition of a repaired machine or it's assemblies is determined by :-
 - Visual inspection
 - No load and load tests
 - Mechanical out put

- Rigidity
- Geometric accuracy tests
- Precision and surface finish tests (for machine with cutting tools)
- ☆ **No load test** : started at the lowest rotational speed the machine under no-load test is then put in every one of its operating speeds gradually, from the lowest to the highest. To maintain the top speed the time of testing depends upon the type of machine.

9.Finishing work

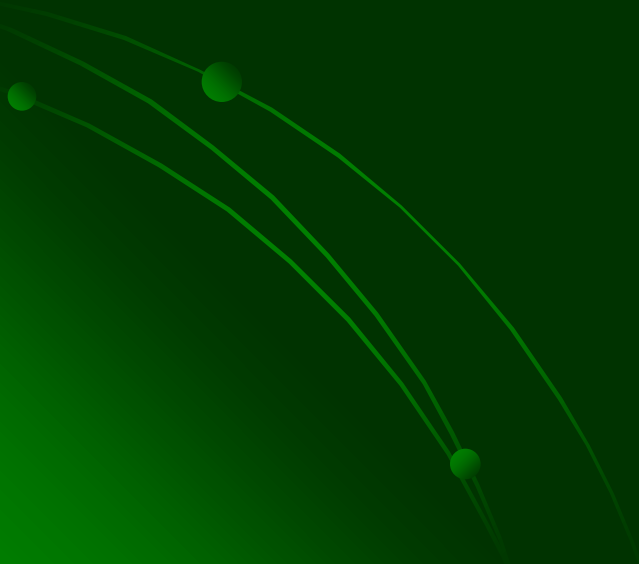
- The finishing work includes
- checking and cleaning of the mechanisms of the machine ,
- polishing , painting etc to give the machine the best external appearance and also to ensure the clean and safe pass of the products.

10.Final running - in and testing of machine


- The dry running - (with out loading) and
- The testing running (after loading)
- Time taken differs depending on the type and purpose of machine and some times it is given in the manufacturers instructions.
- Noise must be regular
- The oil packing and joints should not allow oil leakage
- ☆☆ ALL DEFECTS FOUND AND ELIMINATED SHOULD BE WRITTEN AND DOCUMENTED

Chapter four

- **Introduction to Reliability**



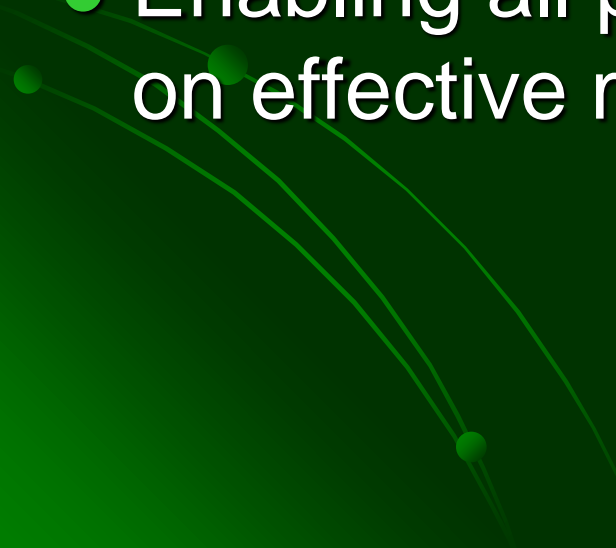
Maintenance planning and implementation

- Once we have decided to follow planned preventive type of maintenance we need to have reasonable plan which can be realized . To do that we have to follow the following steps.
- 

Phase 1 : Assessment

- Here the present situation of the intended work place (factory, machine shop...etc) is assessed.
- Problem identification survey is done.
- In this process the most responsible personnel must give their inputs. Seminars and meetings can be conducted.

Phase 2 : Preparation

- Seminars for top managers, on policy development.
 - Seminars on importance of planned maintenance.
 - Enabling all participants to get know- how on effective maintenance management.
- 

Phase 3 : Implementation and result generation

- Realization of action plans that are based on the steps outlined .
- During implementation , follow- up and monitoring is made.
- Problems encountered will be solved .

Phase 4 : Evaluation

- Evaluation is carried out by the organization applying planned maintenance.
- Some times external evaluators can be invited.
- Evaluation is done on **results achieved** or **impact made** on the total economy of the organization.
- Finally the work is approved.

Implementation steps

1. Make problem identification survey of machinery to be maintained.

- ☞ Is there enough time for maintenance ?
- ☞ Is mal- operation a cause for frequent stoppages of machine ?
- ☞ Are machines very old ?

- 2. Make problem identification survey of maintenance department.
- ☞ Is the number of maintenance crew, regarding the necessary type of trades' men enough?
- ☞ Is the maintenance department equipped with the required machine tools and equipments ?
- ☞ Are the maintenance crew equipped with the required tools?
- ☞ How many shifts is the maintenance department working?

- 3. Make problem identification survey of maintenance stores.

- ☞ Are the parts stored in order, so that, there is no difficulty to locate the needed item?
- Is the store keeper trained in store keeping ?

- 4. Make inventory of plant

- Carryout physical inventory of the plant with the object of planning the maintenance activities.

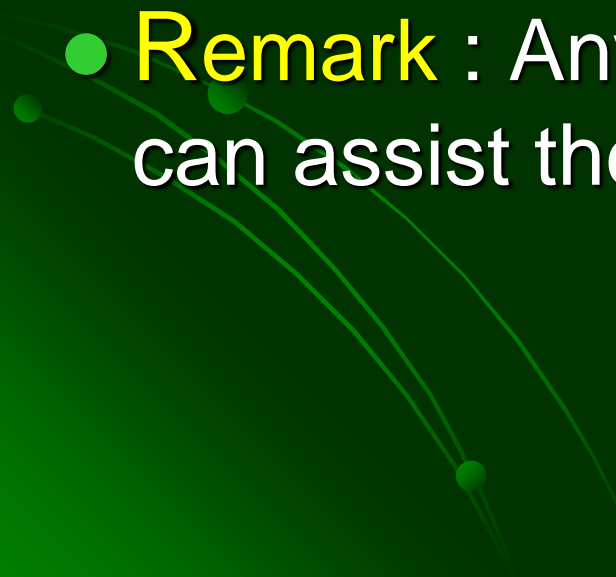


Inventory sheet can have the following form

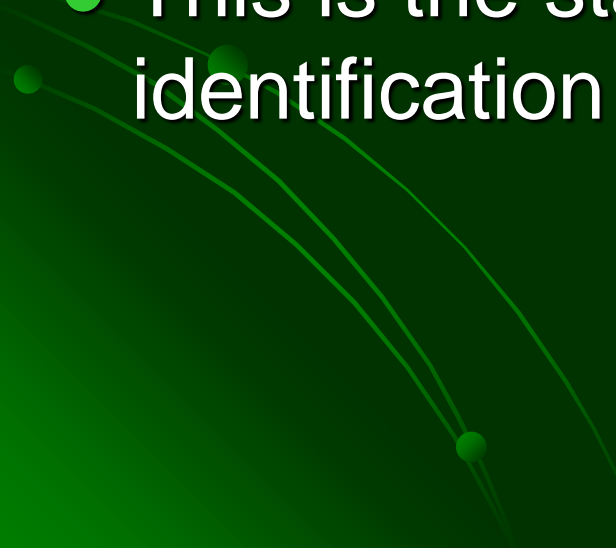
Identification number	Description of facility	Location	Type	Priority rating	Remark
1	2	3	4	5	6

Where :-

- **Identification number** : A number given to each item
- **Description of facility** : A brief description (can be name plate information)
- **Location** : Department , section or area where the item is found.

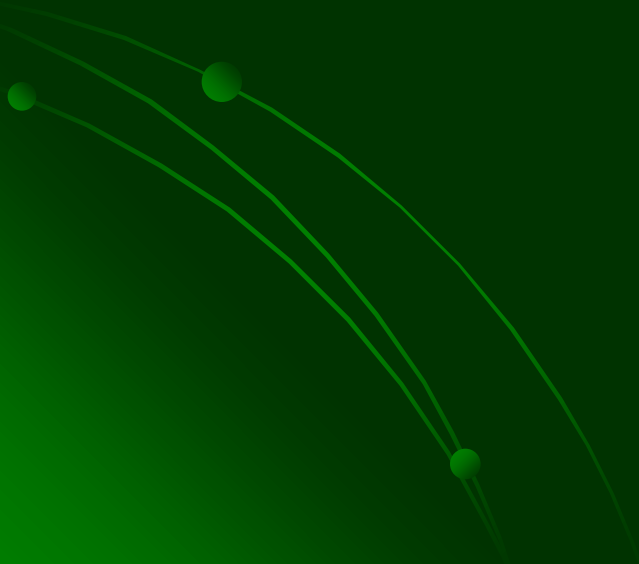
- **Type** : Mechanical or electricaletc
 - **Priority rating** : Indicating the relative importance of the item in the production process.
 - **Remark** : Any relevant information which can assist the planning.
- 

5. Draw block plan:

- Sketch of the machinery lay out, where the relative position of the machinery on the floor is shown.
 - This is the starting point to allocate identification number of the machines.
- 

6. Allocate identification number

- Although there are many different coding systems, numerical identification coding is a basic approach for a relatively big factory divided into various departments.



Example

Location index (building, dept., production line)	machine type index	Nº of machine
01 Blowing	01 Blending feeder 02 waste feeder 03 Horizontal opener	01..... 04 01. 02 01.....02
02 Carding		
03 Drawing		
04 Roving		

For example

- 01 02 04 is waste feeder machine number 04 which is found in the blowing room
- Analogically machine part can also be coded
- Example : G01 -- Gear box number 01
- M02 -- Motor number 02

7. Collect reference drawings , service manuals and technical details

- Reference drawings , service manuals and technical details can be valuable source of information if they are available when required.
- Sometimes they are found scattered in different offices, therefore, collecting, giving them reference numbers and filing is very important.

8. Collect plant log sheets, work records store requisitionsetc

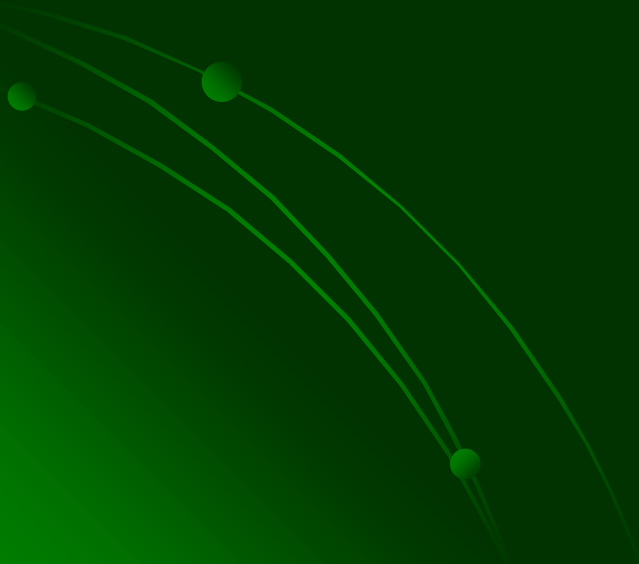
- Study past log sheets, work records and store requisitions and notes and summarize
 - Frequency and type of breakdowns,
 - Frequency and type of replacements,
 - Length of time and cost to carry out the various repairs, inspections and breakdowns,
 - Falling off efficiency over various periods of running time,
 - Allowable limits of wear, etc.

Interview for unrecorded information

- Maintenance personnel who have been working in the department for quite a long period (years) can be the sources of these kind of information.
- Operators working with the machine for a long time.
- Suppliers who are in contractual agreement for considerable period of time.
Etc.

10. Prepare maintenance list

- The volume of work and the maintenance cycle for each item and for each type of preventive maintenance is prepared.
- Volume of work in (I, S, M , O)



- ➤ Maintenance cycle

- Each machine and equipment will undergo the various maintenance stages in a cycle at various intervals of time. For example a machine could have a maintenance cycle as shown below:

