

Welcome to the class....

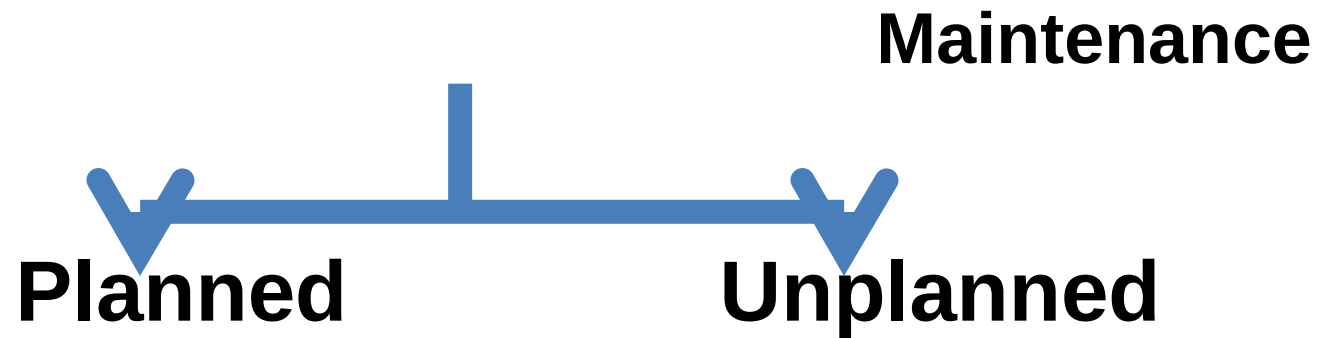
Maintenance Management (FRSI 2153)

Lecture 2 : TYPE OF MAINTENANCE

Lecturer:

Dr Shamsul Sarip (shamsuls.kl@utm.my)

Maintenance Types



Types of Maintenance

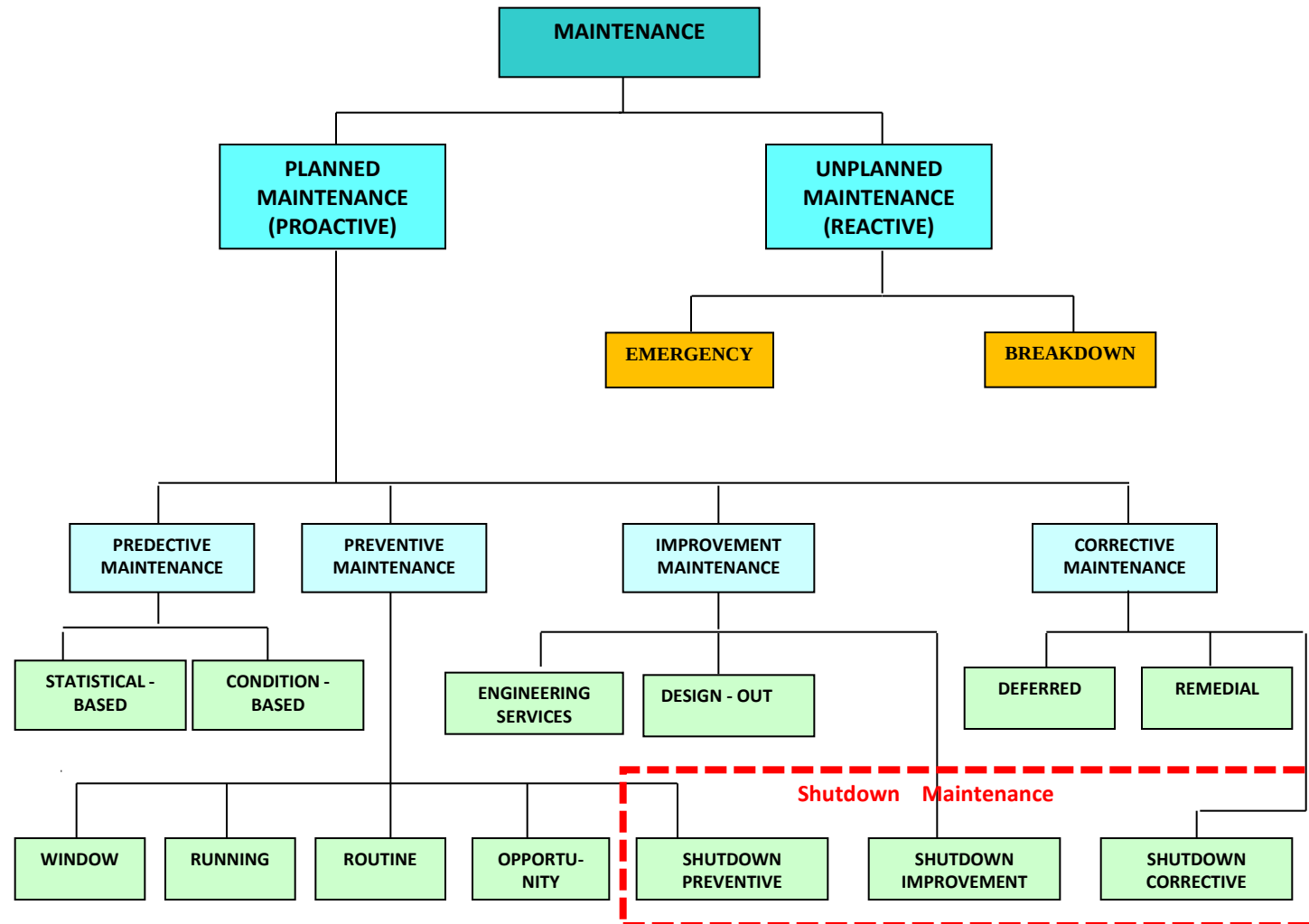


Figure 2.4 Maintenance Types

Unplanned Maintenance

- Repair will be conducted after the equipment fails
- Used when the equipment failure does not considerably affect the operations or generate any notable loss other than the repair cost



Unplanned Maintenance

Advantages

- Low maintenance cost
- Low maintenance staff

Disadvantages

- High down time
- Lower operational efficiency
- Low quality outputs
- Impaired health & safety conditions

Planned Maintenance

- Planned maintenance is organized and executed with **planning and control** by utilizing the application of recorded data.
- It encompasses condition based maintenance, which is planned and progressed information received about a system or company structure's condition.
- This information is gleaned from routine or continuous monitoring processes and preventative maintenance.

Advantages of Planned Maintenance

- Releases front-line foremen from major planning duties and allows them more time to supervise their crews.
- Provides **procedures to plan, execute, monitor and control maintenance resources.**
- **Reduces delays** in waiting for men, material, tools after a job is in progress.
- Provides systematic collection of materials prior to planned jobs.
- **Provides procedures** to implement and continue a PM program

Types of Maintenance

- **Run to Failure Maintenance (RTF)**
- **Preventive Maintenance (PM)**
- **Corrective Maintenance (CM)**
- **Improvement Maintenance (IM)**
- **Predictive Maintenance (PDM)**

Run to Failure Maintenance (RTF)

- The required repair, replacement, or restore action **performed on a machine or a facility after the occurrence of a failure** in order to bring this machine or facility to at least its minimum acceptable condition.
- It is the oldest type of maintenance.

Run to Failure Maintenance (RTF)

- It is subdivided into two types:
 - ✓ ***Emergency maintenance:*** it is carried out as fast as possible in order to bring a failed machine or facility to a safe and operationally efficient condition.
 - ✓ ***Breakdown maintenance:*** it is performed after the occurrence of an advanced considered failure for which advanced provision has been made in the form of repair method, spares, materials, labour and equipment.

Run to Failure Maintenance (RTF)

Disadvantages:

1. Its activities are expensive in terms of both direct and indirect cost.
2. Using this type of maintenance, the occurrence of a failure in a component can cause failures in other components in the same equipment, which leads to low production availability.
3. Its activities are very difficult to plan and schedule in advance.

Run to Failure Maintenance (RTF)

This type of maintenance is useful in the following situations:

1. The failure of a component in a system is unpredictable.
2. The cost of performing run to failure maintenance activities is lower than performing other activities of other types of maintenance.
3. The equipment failure priority is too low in order to include the activities of preventing it within the planned maintenance budget.

Preventive Maintenance (PM)

It is a set of activities that are performed on plant equipment, machinery, and systems **BEFORE THE OCCURRENCE OF A FAILURE** in order to protect them and to prevent or eliminate any degradation in their operating conditions.

Preventive Maintenance (PM)

British Standard 3811:1993 Glossary of terms defined preventive maintenance as:

*The maintenance carried out **at predetermined intervals or according to prescribed criteria** and intended to reduce the probability of failure or the degradation of the functioning and the effects limited.*

Preventive Maintenance (PM)

The advantage of applying preventive maintenance activities is to satisfy most of maintenance objectives.

Preventive Maintenance (PM)

- Principle : “Prevention is better than cure”
- Procedure : Stitch-in-time
- It ;
 - ✓ locates weak spots of machinery and equipments
 - ✓ provides them periodic/scheduled inspections and minor repairs to reduce the danger of unanticipated breakdowns

Preventive Maintenance (PM)

Factors that affect the efficiency of this type of maintenance:

1. The need for an **adequate number of staff** in the maintenance department in order to perform this type of maintenance.
2. The **right choice of production equipment** and machinery that is suitable for the working environment and that can tolerate the workload of this environment.
3. The required **staff qualifications and skills**, which can be gained through training.
4. The **support and commitment from executive management** to the PM programme.
5. The **proper planning and scheduling** of PM programme.
6. The ability to properly apply the PM programme.

Preventive Maintenance (PM)

- It is good for those machines and facilities which their failure would cause serious production losses.
- Its aim is to maintain machines and facilities in such a condition that breakdowns and emergency repairs are minimised.
- Its activities include replacements, adjustments, major overhauls, inspections and lubrications.

Preventive Maintenance (PM)

- Researchers subdivided preventive maintenance into different kinds according to the nature of its activities:
 - ✓ ***Routine maintenance (Schedule Maintenance)*** which includes those maintenance activities that are repetitive and periodic in nature such as lubrication, cleaning, and small adjustment.
 - ✓ ***Running maintenance*** which includes those maintenance activities that are carried out while the machine or equipment is running and they represent those activities that are performed before the actual preventive maintenance activities take place.

Preventive Maintenance (PM)

- ✓ ***Opportunity maintenance*** which is a set of maintenance activities that are performed on a machine or a facility when an unplanned opportunity exists during the period of performing planned maintenance activities to other machines or facilities.
- ✓ ***Window maintenance*** which is a set of activities that are carried out when a machine or equipment is not required for a definite period of time.
- ✓ ***Shutdown preventive maintenance***, which is a set of preventive maintenance activities that are carried out when the production line is in total stoppage situation.

Opportunistic Maintenance

- Reparation of the components which are found to be defective or needs replacement in the immediate future
- The components will be identified during the maintenance of a sub-system or a module
- *Example: identifying and rectifying a defective feeder, during the maintenance actions carried out for a faulty stitch cam in a knitting machine*



Routine Maintenance

- Includes activities which are performed in planned basis to maintain and protect the conditions of equipments /processes
- Most simplest type of planned maintenance
- *Oiling knitting machines in can be identified as an example*



Design Out Maintenance

- Design modifications to stop the failure from occurring
- Usually conducted based on the past experiences
- As an example; a design modifications conducted to a yarn feeding finger in a knitting machine to avoid having plating effect.
- Identification the fault and designing the finger will be conducted based on the past experience



Scheduled Maintenance

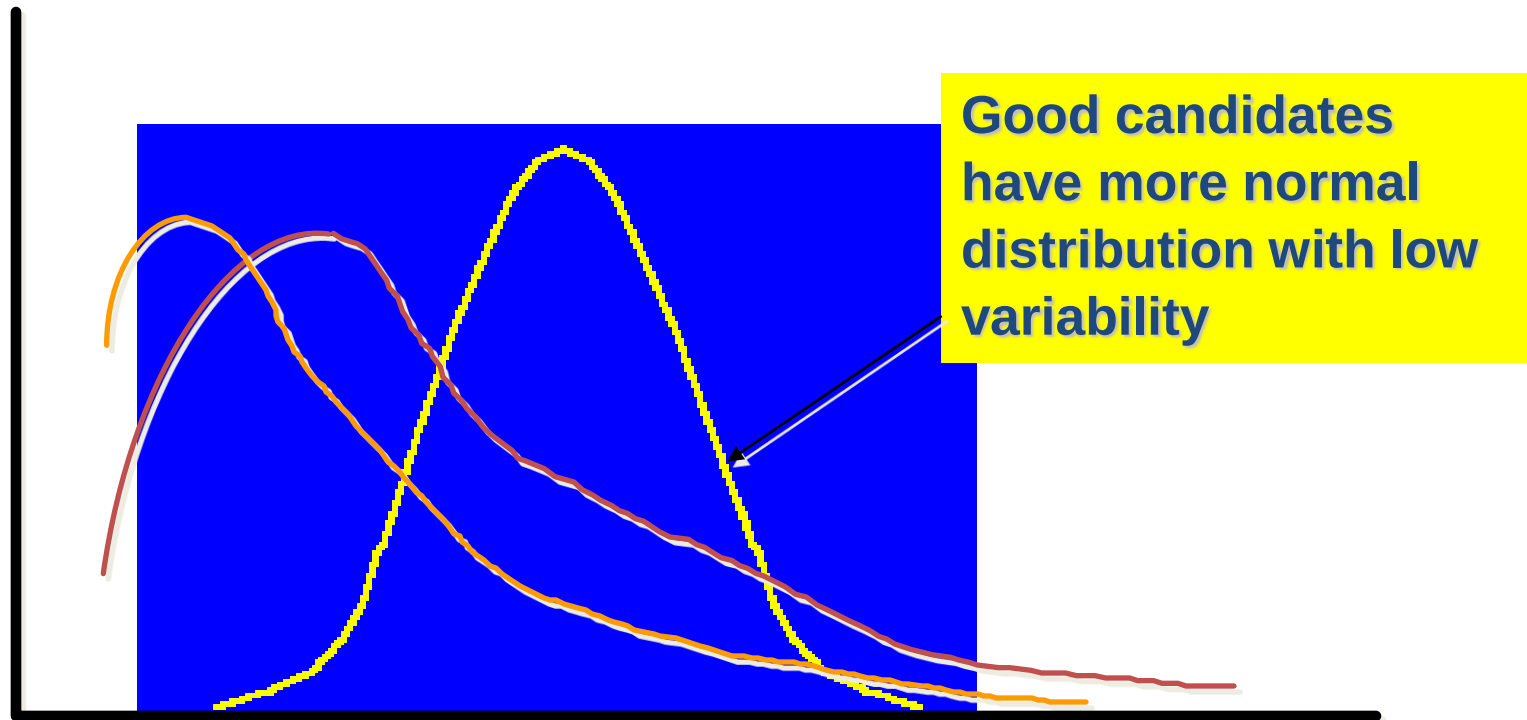
- Scheduled maintenance is a stitch-in-time procedure and incorporates
 - ✓ **inspection**
 - ✓ **lubrication**
 - ✓ **repair and overhaul of equipments**
- If neglected can result in breakdown
- Generally followed for:
 - ✓ **overhauling of machines**
 - ✓ **changing of heavy equipment oils**
 - ✓ **cleaning of water and other tanks etc.**

Advantages of PM

- Advantages:
 - ✓ Reduces break down and thereby down time
 - ✓ Less odd-time repair and reduces over time of crews
 - ✓ Greater safety of workers
 - ✓ Lower maintenance and repair costs
 - ✓ Less stand-by equipments and spare parts
 - ✓ Better product quality and fewer reworks and scraps
 - ✓ Increases plant life
 - ✓ Increases chances to get production incentive bonus

Candidates for Preventive Maintenance

Frequency of Failure



Mean Time Between Failure (MTBF)

Corrective Maintenance (CM)

- In this type, actions such as repair, replacement, or restore will be carried out after the occurrence of a failure in order to eliminate the source of this failure or reduce the frequency of its occurrence.

In the British Standard 3811:1993 Glossary of terms, corrective maintenance is defined as:

the maintenance carried out after recognition and intended to put an item into a state in which it can perform a required function.

Corrective Maintenance (CM)

- This type of maintenance is subdivided into three types:
- **Remedial maintenance:** a set of activities that are performed to eliminate the source of failure without interrupting the continuity of the production process.

The way to carry out this type of corrective maintenance is by taking the item to be corrected out of the production line and replacing it with reconditioned item or transferring its workload to its redundancy.

Corrective Maintenance (CM)

- ***Deferred maintenance***, which is a set of corrective maintenance activities that are not immediately initiated after the occurrence of a failure but are delayed in such a way that will not affect the production process.
- ***Shutdown corrective maintenance***, which is a set of corrective maintenance activities that are performed when the production line is in total stoppage situation.

Corrective Maintenance (CM)

- *The main objectives of corrective maintenance* are the maximisation of the effectiveness of all critical plant systems, the elimination of breakdowns, the elimination of unnecessary repair, and the reduction of the deviations from optimum operating conditions.
- *The difference between corrective maintenance and preventive maintenance* is that for the corrective maintenance, the failure should occur before any corrective action is taken.
- *Corrective maintenance is different from run to failure maintenance* in that its activities are planned and regularly taken out to keep plant's machines and equipment in optimum operating condition.

Corrective Maintenance (CM)

- The way to perform corrective maintenance activities is by conducting four important steps:

- 1. Fault detection**
- 2. Fault isolation**
- 3. Fault elimination**
- 4. Verification of fault elimination**

In the fault elimination step several actions could be taken such as adjusting, aligning, calibrating, reworking, removing, replacing or renovation.

Corrective Maintenance (CM)

- Corrective maintenance has several prerequisites in order to be carried out effectively:
 1. Accurate identification of incipient problems.
 2. Effective planning which depends on the skills of the planners, the availability of well developed maintenance database about standard time to repair, a complete repair procedures, and the required labour skills, specific tools, parts and equipment.
 3. Proper repair procedures.
 4. Adequate time to repair.
 5. Verification of repair.

Disadvantages of Corrective Maintenance

- Breakdown generally occurs inappropriate times leading to poor and hurried maintenance
- Excessive delay in production & reduces output
- Faster plant deterioration
- Increases chances of accidents and less safety for both workers and machines
- More spoilt materials
- Direct loss of profit
- Can not be employed for equipments regulated by statutory provisions e.g. cranes, lift and hoists etc

Improvement Maintenance (IM)

- It aims at reducing or eliminating entirely the need for maintenance.
- This type of maintenance is subdivided into three types as follows:

1. Design-out maintenance : a set of activities that are used to eliminate the cause of maintenance, simplify maintenance tasks, or raise machine performance from the maintenance point of view by redesigning those machines and facilities which are vulnerable to frequent occurrence of failure and their long term repair or replacement cost is very expensive.

Improvement Maintenance (IM)

2. *Engineering services:* includes construction and construction modification, removal and installation, and rearrangement of facilities.

3. *Shutdown improvement maintenance:* a set of improvement maintenance activities that are performed while the production line is in a complete stoppage situation.

Predictive Maintenance (PDM)

- Predictive maintenance is a set of activities that **detect changes in the physical condition of equipment** (signs of failure) in order to carry out the appropriate maintenance work for maximising the service life of equipment without increasing the risk of failure.
- It is classified into two kinds according to the methods of detecting the signs of failure:
 - *Condition-based predictive maintenance*
 - *Statistical-based predictive maintenance*

Improvement Maintenance (IM)

- *Condition-based predictive maintenance (CBM)* depends on continuous or periodic condition monitoring equipment to detect the signs of failure.
- *Statistical-based predictive maintenance* depends on statistical data from the meticulous recording of the stoppages of the in-plant items and components in order to develop models for predicting failures.

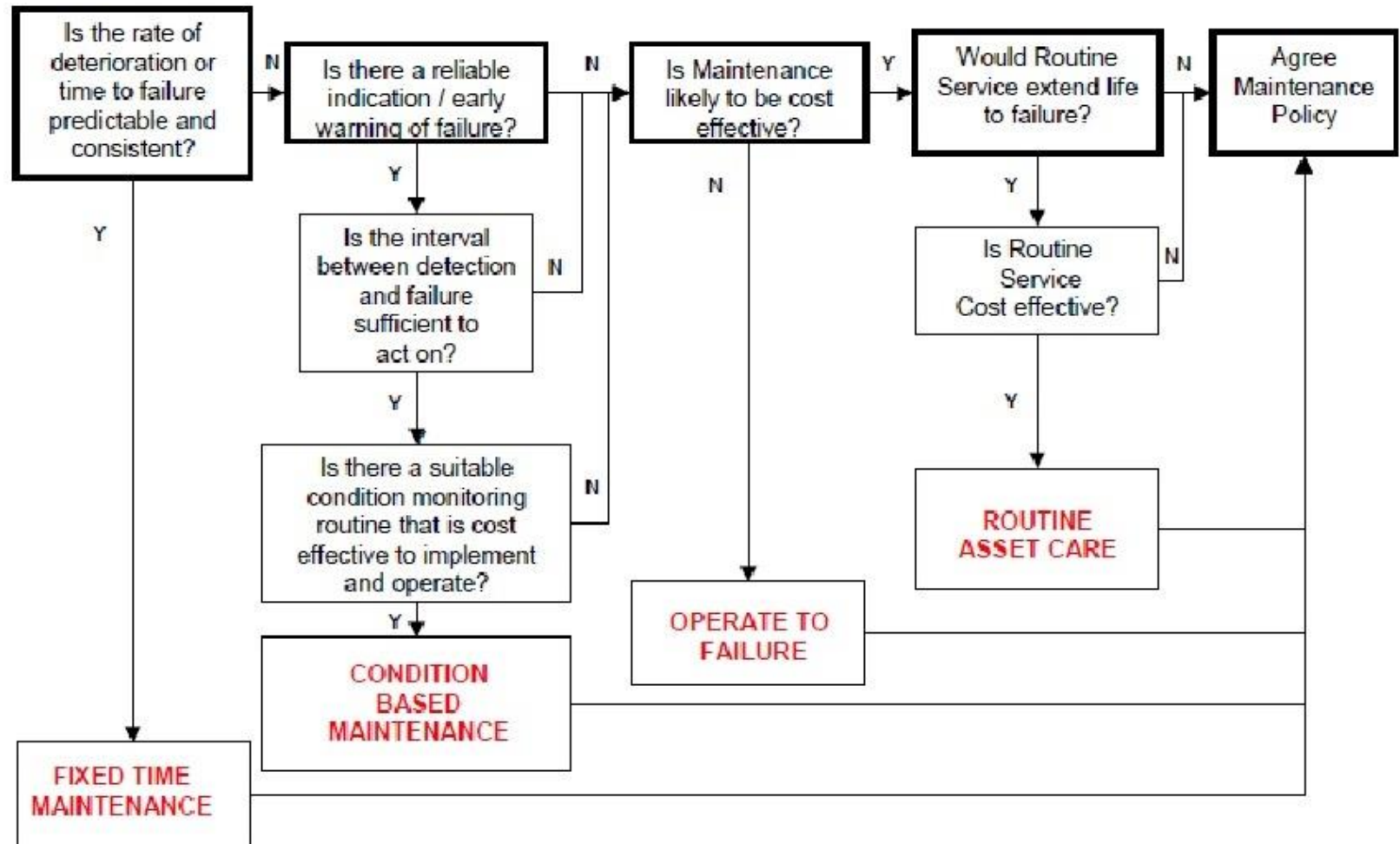
Predictive (Condition-based) Maintenance

- In predictive maintenance, machinery conditions are periodically monitored and this enables the maintenance crews to take timely actions, such as machine adjustment, repair or overhaul
- It makes use of human sense and other sensitive instruments, such as
 - ✓ **audio gauge, vibration analyzer, amplitude meter, pressure, temperature and resistance strain gauges etc.**

Predictive (Condition-based) Maintenance

- The drawback of predictive maintenance is that it **depends heavily on information and the correct interpretation** of the information.
- Some researchers classified predictive maintenance as a type of preventive maintenance.
- The **main difference** between preventive maintenance and predictive maintenance is that *predictive maintenance uses monitoring the condition of machines or equipment to determine the actual mean time to failure* whereas *preventive maintenance depends on industrial average life statistics*.

Maintenance Decision Diagram



Exercise 1: Group

- Based on your experience at workplace, identify and describe the type of maintenance adopted by your organisation/firm.
- What are the advantages and drawbacks.
- How does the maintenance cost affect the overall costs?