CHAPTER 1: The maintenance Function

1.1. DEFINITION OF MAINTENANCE:

Maintenance is defined as the set of processes and activities aimed at keeping or restoring equipment, machinery, and infrastructure in a specified operational condition. It encompasses a variety of actions, including functional checks, servicing, repairs, and replacements necessary to ensure that assets perform their intended functions effectively. According to the European standard NF EN 13306, maintenance includes all technical, administrative, and managerial actions throughout the lifecycle of an asset, with the goal of retaining or restoring it to a state where it can fulfill its required functions. This definition highlights the importance of both preventive measures—such as routine inspections and servicing—and corrective actions taken after failures occur. Overall, maintenance is crucial for ensuring the reliability and longevity of equipment and systems across various sectors, including industrial, commercial, and residential environments.

Objective :

Maintenance departments need to establish their objectives in alignment with the company's policies. The objectives can affect all aspects of management with deadline details:
-Financial.
-Technical.
- Human.

1.2. MAINTENANCE CONCEPTS:

The analysis of the different forms of maintenance is based on four principal concepts:

* The events which are at the origin of the action: reference to a schedule, subordination to a type of event (self-diagnosis, information from a sensor, measurement of wear, etc.), the appearance of a failure.
* The maintenance methods which will be respectively associated with them: systematic preventive maintenance, conditional preventive maintenance, corrective maintenance.
* Maintenance operations themselves: inspection, control, troubleshooting, repair, etc.
* Related activities: improvement maintenance, renovation, reconstruction, modernization, new works, security, etc.

This terminological and conceptual reflection represents a reference base for:

- The use of a common language for all parties (design, production, service providers, etc.)
- The implementation of computerized maintenance management systems.

1.3. Maintenance methods:

The choice between maintenance methods is made within the framework of the maintenance policy and must be made in agreement with the company's management.

To choose, you must know:

- Management objectives.
- Maintenance policy directions.
- The operation and characteristics of the equipment.
- The behavior of the equipment in operation.
- The conditions of application of each method.
- Maintenance costs.
- Costs of lost production.

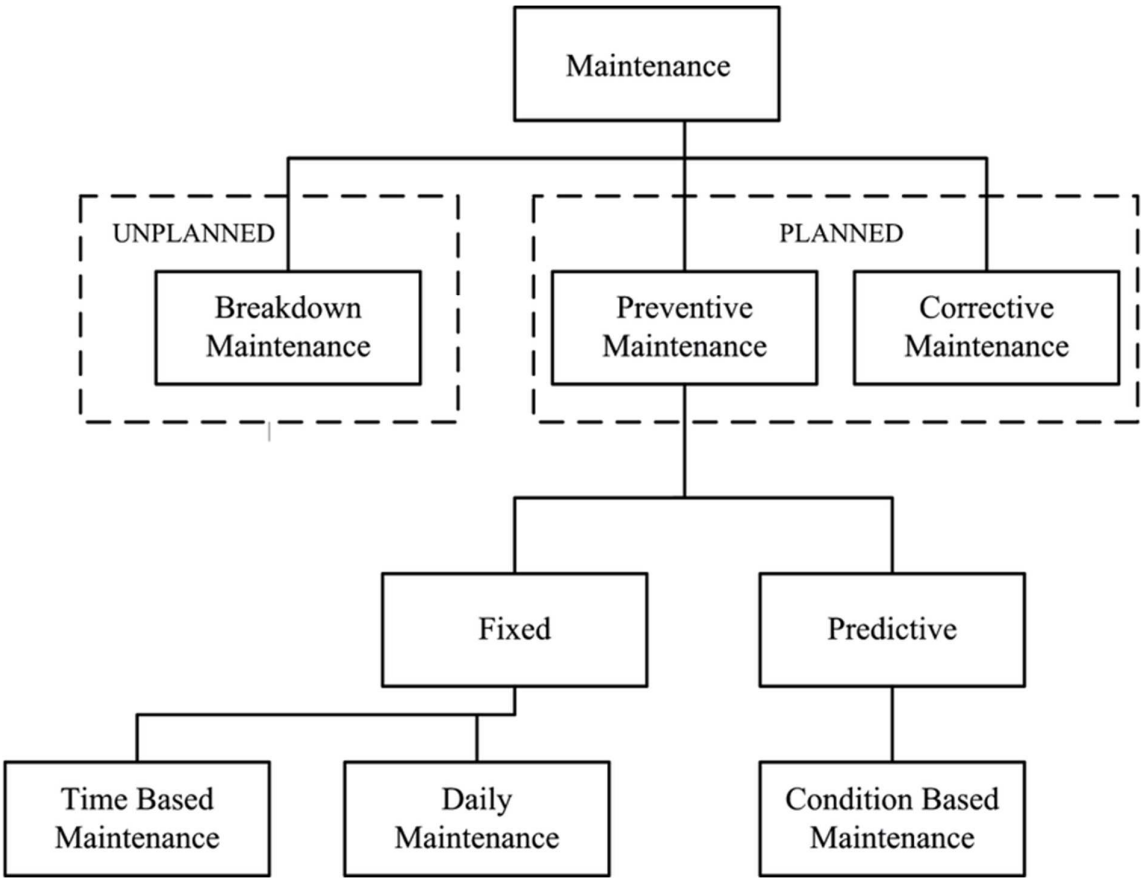

Figure 1.1. Maintenance methods.

Here's a schematic overview of different types of maintenance methods, their intervention conditions, applications, and how they assist in diagnosis:

Table 1.1. Applications and help in diagnosis of maintenance methods.

Maintenance type	Intervention conditions	Applications	Help in diagnosis
Preventive Maintenance	Scheduled based on time or usage; before failure occurs	Regular inspections, lubrication, parts replacement	Identifies potential issues early through routine checks
Corrective Maintenance	After a failure occurs; reactive to equipment breakdowns	Repairing equipment to restore functionality	Diagnoses faults post-failure to determine necessary repairs
Predictive Maintenance	Based on data analytics and condition monitoring	Forecasting maintenance needs using real-time data	Utilizes sensor data to predict failures before they occur
Condition-Based Maintenance	Monitors equipment condition; interventions based on actual status	Real-time monitoring using techniques like vibration analysis	Detects early signs of wear or failure through condition assessments
Time-Based Maintenance (TBM)	Fixed intervals regardless of condition; periodic checks	Routine maintenance tasks performed at set times	Helps establish a baseline for performance and identify deviations
Risk-Based Maintenance (RBM)	Prioritizes maintenance based on risk assessment	Focuses resources on high-risk assets	Analyzes potential failure impacts to prioritize maintenance efforts
Failure Finding Maintenance (FFM)	Scheduled inspections to detect hidden failures	Regular checks to uncover latent issues	Identifies undetected failures that could lead to operational problems
Total Productive Maintenance (TPM)	Involves all employees in maintenance activities	Enhances overall equipment effectiveness	Promotes a culture of proactive identification of issues

1.4. MAINTENANCE TYPES:

There are two most important maintenance:

1.4.1. Corrective maintenance:

Corrective maintenance is defined as the maintenance task performed to identify, isolate, and rectify faults in equipment, machines, or systems to restore them to operational condition. This type of maintenance occurs after a failure has been detected and aims to return the asset to a state where it can perform its intended function. Corrective maintenance can be categorized into two types: **immediate corrective maintenance**, which is initiated right after a failure, and **deferred corrective maintenance**, which is scheduled for a later time based on specific maintenance protocols. It is essential for addressing both planned repairs following inspections and unplanned repairs that arise during operations.

There are two main factors in corrective maintenance, corrective maintenance operations and time in corrective maintenance, that are explain below:

a- Corrective maintenance operations:

After a failure appears, the maintainer must implement a certain number of operations, the definitions of which are given below. These operations are carried out in stages (in order):

- **test** : i.e. the comparison of measurements with a reference.
- **detection** or action of detecting the appearance of a failure.
- **location** or action leading to the precise search for the elements through which the failure manifests itself.
- **diagnosis** or identification and analysis of the causes of the failure.
- **troubleshooting, repair** or restoration (with or without modification).
- **check** that it is functioning correctly after intervention.
- **possible improvement** : i.e. avoid the reappearance of the fault.
- **history** or storage of the intervention for later use.

b- Time in corrective maintenance:

Since corrective maintenance actions are very diverse, it is always difficult to predict the intervention duration:

- It can be low (from a few seconds to reset a circuit breaker or change a fuse to a few minutes to change a leaking joint).
- It can be very significant (from 0.5 to several hours) in the case of changing several organs simultaneously (engine flooded by a flood).
- It can be major in the event of the death of a man (several days if police investigation).

The maintenance manager must therefore take these distortions into account and have at his disposal a team that is “responsive” to random events. To reduce the duration of interventions, and therefore direct and indirect costs (equipment unavailability costs), we can:

- Implement rational and standardized intervention methods (specific tools, standard exchanges, adapted logistics, etc.) .
- Take into account the maintainability of equipment from the design stage (accessible inspection hatch, visible wear indicators, etc.) .

1.4.2. Preventive maintenance:

Maintenance carried out according to predetermined criteria, with the intention of reducing the probability of failure of an asset or degradation of a service provided.
It must make it possible to avoid failures of equipment in use.
The cost analysis must highlight a gain in relation to the failures it avoids.

Objectives of preventive maintenance:

- Increase the lifespan of the equipment.
- Reduce the probability of failures in service.
- Reduce downtime in the event of a service or breakdown.
- Prevent and also plan for costly corrective maintenance interventions.
- Allow corrective maintenance to be decided in good conditions.
- Avoid abnormal consumption of energy, lubricant, etc.
- Improve the working conditions of production staff.
- Reduce the maintenance budget.
- Remove the causes of serious accidents.

a- Systematic preventive maintenance:

This is preventive maintenance carried out according to a schedule established according to time or the number of units of use.
Even if time is the most common unit, other units can be used such as:
The quantity, length and mass of the products produced, the distance traveled, the number of cycles performed, etc.
This intervention frequency is determined from commissioning or after a complete or partial overhaul.
This method requires knowing:

- The behavior of the material.
- Modes of degradation.
- The average time of good operation between 2 failures.

Application case:

- Equipment subject to current legislation (regulated safety): lifting devices, fire extinguishers, pressure tanks, conveyors, elevators, freight elevators, etc.
- Equipment whose breakdown risks causing serious accidents: any equipment ensuring the public transport of people, planes, trains, etc.

- Equipment with a high failure cost: elements of an automated production line, processes operating continuously (chemical or metallurgical industries).
- Equipment whose operating expenses become abnormally high during their service life: excessive energy consumption, lighting by used lamps, improper ignition and carburetion (heat engines), etc.

b- Conditional preventive maintenance:

It is also called predictive maintenance (non-standardized term). It is preventive maintenance subject to a predetermined type of event (self-diagnosis, information from a sensor, measurement of wear, etc.).

Conditional maintenance is therefore maintenance dependent on experience and involving information collected in real time. It is characterized by highlighting weak points. Depending on the case, it is desirable to put them under surveillance and, from there, to decide on an intervention when a certain threshold is reached. But the checks remain systematic and are part of the non-destructive means of testing.

All equipment is affected; this conditional preventive maintenance is carried out by relevant measures on the equipment in operation.

The parameters measured can relate to:

- The level and quality of the oil.
- Temperatures and pressures.
- The voltage and intensity of electrical equipment.
- Vibrations and mechanical play.
- The equipment necessary to ensure conditional preventive maintenance must be reliable so as not to lose its reason for existence. It is often expensive, but in well-chosen cases, it pays for itself quickly.

c- Preventive maintenance operations:

These operations find their definitions as follow:

- **Inspection** : conformity check carried out by measuring, observing, testing or calibrating the significant characteristics of a good; it makes it possible to identify anomalies and carry out simple adjustments that do not require specific tools or stopping production or equipment (no dismantling).

- **Control** : verification of conformity with pre-established data, followed by a judgment. This control may lead to a corrective maintenance action or include a decision of refusal, acceptance or postponement.
- **Visit** : detailed and predetermined examination of all (general visit) or part (limited visit) of the different elements of the property and which may involve first and second level maintenance operations; it can also lead to corrective maintenance.
- **Test** : comparison of the responses of a system in relation to a reference system or to a physical phenomenon significant for correct walking.
- **Standard exchange** : replacement of a defective part or sub-assembly with an identical part, new or previously reconditioned, in accordance with the manufacturer's instructions.
- **Review** : complete set of examinations and actions carried out in order to maintain the level of availability and security of an asset. A review is often conducted at prescribed intervals of time or after a specified number of operations. An overhaul requires total or partial dismantling of the property. The term review should therefore not be confused with monitoring. An overhaul is a level 4 maintenance action.

The first three operations are still called " **operations surveil** ".

They perfectly characterize the learning phase and are absolutely necessary if we want to control the evolution of the real state of an asset. We therefore agree to pay to know and then to prevent. They are carried out continuously or at predetermined or non-predetermined intervals, calculated over time or the number of usage units.

1.5. IMPROVED MAINTENANCE :

Improved maintenance refers to the enhancement of processes, practices, and strategies related to maintaining equipment, systems, or facilities. It focuses on optimizing efficiency, reducing downtime, extending asset lifespan, and minimizing costs through better planning, use of technology, and preventive measures.

Key aspects of improved maintenance include:

1.5.1. Proactive Maintenance:

Shifting from reactive repairs to preventative or predictive approaches, anticipating issues before they occur, and addressing them promptly to avoid breakdowns.

1.5.2. Data-Driven Insights:

Using advanced monitoring tools and analytics to track performance, detect anomalies, and predict future maintenance needs, often through Internet of Things (IoT) sensors or predictive algorithms.

1.5.3. Standardization:

Implementing best practices, standardized procedures, and reliable workflows to ensure consistency, safety, and quality across operations.

1.5.4. Training and Skill Development:

Continuously improving the skills of maintenance personnel to handle more complex tasks and use the latest tools and technologies.

1.5.5. Resource Optimization:

Better management of spare parts, tools, and labor to minimize unnecessary inventory and maximize the effectiveness of maintenance activities.

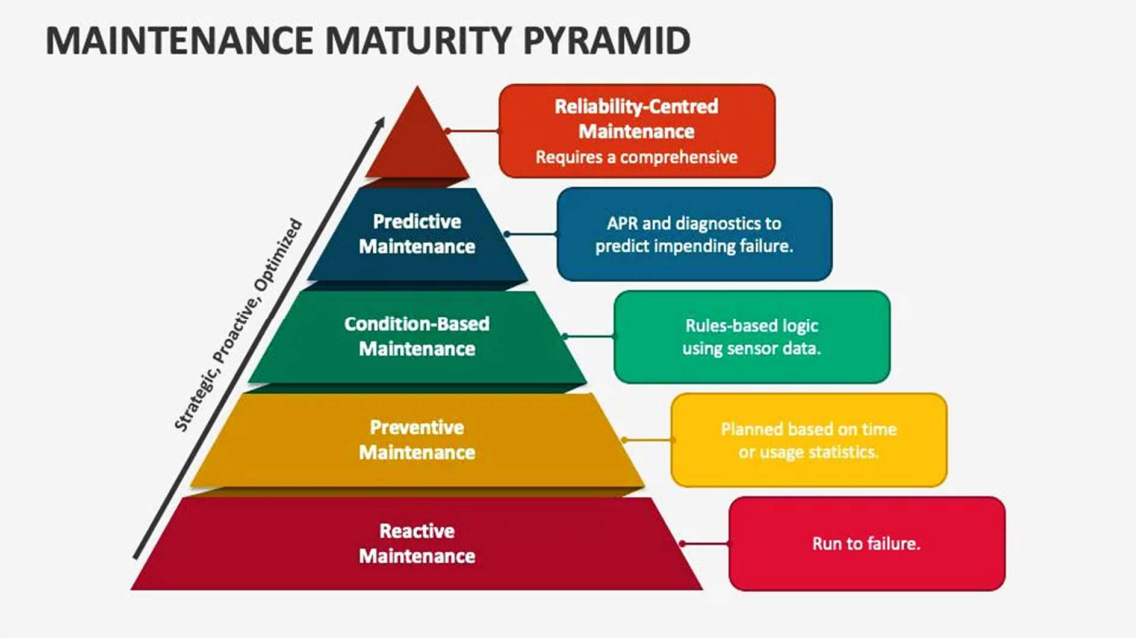

Figure 1.2. Pyramid about steps improvement maintenance.

1.6. OBJECTIVE OF IMPROVED MAINTENANCE

The objectives of improved maintenance focus on enhancing operational efficiency, reducing costs, and ensuring the reliability of equipment and systems. Here are the key objectives derived from the search results:

1.6.1. Reduce Equipment Failures and Downtime:

One of the primary goals is to decrease the frequency of equipment failures, which helps maintain high throughput levels and optimal performance. Regular inspections and preventive maintenance tasks are essential for identifying issues before they lead to significant failures.

1.6.2. Minimize Maintenance Costs:

Improved maintenance aims to control and reduce overall maintenance expenses by shifting from reactive to proactive strategies. This includes implementing preventive and predictive maintenance to avoid costly emergency repairs and unplanned downtime.

1.6.3. Enhance Asset Reliability:

Ensuring that assets remain reliable is crucial for preventing production halts and meeting service-level agreements. Scheduled preventive maintenance helps in achieving this objective by reducing the risk of unexpected failures.

1.6.4. Improve Product Quality:

Well-maintained equipment contributes to better product quality, reducing defects and rework. This leads to higher customer satisfaction and potentially increased sales.

1.6.5. Extend Equipment Lifespan:

By implementing proactive maintenance strategies, organizations can prolong the useful life of their machinery and equipment, thereby maximizing return on investment.

1.6.6. Increase Safety Compliance:

Regular maintenance activities help ensure compliance with safety regulations, minimizing accidents and enhancing workplace safety for employees.

1.6.7. Optimize Resource Utilization:

Improved maintenance strategies focus on maximizing the efficient use of resources, including personnel, parts, and materials, leading to more effective operations.

1.6.8. Facilitate Continuous Improvement:

The objective also includes developing better policies, procedures, and standards that enhance maintenance practices over time, ensuring adaptability to changing operational needs.

1.7. MAINTENANCE LEVELS:

The concept of maintenance levels categorizes maintenance activities based on their complexity, expertise required, and the resources needed. Here's an overview of the different levels of maintenance:

1.7.1. Level 1 Maintenance:

- **Description**: Involves basic preventive actions with low complexity.
- **Intervention Conditions**: Tasks that require few or no parts, such as lubrication, meter readings, and minor corrective actions (e.g., bulb replacements).
- **Applications**: Performed by operators following visual work instructions on easily accessible components without safety risks.

1.7.2. Level 2 Maintenance:

- **Description**: Slightly more complex than Level 1, involving preventive maintenance and simple repairs.
- **Intervention Conditions**: Tasks performed using straightforward procedures by trained technicians.
- **Applications**: Includes adjustments, sensor checks, and replacing belts or filters.

1.7.3. Level 3 Maintenance:

- **Description**: Requires specialized technicians for more complex procedures.
- **Intervention Conditions**: Involves diagnosis before intervention, such as checking combustion in boilers or changing pumps.
- **Applications**: Conducted on-site or in dedicated maintenance areas, focusing on preventive and corrective actions.

1.7.4. Level 4 Maintenance:

- **Description**: High-level maintenance operations requiring specific technical expertise.
- **Intervention Conditions**: Performed by qualified technicians under supervision, often involving teamwork.

- **Applications**: Includes advanced preventive interventions like vibration analysis and corrective tasks such as pump overhauls.

1.7.5. Level 5 Maintenance:

- **Description**: The most complex maintenance operations typically handled by manufacturers or specialized service providers.
- **Intervention Conditions**: Involves significant resources and expertise similar to manufacturing processes.
- **Applications**: Focuses on heavy equipment repair, rebuilding, or compliance updates with regulations.

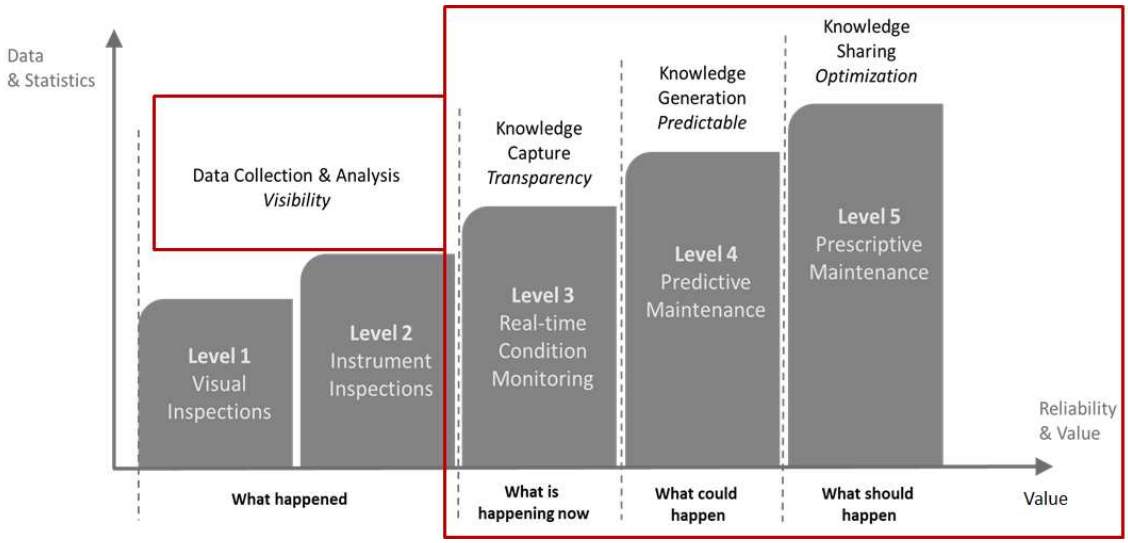

Figure 1.2. Maintenance levels.

1.8. CONCLUSION

The maintenance function plays a vital role in ensuring that organizational assets operate effectively and efficiently, thereby supporting overall operational continuity. By implementing strategic maintenance practices, businesses can minimize downtime, enhance productivity, and control costs associated with equipment failures. Improved maintenance approaches emphasize proactive measures, such as preventive and predictive maintenance, which allow organizations to identify and address potential issues before they escalate into significant problems. This shift not only extends the lifespan of assets but also contributes to a safer working environment and

compliance with regulatory standards. As we transition to the next chapter, we will explore the mechanisms and modes of failures that can impact equipment performance. Understanding these failure modes is essential for developing effective maintenance strategies that can mitigate risks and enhance reliability in operations.