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جامعة الشهيد حمه لخضر - الوادي

University Echahid Hama Lakhdar El Oued

Faculty of Technology

Department of Mechanical Engineering

Course about

Organization and management Of industrial maintenance

Destined to students in Master 2 electromechanical.

Accomplished by : AROUDJ Mohammed

Grade “ MCB”

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Course information

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- Department: Mechanical Engineering
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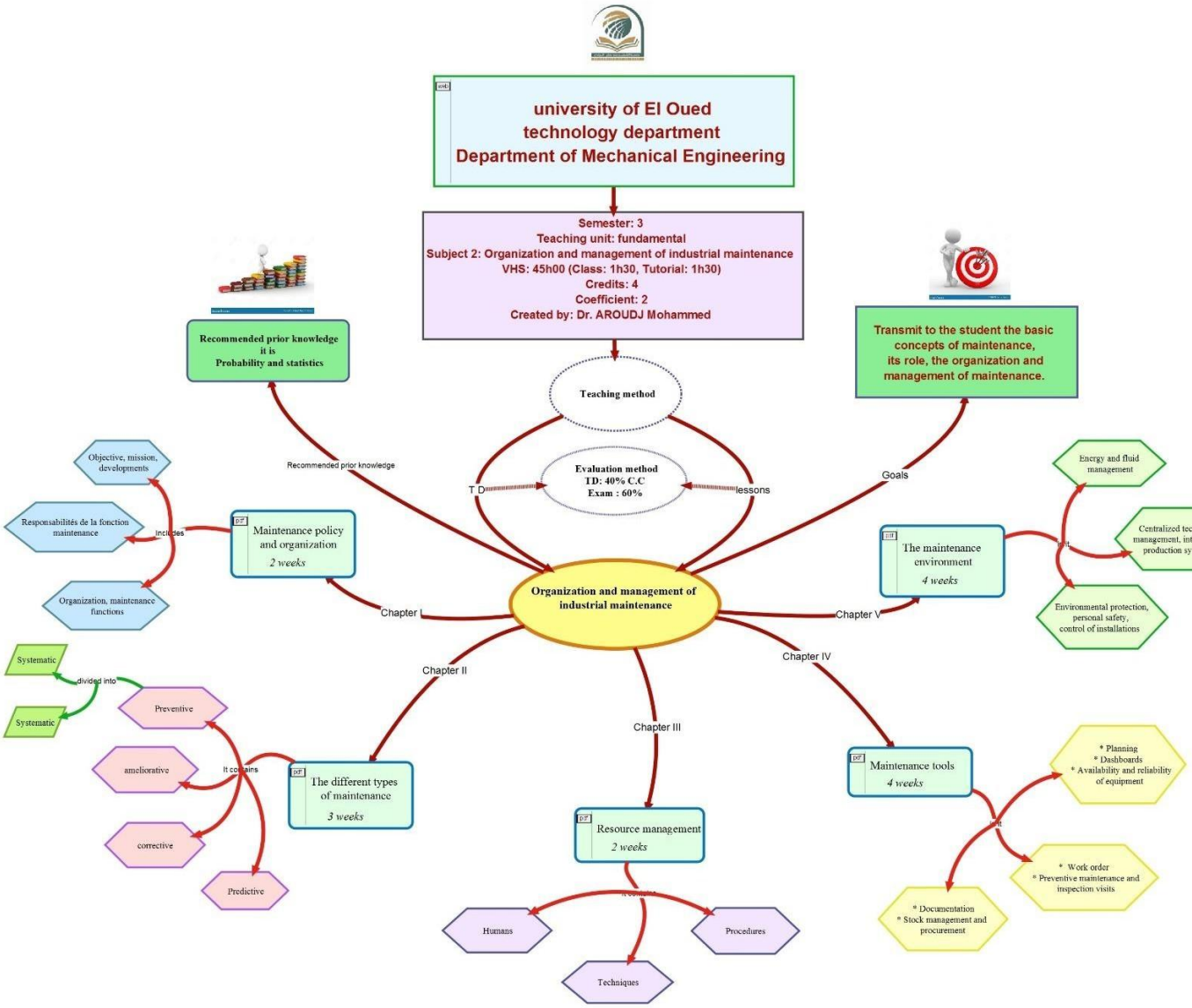
university of El Oued
technology department
Department of Mechanical Engineering
Semester: 3
Teaching unit: fundamental
Subject 2: Organization and management of industrial maintenance
VHS: 45h00 (Class: 1h30, Tutorial: 1h30)
Credits: 4
Coefficient: 2
Created by: Dr. AROUDJ Mohammed
Recommended prior knowledge it is Probability and statistics
Transmit to the student the basic concepts of maintenance, its role, the organization and management of maintenance.
Teaching method
Evaluation method
TD: 40% C.C
Exam : 60%
Recommended prior knowledge
T D
lessons
Goals
Organization and management of industrial maintenance
Chapter I
Maintenance policy and organization
2 weeks
Objective, mission, developments
Responsabilités de la fonction maintenance
Organization, maintenance functions
includes
Chapter II
The different types of maintenance
3 weeks
Systematic
divided into
Systematic
Preventive
ameliorative
corrective
Predictive
It contains
Chapter III
Resource management
2 weeks
Humans
Procedures
Techniques
Chapter IV
Maintenance tools
4 weeks
* Planning
* Dashboards
* Availability and reliability of equipment
* Work order
* Preventive maintenance and inspection visits
* Documentation
* Stock management and procurement
Chapter V
The maintenance environment
4 weeks
Energy and fluid management
Centralized technical management, integrated production system
Environmental protection, personal safety, control of installations

Abstract:

This document is a comprehensive educational resource titled "Organization and Management of Industrial Maintenance," developed by Dr. Mohammed Aroudj for Master's students in Electromechanical Engineering at the University of El Oued. It defines maintenance as a strategic combination of technical and administrative actions intended to maintain or restore assets to their functional state, emphasizing two core activities: technical (diagnostics and repair) and management (spare parts, budgeting, and resource allocation). The curriculum explores the historical evolution of maintenance from a secondary "break-fix" activity to a vital industrial pillar that ensures safety, environmental compliance, and cost-effectiveness. It details various maintenance methodologies, specifically distinguishing between corrective maintenance (performed after failure) and preventive maintenance, which includes systematic scheduled actions and condition-based monitoring. Furthermore, the document outlines the five levels of maintenance intervention—ranging from simple operator adjustments to complex general overhauls—and stresses the importance of organizational functions like scheduling, which acts as the "conductor" for all maintenance tasks. To maximize efficiency, the text introduces key performance indicators like reliability and availability, and highlights advanced management systems such as Total Productive Maintenance (TPM), which fosters a culture of "zero failures" by involving production operators in equipment care. Ultimately, the file serves as a blueprint for implementing a robust maintenance management system that integrates technical documentation, spare parts logistics, and safety standards to prolong equipment life and enhance industrial competitiveness.

Keywords: Industrial Maintenance, Performance, Reliability, Maintainability, Availability, TPM, GMAO, Corrective, Preventive, Conditional, Industrial Safety

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CHAPTER 1

Policy and organization of maintenance

1 Chapter 1 : Policy and organization of the maintenance

1.1 Definition of the maintenance

Maintenance is the set of technical, administrative and management actions during the life cycle of an asset, intended to maintain it or restore it to a state in which it can perform the required function.

Several authors present the maintenance function as a set of activities grouped into two subsets: activities with a predominantly technical focus and activities with a predominantly management focus (see figure 1.1).

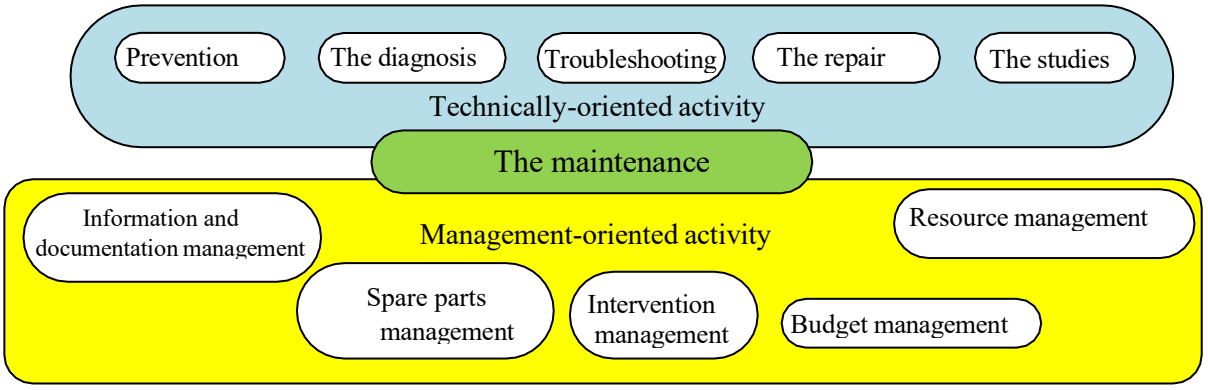

Figure 1: The content of the maintenance function

In the definition of maintenance, we find two key words: maintain and restore. The first refers to a preventive action. The second refers to the corrective aspect.

1.2 The goals of the maintenance

The goals of maintenance are closely related has the mission of the company :

- The limitation of number of interruptions of service and the reduction of the durations accidental breakdowns;
- The maintenance of equipment in element condition for operate in all security ;
- The maximization of efficiency of the equipment ;
- The minimization of the costs of operation ;
- Maintaining a high level of quality of work carried out by the maintenance department For, between others, improve the quality of the products and to lengthen the duration equipment life;
- Ensure the security elements and men.

1.3 The missions of the maintenance

Maintenance is no longer limited to simply restoring an asset. Through this mission, it must satisfy the needs of production:

- Improve the quality of the equipment of the production ;
- Improve the production-maintenance interface, i.e. Know and apply the methods and tools to improve communication (TPM (Total Productive Maintenance), CMMS);
- Get the cost global minimal for the equipment ;
- To put in accordance with the legislation on the security ;
- To put in accordance with the legislation on the environment ;
- Participate has the quality of the products manufactured ;
- Participate has improvement costs of manufacturing ;

1.4 Evolution of the maintenance

Between the 1960s and 1980s, industrial maintenance was seen as a background activity, considered to be of little use and only called upon when the machine broke down.

At Over time, companies have gradually become aware of the safety aspect. They therefore looked at the maintenance aspect to develop it and give it more importance. As machines evolved and were equipped with more advanced technologies, the risks were proportionally higher and companies wanted to counter the increased risks of accidents.

Industrial maintenance has therefore taken on a more important place within factories: the first maintenance procedures have emerged. It is surprising to note that companies have been more keen to develop maintenance and give it pride of place for human reasons than for purely economic reasons.

Between 1980 and 2000, the industrial world evolved in all areas. As for industrial maintenance, it was completely transformed with the arrival of new approaches, such as total productive maintenance (TPM), a concept straight imported from Japan which revolutionized the global vision of the sector.

Today, companies are still looking to assert themselves in industrial markets and prove that they are resourceful, building on the advances made in this area over the past few years. Course of the twenty latest years. Each, has its way, day before has improve the management

Of its maintenance in order to reduce production stoppages while increasing the quality and production capacity of its machines.

1.5 Policy of maintenance

It consists of setting the guidelines (methods, program, budget, etc.) In terms of maintenance. In the frame of the goals fixed by the direction of the company. These orientations may favor some objectives over others taking into account the overall policy of the company. It must take into account:

a) The choice of the methods maintenance (The different modes of maintenance);
b) The improvements ;
c) The place equipment In the process manufacturing (hierarchy);
d) The training of staff of maintenance and of production.

1.5.1 Method maintenance

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 a maintenance method, one must be informed of the management's objectives, political decisions on maintenance, but it is also necessary to know the operation and characteristics of the equipment; the behavior of the equipment in operation; the conditions of application of each method; the maintenance costs and the costs of loss of production.

1.6 Organization of the maintenance :

An example of an organization chart is given in Figure 1.2. This is only one possibility, each technical director being free to organize it according to his own conviction. However, it does show essential functions for the maintenance function to be effective.

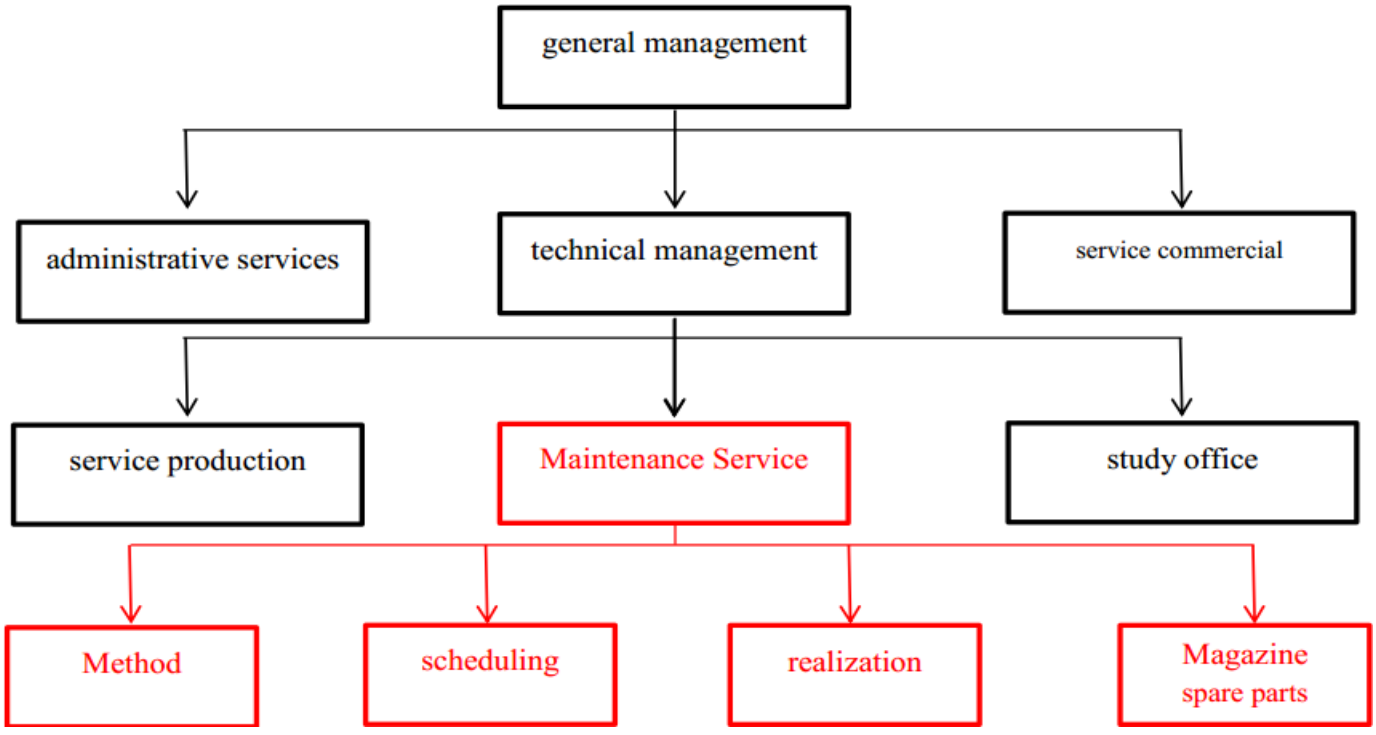

Figure 2 : Structure kind with sectorization partial

1.6.1 Function realization :

The production team is multi-ethnic and of a composition adapted to the material. For example, a chef team, A electrician, A mechanic And a hydraulic engineer. She East loaded of the execution of maintenance tasks planned by the method department.

The main tasks For fill this function are the following :

- Install the machines And the material (reception, control, etc.);
- Inform the staff on the way to use the equipment And TO DO the bet has level;
- Apply the hygiene instructions, of security And of the terms of work ;
- Manage maintenance scheduling and intervention and establish equipment failure diagnosis;
- Coordinate the interventions of the maintenance And to put back in walk the material after intervention;
- Manage the resources material (the pieces of spare, the tools, etc.).

1.6.2 Methods function :

The methods function consists of optimizing all tasks according to the criteria selected in the formulation of the maintenance policy. This part groups together four main tasks.

The first task, relative has the technical study as noted In the figure1.3, consists has :

- Look for improvements in the production system that could provide the desired added value;
- Participate in the design of new works while taking into account the maintenance aspect of the production equipment;
- Participate in the analysis of work accidents to try to remedy them by providing safety instructions in the first instance, and corrective and preventive maintenance actions in the second instance.

The second task, relative has the preparation and scheduling, consists has :

- Establish the cards of instructions necessary for perform the interventions ;
- To constitute the documentation for all the types of intervention ;
- Establish the schedules of the interventions preventive and supply (the stock management policy being dependent on that of the company);
- Receive and to classify the documents relative has the intervention.

The third task, relating to the economic and financial study, involves several stages such as:

- Manage supplies to optimize the management of raw materials required for the production process;
- Analyze the costs of maintenance, of failure and of functioning, what will have an impact direct on politics of selected maintenance by the company manufacturing and also on the cost of production;
- Participate in the drafting of specifications to take into account the maintainability and reliability of the systems to be controlled;
- Manage the monitoring and completion of work in order to update the historical part of the technical file of the machines.

To fulfill the study and method function with all its components as mentioned above, the staff must have technical files summarizing the technical characteristics of the machines and wear parts; history sheets summarizing the operations already carried out, in other words, the behavior of the machine; constantly updated supplier documentation summarizing the evolution of the techniques and databases (possibly).

1.6.3 Function scheduling :

The Scheduling function allows for optimal intervention, at the right time and with all the necessary resources: personnel, tools, preparation, technical file, safety instructions, special resources (lifting equipment, scaffolding, etc.), spare parts.

1.6.3.1 *Role of the scheduling in maintenance*

Scheduling represents the "conductor" function. In a maintenance department characterized by the extreme variety of tasks in nature, duration, urgency and criticality, the absence of the conductor quickly leads to cacophony regardless of the brilliance of the soloists. Scheduling is located between the method function, responsible for defining the tasks to be performed and the means to be implemented, and the implementation function responsible for their execution.

The term scheduling East often replaced by the term planning In the companies. But for us and according to the standards, scheduling is planning that takes into account the means and resources available.

1.6.3.2 ***Missions of the scheduling***

Having the responsibility of the conduct and of the synchronization of the actions of internal or outsourced maintenance, the scheduling function has the following mission:

- Of to expect the chronology of the progress of the different tasks ;
- To optimize the means necessary in function of the time limit And of the paths reviews ;
- To adjust the charges to the capacities known ;
- To start the work at the chosen time, making all necessary means available;
- Of control advancement and the end of the works ;
- To manage projects (forecasting, logistics optimization, progress and compliance with deadlines);
- To analyze the gaps between forecasts and realization.

This can be expressed in the form: provide a time t and a place x where personnel p equipped with tools o and materials m will carry out task M in harmony with other related work.

1.7 The terms of success of a program of management of the maintenance

A maintenance management program cannot achieve the desired results without site preparation and staff involvement. These two conditions are important for the success of a maintenance management system. Other conditions will also need to be added for the successful implementation of the system:

- Set a fixed objective: this objective will allow you to draw up the guidelines for the maintenance policy. It depends greatly on the company's mission. Take, for example, a hotel company that seeks the comfort of its customers. It cannot have the same maintenance department as a mining company that seeks to reduce the cost price per kilogram of ore;
- To favor a direction and one staff motivated for the establishment of the maintenance ;
- Have rigorous procedures for collecting, processing and archiving relevant data. This data will be used in the maintenance management system;
- Ensure the communication between the different members of the team ;
- Establish procedures for monitoring, evaluating performance and displaying performance indicators.

CHAPTER 2

The different types of maintenance

2 Chapter 2 : The different types of maintenance

2.1 Introduction

For the non-specialists, the maintenance suggests First of all action corrective on defective element, **corrective maintenance**, which is in some way a first impression of the functionality.

Then we thought that by fixing it before it breaks down, we could avoid unplanned downtime. All we need to do is regularly replace potentially defective parts before they become defective: this is **systematic maintenance.** A little further from the breakdown, from the toolbox (often the first image evoked by the word "maintenance"), we can be interested in the mechanisms of degradation and the ways of observing them. The objective is then to restore the asset only if the threat of deterioration trains a failure has short term. This introduced **the maintenance conditional preventive.** Of the analysis and of the means techniques more elaborated drive has talk sometimes of maintenance forecast Who is not in do that a maintenance sophisticated conditional allowing more precise prediction of the moment of failure.

2.2 The concepts

The analysis of the different forms of maintenance rest on 4 concepts :

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

This reflection terminological and conceptual represents a base of reference for :

- The use of a common language for all parties (design, production, service providers, etc.)
- The bet in place of systems computerized of management of maintenance Structure general of an industrial network.

2.3 The methods :

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

For choose, he must so be informed of the goals of the direction, of the directions policies maintenance, but it is necessary to know the operation and characteristics of the equipment, the behavior of the equipment in operation, the conditions of application of each method, maintenance costs and production loss costs.

The diagram in figure 2.1 summarizes the maintenance methods according to standard NF EN 13306.

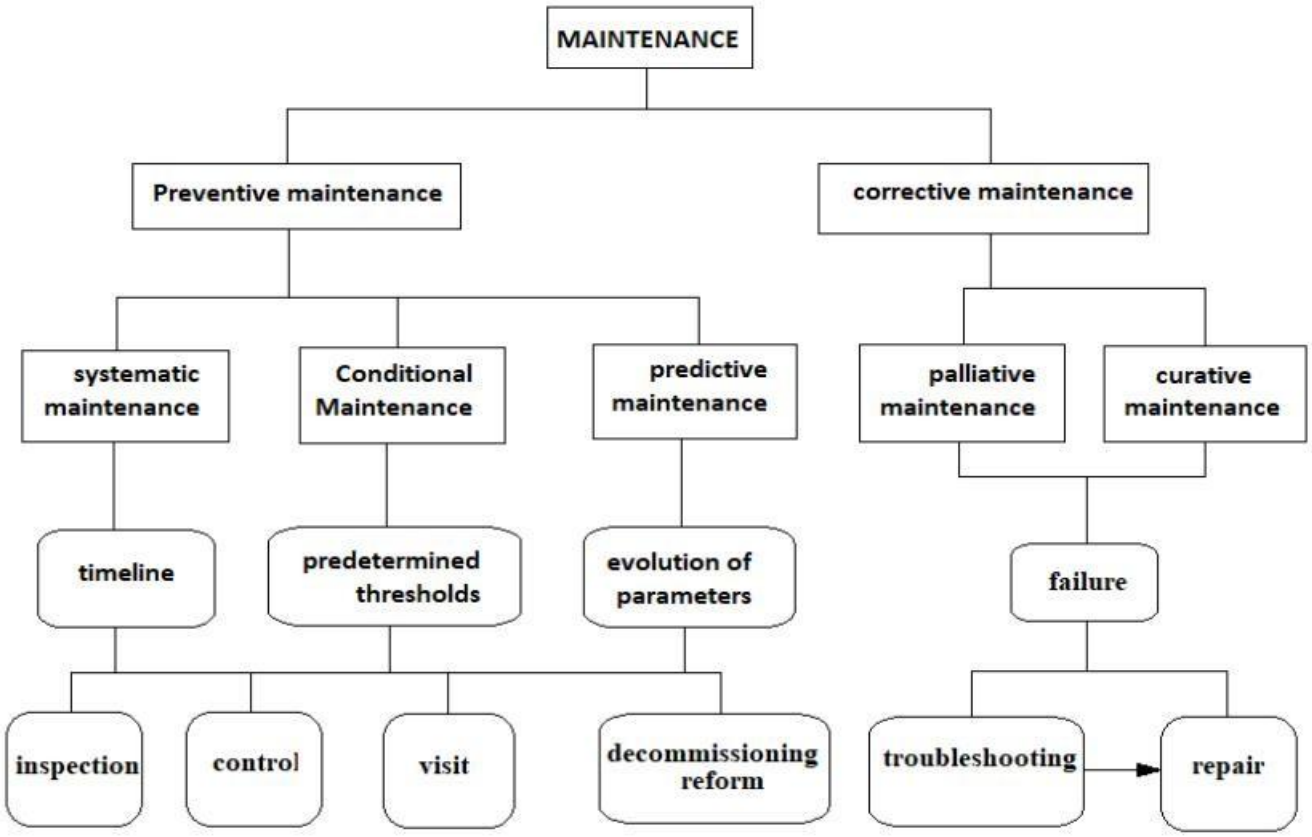

Figure 3 : The different forms of the maintenance

2.3.1 The maintenance corrective :

Definitions (extracts standards NF IN 13306) :

Failure : alteration Or cessation of the ability of a ELEMENT has accomplish the function required. The are 2 forms of failure:

Failure partial : alteration of the ability of a ELEMENT has accomplish the required function .

Failure complete : cessation of the ability of a element has accomplish the required function .

Corrective maintenance, sometimes called curative (non-standardized term), aims to restore lost qualities to equipment that are necessary for its use.

According to the standard NF IN 13306, maintenance corrective can be :

- ***Deferred : corrective maintenance that is not performed immediately after a failure is detected, but is delayed in accordance with given maintenance rules .***
- ***Emergency : corrective maintenance carried out without delay after detection of a failure in order to avoid unacceptable consequences.***

Defects, breakdowns or various faults requiring corrective maintenance result in immediate or very short-term unavailability of the affected equipment and/or a depreciation in the quantity and/or quality of the services provided.

2.3.1.1 ***The phases of a intervention of corrective maintenance***

The figure below shows the different phases of a typical corrective maintenance intervention.

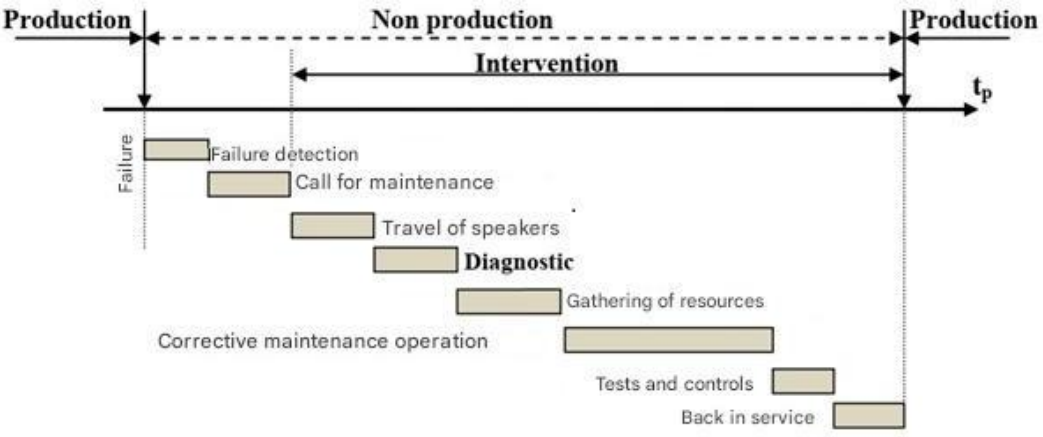

Figure 4 : The phases of operation of corrective maintenance

1. **Failure Detection** = Time taken by the system user to notice a drift in operation.
2. **Maintenance call** = Time used to inform the maintenance department with a minimum of details (location, consequences, first symptoms, etc.).
3. **Shift of the speakers** = Time necessary to technicians for to go to the place of failure.
4. **Diagnosis** = Time necessary to technicians of maintenance for identify the cause of the failure and organize the intervention (detection, localization, analysis).

5. **Gathering of resources** = Time needed by maintenance technicians to obtain tools and spare parts.
6. **Corrective maintenance operation (troubleshooting or repair)** = Time required by maintenance technicians to restore the system to working order to accomplish its mission.
7. **Testing and inspections** = Time required for maintenance technicians to validate the system's skills upgrade.
8. **Recommissioning** = Time required by maintenance technicians possibly associated with the user to allow the system to reach its nominal cadence.

2.3.1.2 ***Diagnosis After failure***

1. Approach of localization.
   - ☐ Notice the failure;
   - ☐ Identify the function failing;
   - ☐ Identify and list components linked to the non-performance of the function and likely to be faulty;
   - ☐ Define and prioritize the hypotheses;
   - ☐ Define and carry out the tests, measurements and controls to validate or not the hypotheses;
   - ☐ In deduce the element failing.
2. Research causes.
   - ☐ Analyze the mechanism of failure;
   - ☐ Identify the cause of failure;
   - ☐ To propose A plan of action (remedy immediate, recommendations …).

2.3.2 The maintenance preventive:

Maintenance performed at predetermined intervals or according to prescribed criteria and intended to reduce the probability of failure or degradation of operation. Of an element (EN 13306: April 2001).

It must make it possible to avoid failures of equipment in use. The cost analysis must highlight a gain in relation to the failures that it makes it possible to avoid.

2.3.2.1 ***Goals of the maintenance preventive***

- ⇨ Increase the duration of life of materials
- ⇨ Decrease the probability of the failures in service

- ⇨ Decrease the time stop in case of revision or of breakdown
- ⇨ Prevent and also predict the interventions expensive of corrective maintenance
- ⇨ Allow of decide maintenance corrective in of element conditions
- ⇨ Avoid the consumption abnormal of energy, of lubricant, etc.
- ⇨ Improve the conditions of work of staff of production
- ⇨ Decrease the budget maintenance
- ⇨ Delete the causes of accidents serious

the are two types of preventive maintenance:

1. Systematic preventive maintenance: The activities corresponding to this type of maintenance are triggered according to a schedule (fixed period) established from a predetermined number of usage units.
2. Conditional preventive maintenance: Activities corresponding to this type of maintenance are triggered according to of the criteria predetermined significant of the state of real degradation of the element or service through sensors.

2.3.2.2 ***The maintenance preventive systematic :***

Maintenance preventive executed has of the intervals of time pre-established Or according to A defined number of units of use but without control prior of the state of ELEMENT (IN 13306 : april 2001).

Even if the time East the unit the more widespread, others units can be deductions such that: the quantity of products manufactured, the length of products manufactured, the distance traveled, the mass of products manufactured, the number of cycles carried out, etc.

This frequency of intervention is determined from the commissioning or after a complete or partial overhaul.

This type of maintenance to characterizes by :

- o A degradation theoretical likely : She represents the duration of life theoretical of the entity

  Given by the manufacturer (example: the theoretical lifespan of a bearing is 2000 hours of operation).
- o A degradation planned : She represents the duration of life estimated by the operator (technicians of the maintenance) in function of back of experience (in takes by

Example 1800 hours). She correspond has the periodicity tbf_i of change systematic of the organ.

The gap between the degradation theoretical likely and that planned by the operator represents " The margin of security » that note it by 'T_s'.

- The greater the safety margin (T_s), the greater the risk the operator has of an unforeseen breakdown.
- The lower the safety margin (T_s), the more the operator exchanges an almost new part, which will result in a greater waste of potential (part). We will see in paragraph following " the maintenance conditional » A best average to solve this problem.

The frequency (TBF_i) of systematic intervention is determined by the maintenance department using the failure history

At a certain admissible threshold sought (corresponding to a TBF schedule $_i$ constant), a stop program by the service maintenance for intervention systematic scheduled. TA: Downtime for systematic maintenance intervention.

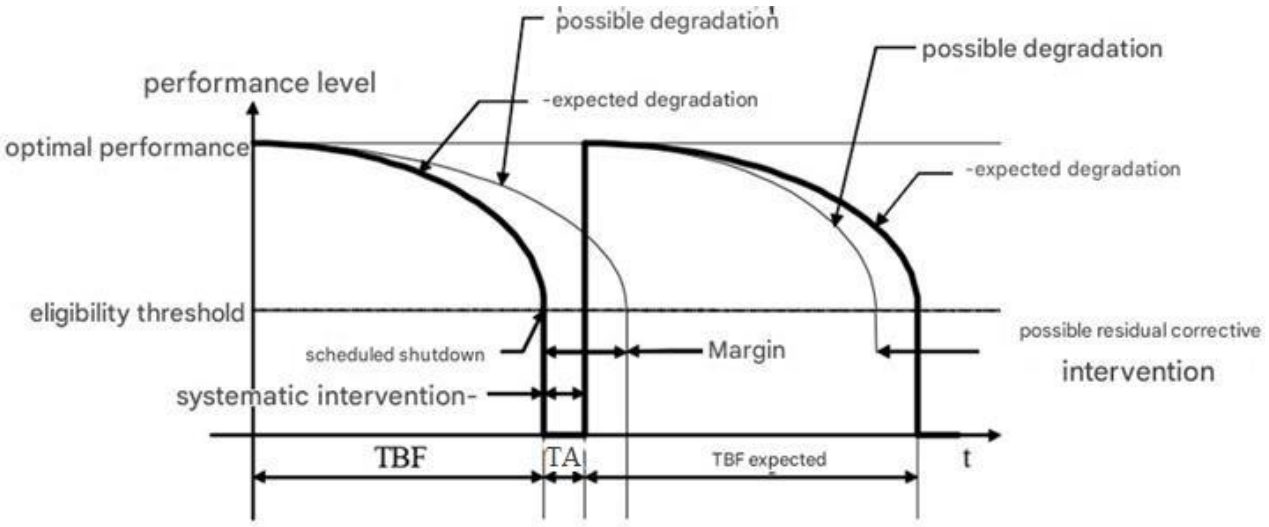

Figure 5 : Principle of the maintenance systematic preventive .

Noticed : increasingly, systematic maintenance interventions are carried out by standard exchanges.

Case of application :

- Equipment subject to current legislation (regulated safety): lifting equipment, fire extinguishers, pressure tanks, conveyors, elevators, hoists, etc.

- Equipment whose failure could cause serious accidents: all equipment providing public transport for people, planes, trains, etc.
- Equipment with high failure cost: elements of an automated production line, processes operating continuously (chemical or metallurgical industries).
- Equipment whose operating costs become abnormally high during their service life: excessive energy consumption, lighting by worn lamps, ignition and carburetion out of adjustment (thermal engines), etc.

The activities of the maintenance preventive systematic.

The activities of the maintenance preventive systematic to summarize by the figure 2.3

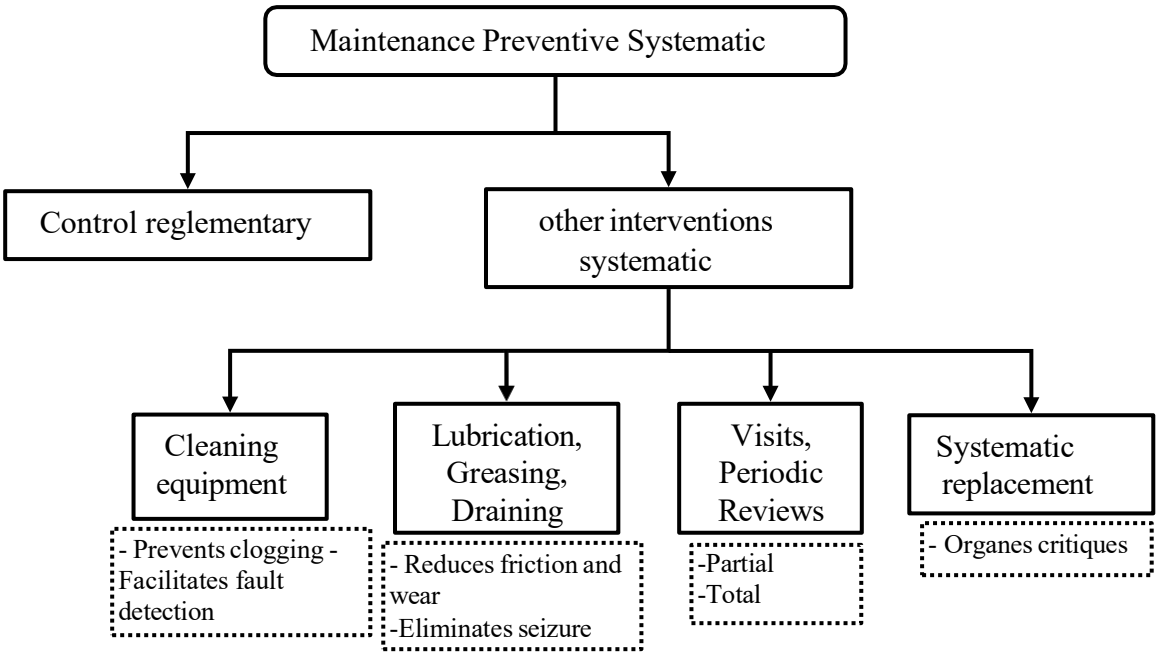

Figure 6 : Activities of the systematic maintenance .

2.3.2.3 ***The maintenance preventive conditional :***

Preventive maintenance based on monitoring the operation of the asset and/or the significant parameters of this operation, integrating the actions resulting from it. Monitoring of functioning and of the settings can be executed according to A schedule, or on demand, or continuously (EN 13306: April 2001).

Noticed: conditional maintenance is the fore maintenance dependent on experience and involving information collected in real time.

Conditional preventive maintenance is characterized by the identification of weak points. Depending on the case, it is desirable to monitor them and, from the, decide on an intervention when a certain threshold is reached. But the checks remain systematic and are part of the non-destructive control methods.

All equipment is affected. This conditional preventive maintenance is carried out by relevant measurements on the equipment in operation.

The settings measures can to carry on :

- The level and the oil quality
- The temperatures and the pressures
- The tension and the intensity of the electrical equipment
- The vibes and the mechanical games
- Etc.

Of all the parameters listed, vibration analysis is by far the richest in terms of the information collected. Understanding it allows decisions to be made that are the basis for conditional preventive maintenance.

The monitoring East either periodic, be continuous.

Advantage : knowledge of behavior is done in real time provided that we know how to interpret the results. In this level, it takes a primordial place.

The equipment needed to ensure conditional preventive maintenance must be reliable so as not to lose its reason for being. It is often expensive, but for well-chosen cases it is quickly profitable.

This maintenance method, to be effective, must in all cases be understood and accepted by production managers and have the support of all personnel.

These methods should be standardized as far as possible between the different sectors (production and peripherals) ; which does not exclude the essential adaptation of the method to the material.

With the current evolution of equipment and its tendency to be more and more reliable, the proportion of accidental breakdowns will be better controlled. Preventive maintenance will decrease quantitatively in a systematic way but will improve qualitatively by conditional maintenance.

2.4 The operations of maintenance :

2.4.1 The operations of maintenance corrective :

HAS - the troubleshooting :

Physical actions performed to enable a failed asset to perform its required function during a duration limited until This that the repair either executed (EN 13306 : April 2001).

B – The repair :

Physical actions performed to restore the required function of a failed asset (EN 13306: April 2001).

The application of the repair can be decided either immediately to the following of a incident or failure, either after troubleshooting or after a conditional or systematic preventive maintenance visit.

Noticed : repair corresponds to a definitive action. The repaired equipment must ensure the performance for which it was designed.

2.4.2 THE operations of maintenance preventive :

- **Inspections :** conformity checks carried out by measuring, observing, testing or calibrating significant characteristics of an item. In general, the inspection may be carried out before, during or after other maintenance activities (EN 13306: April 2001).
- **Visits :** monitoring operations which, as part of systematic preventive maintenance, are carried out at a specific frequency. These interventions correspond to a list of previously defined operations which may result in the dismantling of components and immobilization of equipment. A visit may result in corrective maintenance action.
- **Controls :** conformity checks against pre-established data followed by a judgment. The control can:
    - Include a information activity
    - Include a decision : acceptance, rejection, adjournment
    - Unblock as the visits on some operations of maintenance corrective

Monitoring operations (checks, visits, inspections) are necessary to control the evolution of the real state of the property. They are carried out continuously or at intervals predetermined or non-predetermined intervals, calculated on the time or the number of usage units.

2.4.3 Others operations :

Revision :

Set of examination, control and intervention actions carried out with a view to ensuring the property against any major or critical failure, for a period or for a given number of usage units.

Depending on the scope of the operations to be carried out, a distinction must be made between partial overhauls and general overhauls. In both cases, this operation requires the removal of various sub- assemblies.

The term revision should in no case be confused with the terms visits, checks, inspections.

The 2 types of operations defined (general or partial overhaul) fall under the 4th level of maintenance (see following paragraph).

2.5 Levels of maintenance :

The maintenance and operation of a property is carried out through numerous operations, sometimes repetitive, Sometimes occasional, commonly defined until then in 5 levels maintenance .

The classification of these operations allows them to be prioritized in multiple ways. This can be based on the following criteria:

Define who does what at look of each of the levels of maintenance :

- The staff of production ;
- The staff of maintenance in holding account of the qualification of the speaker ;
- The staff of the company or a subcontractor ;
- A combination of the 3.

Table 1: The levels of maintenance

Level	Nature	Staff	Means
1st	Simple settings using of elements accessible without any disassembly or opening of the equipment (clearance of a Product stuck, seers, fuses).	Operator	Light tooling defined in the instructions for use.
2nd	Troubleshooting by standard exchange of the elements provided for this purpose and minor preventive maintenance operations (greasing).	Qualified technician.	Tools of base and spare parts on site.

3rd	Identification and diagnosis of faults, repairs by exchange of components (replacing a key).	Specialized technician.	Provided tools and measuring devices .
4th	Major corrective or preventive maintenance work except renovation and reconstruction (replacement of a box Electric).	Team having a specialized technical supervision .	Specific tools.
5th	Renovation, reconstruction or major repairs (compliance).	Workshop central maintenance , Subcontracting , builder.	Means close to those of manufacturing.

2.6 Echelons of maintenance :

It is important not to confuse maintenance levels with the concept of maintenance echelon which specifies where interventions are carried out. We generally define 3 echelons which are:

- **On-site maintenance** : the intervention is carried out directly on the equipment in place;
- **Workshop maintenance** : the equipment to be repaired is transported to a location on site that is suitable for the intervention;
- Maintenance **at the manufacturer** or a **specialist company** : the equipment is then transported so that operations requiring specific means can be carried out.

Although the two concepts of maintenance level and echelon are quite distinct, the is often a correlation between level and echelon: Level 1 to 3 operations, for example, carried out on site, those of level 4 in the workshop, and those of level 5 at a specialist off-site (manufacturer or specialized company).

2.7 The activities related :

These activities complement the maintenance actions mentioned above and contribute significantly to the optimization of operating costs.

2.7.1 The maintenance improvement :

The improvement of capital elements consists of making modifications, changes, of the transformations on A material. In This domain, a lot of things

Remain at to do. It is enough to be refer has the adage following : " we can always improve ". It is a state of mind that requires a creative attitude. However, for any improvement maintenance a serious economic study is required to ensure the profitability of the project.

The improvements to be made may aim to increase the production performance of the equipment; increase reliability (reduce the frequency of interventions); improve maintainability (improve the accessibility of subsystems). And elements to high risk of failure) ; the standardization of some elements to have a more coherent policy and improve maintenance actions, increasing personnel safety.

2.7.1.1 ***The renovation (extract from the NF standard X 50-501, February 1982) :***

Complete inspection of all parts, complete dimensional recovery or replacement of deformed parts, verification of characteristics and possibly repair of faulty parts and sub-assemblies, conservation of element parts.

The renovation so appears as moon suites possible of a general revision .

2.7.1.2 ***The reconstruction :***

Restoration to the condition defined by the initial specifications, which requires the replacement of vital parts with original parts or equivalent new parts.

The reconstruction can be assorted of a modernization or modifications.

The changes made may concern, in addition to maintenance and durability, production capacity, efficiency, safety, etc.

Note: Currently, between renovation and reconstruction, an intermediate form is developing: "cannibalization". It consists of recovering, from discarded material, elements in element condition, of known lifespan if possible, and using them as spare parts or renovation elements.

2.7.1.3 ***The modernization :***

Replacement of equipment, accessories and devices or possibly software providing, thanks to technical improvements not existing on the original element, an improvement in the suitability for use of the element.

This operation can also element be executed in the case of a renovation, that in that of a reconstruction.

The renovation or reconstruction of a durable element may give rise to the practice of a standard exchange for some of its subassemblies or components.

2.7.2 The works new

The addition of responsibility for new work to the maintenance function is widespread, particularly in medium-sized companies. It is based on the principle that, for any additional investment in replacement or expansion, it makes sense to consult maintenance specialists who, on the one hand, are familiar with the old equipment in place, and on the other hand will have to maintain the new equipment in working order. From the, it is often decided to entrust them with all the responsibilities for implementation new installations. A service called **“maintenance-new works” is then created.**

The scope of responsibilities for new works varies greatly from one company to another. This may involve the construction of a dock or a building, the installation of a machine purchased from outside (connection to the energy source, etc.), or even the complete production of the machine itself. In some cases, "new works" will involve the manufacturing of the company which will carry out the orders placed by itself.

Note that even if the maintenance function is not supplemented by the “new works” function ", The service will take care of of the facilities succinct of kind modifications (refurbishment of an office, etc.).

2.7.3 Security

Security is the set of methods whose object is, if not to eliminate, at least to minimize THE consequences of failures or incidents of which a device or an installation may be the object, consequences which have a destructive effect on the personnel, equipment or the environment of each other.

Knowing that a mechanical incident, a breakdown, can cause an accident, knowing also that maintenance must keep the protective equipment in element condition or even that certain maintenance operations are themselves dangerous, it appears that the relationship between maintenance and safety is particularly close.

For all these reasons, as well as for his knowledge of the equipment, the maintenance manager must participate in the meetings of the Health and Safety Committee (CHS) as a member or as a guest, and develop his collaboration with the safety engineer when the company has one.

In an average company where security does not have its own department, it is considered normal to call on at service maintenance for the interventions concerning the security. These are of two orders:

- ⇨ On the one hand, those that can be classified as "official" security. This is the keeping of registers concerning boilers, visits to pressure vessels, the inspection of electrical installations, etc., the keeping of files of visit reports by the Labor Inspector, the Social Security controller, etc.
- ⇨ On the other hand, those which, while being inspired by the first, apply them in a specific context.

CHAPTER 3
The management of the means

3 Chapter 3 : The management of the means

3.1 Introduction :

Within this management function, they are tasks that provide the means necessary for maintenance activities. This is a cross-functional function where each stakeholder is involved to varying degrees and levels. It will also provide management with economic data that will help it make decisions.

3.2 The relevance of a system of management of the maintenance

A properly implemented maintenance management system has a significant impact on different levels, such as infrastructure, resources (human and material), spare parts management, tool management, inventory and safety.

3.2.1 The impact of the management on the plan infrastructure :

On the plan of infrastructure, location of system of management allow of :

- Protect investments by ensuring that machines and buildings have a prolonged useful life through regular and effective maintenance;
- Ensure the return on these investments by using the equipment to the maximum and thus minimizing periods of (unplanned) interruption of the production system.

3.2.2 The impact of the management on the plan of the resources :

In terms of resources, the effect of the maintenance management system is at the level of both human resources and material resources.

In This which concerns the first part, This system allows of :

- Supervise and direct maintenance department personnel to maximize the use and allocation of these resources;
- Effectively provide technical training to staff so that they master the tasks they are performing.

In This which concerns the shutter material, the system of management of maintenance allows to:

- Improve the use of these resources (equipment, tools and spare parts);
- To optimize their allocation (For avoid the waste);
- Reduce the costs of production.

3.2.3 The impact of the management on the cost of the production :

The system of the management of the maintenance has an impact very important on the cost of production, it allows:

- To record the expenses and of element estimate the costs of the works maintenance and maintenance in order to try to reduce them;
- Monitor maintenance costs in order to keep accounts for future budgeting.

3.2.4 The impact of the management on the plan of the security :

The implantation of a system of management of the maintenance on the plan of the security allows to:

- Establish an accident prevention system by ensuring the operational safety of equipment and the safety of buildings;
- Have a peaceful working climate within the company, thus creating a safe working environment.

Finally, the maintenance management system also influences the company's competitiveness criteria, namely quality, price, time, flexibility, service and reputation. These are dependent on the following maintenance actions:

- Ensure a long life useful to machines and buildings ;
- Decrease the periods interruption of production ;
- Supervise the staff of the services maintenance ;
- Reduce the costs of the services maintenance ;
- Improve efficiency of the resources human ;
- Avoid T the waste resources material ;
- Ensure the training technical of staff of service ;
- Ensure the technical independence of local managers and workers and during the operating phase;
- Estimate the costs of the works maintenance ;
- Put in place a system of prevention accidents of work ;
- Assess the functioning of the equipment in view of the decisions purchase future.

3.3 Presentation of a system of management of the maintenance

The reference framework of the maintenance management system that we let us present to the Figure 3.1, includes four equally important steps.

- The first stage concerned the reception of material and the documentation.
- The second step is related to the choice of the type of maintenance to be carried out in depending on the parameters chosen. Based on the type of maintenance chosen (conditional, systematic, corrective or improvement preventive),
- The third step presents the maintenance process such as intervention planning, failure detection procedures, execution and monitoring of the intervention.
- The last stage concerned the realization and the followed by the operation of maintenance.

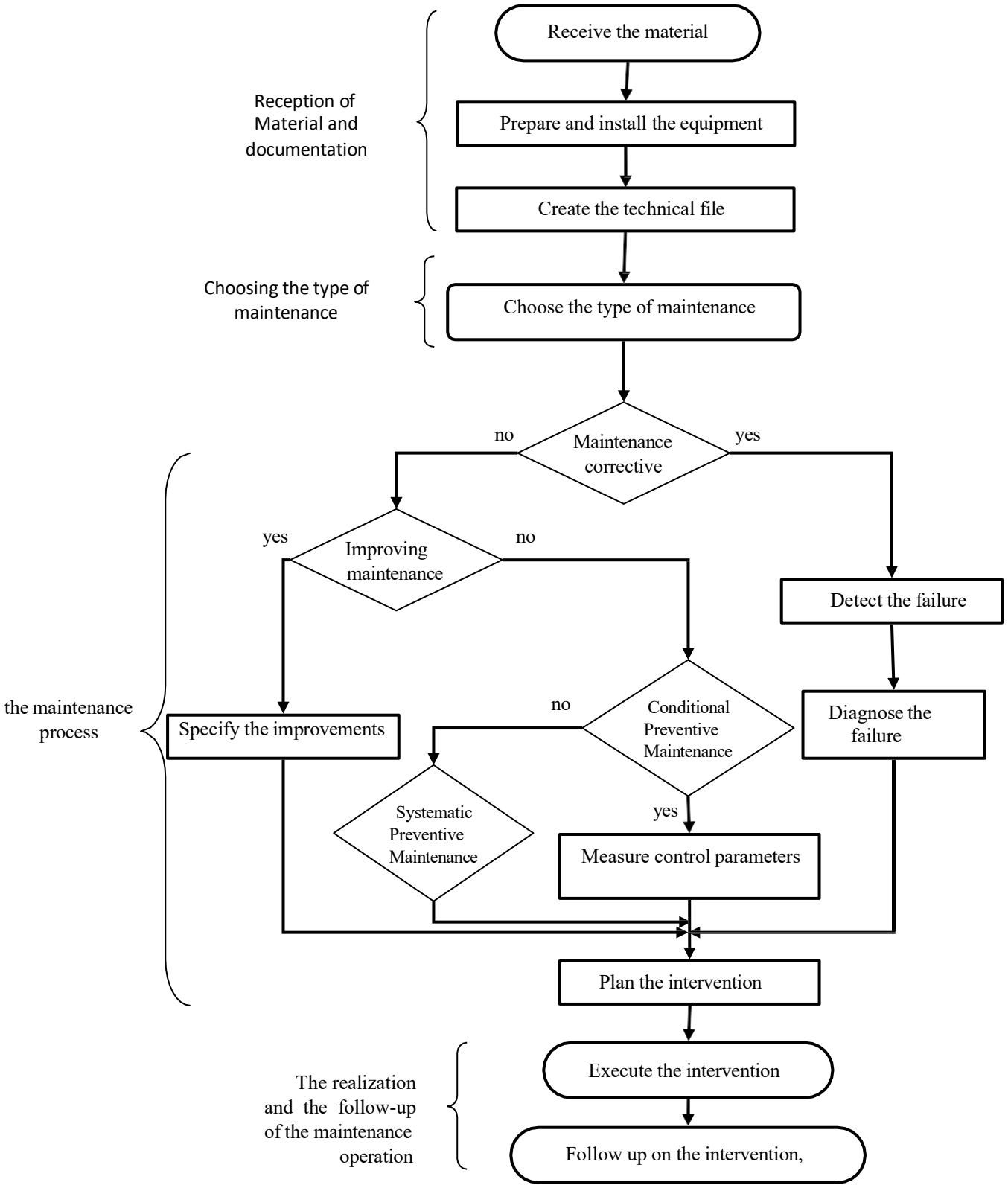

Figure 7 : The system of management of the maintenance

3.4 The management of the flow information

The system of management of the maintenance can be subdivided in three subsystems :

- The subsystem of decision and piloting,
- The subsystem information,
- The subsystem operating.

The decision subsystem includes many functions: regulation, decision and coordination. It defines, among other things, medium and long-term objectives and orientations.

The operating subsystem includes the performance of operations that ensure the achievement of the company's objectives. In general, it receives inputs, transforms them through the use of resources in output (products or services has added value). It is charge of execution works and management of maintenance operations.

An information subsystem can be more or less simple to design, it depends essentially on the effort required to investigate beyond the limits of the action and to force a fundamental revision of the way things are done.

3.4.1 Role of system information In the maintenance

A maintenance management system generates a large volume of information (Figure 3.2). Until very recently, this information was used to bill for services provided by maintenance teams and to establish budgets for purchasing new equipment and tools. The use of this information to ensure the planning, launch and monitoring of operations was very limited. On the technical level, very few companies have usable databases. If necessary, the data is generally entered by technical staff. It is incomplete, imprecise and unreliable .

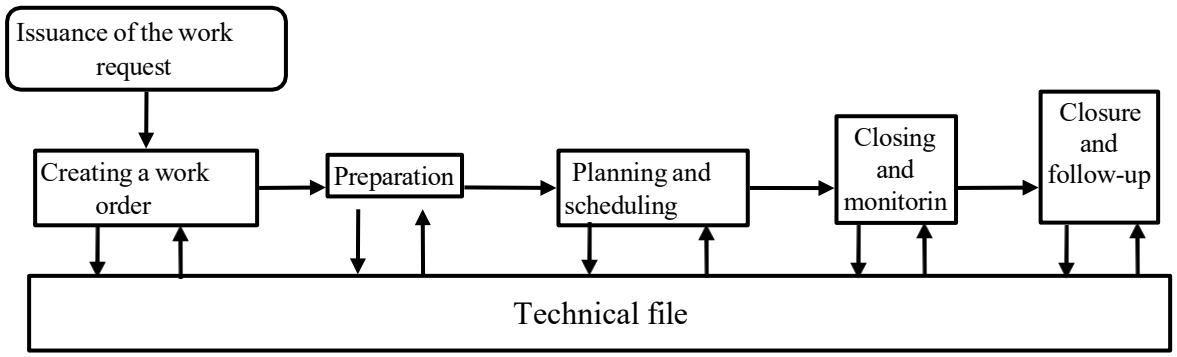

Figure 8 : The procedure of treatment of a request of work

The information and decision system's mission is to plan and schedule maintenance work, collect information and monitor the execution of the work. The mission of the operating system is to carry out the work, submit intervention reports and of discuss with the members of system of decision the different

Difficulties encountered during the work and possible improvements that could be made to the overall system.

Figure 3.4 presents a diagram of the information flows between the different actors. Of the maintenance management system.

To make the operator's task easier, and so that he can transmit accurate intervention reports, the latter must use clear and detailed procedures and diagrams with topological reference points of the components.

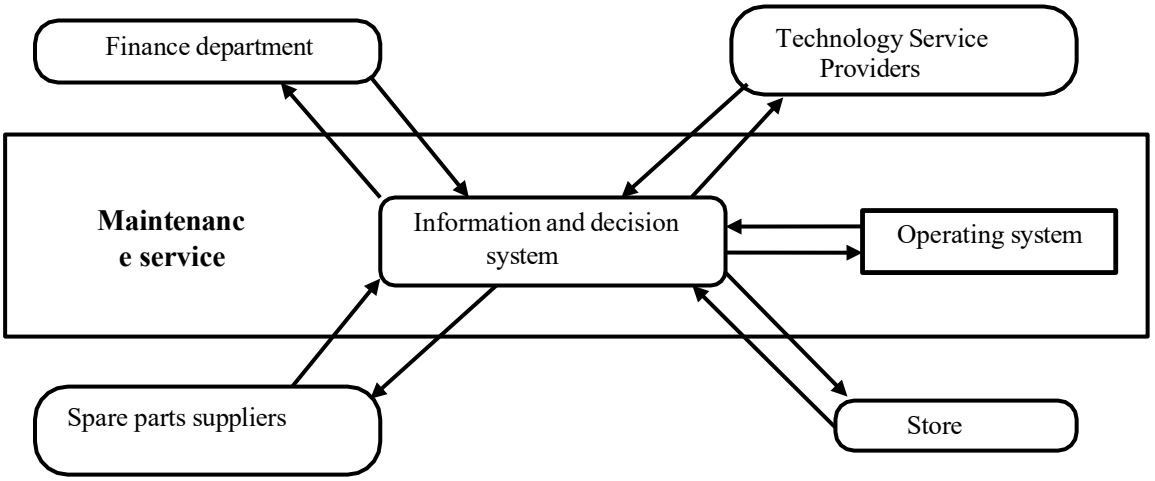

Figure 9 : The flow information has across the service of maintenance

In his report, the operator must clearly indicate all the components changed, the failure mode and all useful information on the probable causes and conditions under which the failure occurred.

Chapter 4 : The tools of maintenance

4 Chapter 4 : The tools of the maintenance

4.1 Documentation :

All stakeholders in the maintenance function recognize that documentation plays a very important role in the design and implementation of asset maintenance operations. The same goes for its daily operations. It is still necessary to understand what documentation means. Indeed, the document must be adapted to the needs that may be felt by the people concerned. In particular, great attention must be paid to all documents intrinsically linked to the equipment, commonly called " ***Operating and Maintenance Documents*** ".

However, for reach his goals and fill its assignment, the function maintenance must be documented in various other documents, whether general in nature or tailored to the operation and management of the function.

The fore, as a sub-function of the maintenance function, you are asked to consider all aspects of these documentation needs. Facilitate documentation. This is usually the responsibility of maintenance methods.

4.2 The system documentary :

No important technical action can be carried out in maintenance without documentary reference. One of the essential roles of the maintenance function is to " **ensure the "mastery of equipment documentation** " with the main objective of technological and operational knowledge of the equipment.

This objective allow :

- A preparation of interventions more safe And more efficient
- A help to agents of maintenance
- A traceability of the activities of ground has of the end's improvement of the organization
- An analysis of the behavior of materials for the purposes of technical improvements and economic optimization

CMMS (computer-aided maintenance management), with its capacity for memorization and rapid processing of data, will be the essential element in mastering the documentation.

***The quality of the documentation system in maintenance is a necessary condition for the quality of maintenance*.**

It is therefore up to the maintenance department to develop its own documentary system in line with the procedures of the company's quality assurance (QA) system.

In particular, within the framework of the new ISO 9000 certification, the standard has identified two basic procedures:

- PGM (procedure general of maintenance) : This procedure understand the next steps:
    1 Need of the interview of the equipment ;
    2 Dresser the list of equipment ;
    3 Establish A calendar investigation ;
    4 Put in artwork of the investigation ;
    5 Establish A calendar maintenance ;
    6 Estimate of material ;
    7 Put in artwork ;
    8 Put has day files .
- PQE (equipment quality plan): here is what element equipment management can bring:
    - A gain of time ;
    - A optimization of costs ;
    - A bigger supervision and better mastery risks ;
    - More of security of the environment of work for the operatives and fewer accidents;
    - The respect of the time limit of production ;
    - Insurance of the quality of product made, grace has of the periodic adjustments;
    - The guarantee of the compliance of product, grace has A follow up of the developments regulatory;
    - The preservation of the environment, etc.

4.3 Definitions prerequisites :

Maintenance document: Information held in written or electronic form required to carry out maintenance work.

Maintenance functions require an appropriate flow of information between the different nodes of the internal organization. Documentation is the fore relevant at all levels of the maintenance department:

- Files techniques for the preparation of interventions more effective and more safe,
- Modes operative for the interventions properly say,
- Files historical for the policy of maintenance to put in place (traceability interventions and analysis of equipment behavior),
- Catalogs builders for the management of stock maintenance,

Figure 10 shows the general structure of a maintenance service document. This documentation is divided into two main parts: general documentation and strategic documentation.

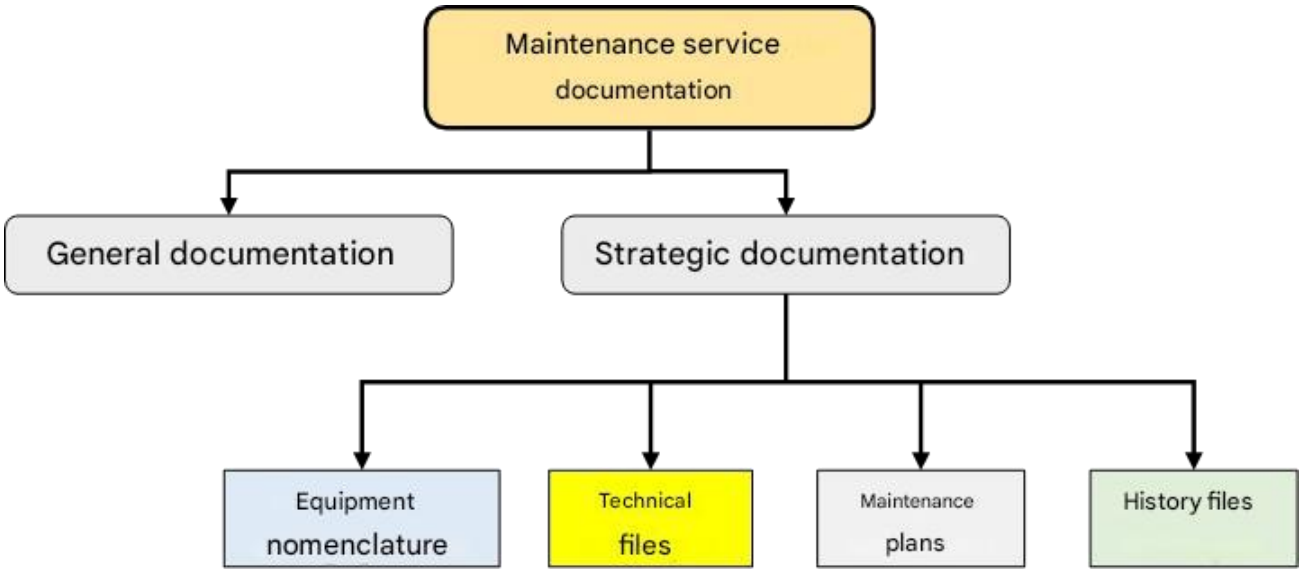

Figure 10 : Structure of the documentation of maintenance service

4.3.1 Documentation general :

The maintenance department must have a general documentation department regularly updated. This includes all technical documentation not related to a specific device, but necessary for service personnel to answer more general technical questions. In particular, it contains:

- All basic technical works (mechanics, electricity, hydraulics, pneumatics, thermal) where you will find the forms and charts necessary for the rapid dimensioning of technical elements or components;
- More specialized works, intended for more informed readers, and very useful when you want to conduct a study to improve and make equipment more reliable.

Else part, this service must be subscriber has :

- ❖ All the reviews techniques and items of conferences allowing to perform a " day before technological » (by example " Maintenance And business ", " Production Maintenance, “New Factory”, “Measurements”, “Control”, etc.),
- ❖ All the standards (international if possible, national) and conventions or " habits » business (For example " standards ISO ", " standards AFNOR »).
- ❖ The catalogs of suppliers.

4.3.2 Documentation strategic :

She to decomposed in four large parts, see figure 4.1 :

- ➢ The nomenclature equipment or inventory of the equipment park ,
- ➢ The case technical of the equipment (DTE),
- ➢ The plan of maintenance equipment ,
- ➢ The file historical ones .

Let us recall in effect that put in place a system quality, and in having in head the wheel Deming's PDCA is:

- o Write down what you are going to do (definition of procedures: preparation of interventions = Plan),
- o Do this that one has writing (intervention maintenance = Do),
- o To write This that one has do (traceability) And analyze the return of experience = Check
- o To act, that's to say standardize = Act and improve.

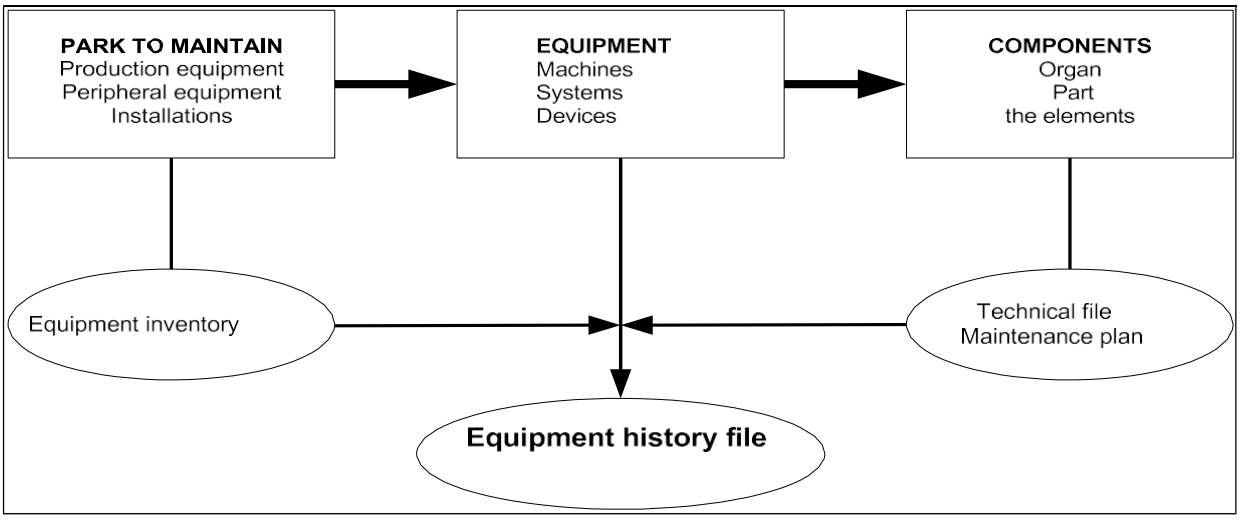

Figure 11 : The elements of base of a system documentary

4.3.3 Nomenclature of the equipment :

All equipment and durable elements of the company must be inventoried, classified and organized to form a nomenclature. Such a nomenclature facilitates the establishment of maintenance budgets, the implementation of preventive maintenance plans and general maintenance practices.

4.3.4 THE case technical equipment (DTE)

The effectiveness of the preparation work of the maintenance methods office and the intervention teams depends on an element knowledge of equipment maintain : knowledge of the equipment (origin, technologies, performance) and knowledge of its health (failures, corrective and preventive actions). The health status will be determined from the history.

The DTE, also called the "machine file", is intended to provide maintenance with all information relating to the equipment and likely to help preparers and operators. The DTE is generally made up of 2 or 3 parts:

- The manufacturer's file, with all the original information, negotiated and provided by the manufacturer;
- The case internal, established And put to day by maintenance ;
- The plan of maintenance Who can be or no integrated in DTE.

The DTE must be operational and must present the following information:

- Below the form the more useful to their exploitation in preparation or in intervention ;
- Proportionally has the «criticality » of the equipment : a grinding wheel does not need the same DTE as the production «bottleneck» machine.

This file lists and defines the complete set of documents and information to be taken into consideration when acquiring an asset in order to make it possible to organize its maintenance, as indicated in table 4.1.

Table 2 : Normative documents

Machine name		**Machine code**
Landmark	**Title headings**	
1	Data techniques	
2	Manual of bet in artwork	
3	Manual maintenance	
4	List components	
5	Provisions	
6	Detail	
7	Plan of lubrication	
8	Single line diagram	
9	Logic diagram	
10	Electrical diagram	
11	Plan of the piping and instruments	
12	Location	
13	Plan of mass	
14	Report of program test	
15	Certificates	

The DTE is an excellent working tool for maintenance preparers, but it is also a great tool for operational teams. CMMS allows it to be completely computerized. Some DTP (desktop publishing) software, which can be interfaced with CMMS, allows you to obtain 3D diagrams, exploded perspectives, etc.

4.3.5 Plan of maintenance of equipment

This comes from the operational phase of the life cycle, the phase where maintenance is performed. It is therefore rich in information and it is up to each company to produce it. The maintenance plan should only contain what is strictly necessary for the daily work of the maintenance team. The objective is to adapt the documentation to the notion of risk (loss of availability of devices). Limit the time lost during interventions and manage the documentary space more efficiently.

This means that a maintenance plan that is too rich or too sophisticated, and therefore very expensive, can go against element intentions. It is then necessary to select its documents: the is no point in creating a maintenance plan for equipment that never breaks down. To highlight the equipment at risk, a criticality study is carried out.

4.3.5.1 ***Definitions***

- **Operating procedure (OM)** : set of sequential steps to follow in order to carry out a maintenance operation, from preparatory activities, such as study and definition policies, to analysis when the work is completed and to definition of actions to be taken to improve similar future cases.
- **Work Order (WO)** : document containing all information relating to a maintenance operation and references to other documents necessary for the execution of the maintenance work.
- **Movement voucher (MV)** : document allowing the logistician to track the movements of mobile equipment.
- **Store exit voucher (SEV)** : document that allows the maintenance technician to remove equipment or a component from the store; it also allows the storekeeper to record and track the stock of spare parts.
- **Production equipment specifications** : document made available to operators for note all the incidents of functioning. The operator begin

His activity by opening this notebook and takes note of the incidents that occurred during the previous shift. He ends his shift by closing this notebook after having completed it if necessary. It is then up to the maintainer to come and consult this notebook regularly.

- **Technical intervention sheet** : It serves as a link between the maintenance technician and the "maintenance methods". It indicates in particular the operations carried out, spare parts and consumables used, etc.
- **Equipment tracking sheet** : it allows you to trace all the events occurring during the operational phase of the equipment. This is the concept of history that we will deal with separately.
- **List of consumable items** : a collection containing the reference of all components intended to be consumed during normal use of the equipment. These items are designed so that they are not repairable or that they disappear during use of the equipment.
- **Wear parts list** : list containing the reference of all parts expected to wear out during normal use of the equipment. These items may be repairable or non-repairable. Knowledge of wear parts allows for optimized management of spare parts inventories.
- **List of the pieces of spare** : list container the reference of all the pieces intended to be exchanged due to wear or deterioration during use normal equipment. These items may be repairable or non-repairable.
- **Non-Consumable Items List** : A collection containing the reference of all components intended for the refurbishment of the equipment before reuse. These items are designed so that they are repairable during the life cycle of the equipment.

4.3.6 File historical of Equipment

- This is the part of the maintenance documentation that records failures, breakdowns and information relating to the maintenance of an asset. The history of a piece of equipment is therefore the equivalent of an individual's "health record". It traces the life of the equipment by indicating chronologically all the significant maintenance events as well as the improvements that have been made to the equipment. Since its commissioning. The maintenance technician must be aware of the developments of a piece of equipment for the following reasons:

- Some facts past can very good explain a failure a few months, or even a few years later; the history is therefore the technical memory of the equipment.
- The history will make it possible to conduct and carry out reliability and improvement studies on the equipment, in light of all the work carried out on it.

The historical file is therefore of vital importance for the maintenance of the equipment; it must be “alive”, that is to say updated regularly:

- □ It should be started as soon as the equipment is installed because early failures can contribute to the search for the causes of later failures .
- □ All the events are systematically instructions, even the more harmless ; he is It's always easier to remember a major failure than a micro failure. Repetitive which will generate term a failure severe ; in fact, micro failures, temporary disruption of a parameter quickly become habits; however, it has been proven that they generate loss of availability, therefore lower productivity and of course poor quality.
- □ When a failure occurs, everything that happened must be noted (date, machine meter reading in hours or units of use, effects, causes analyzed, remedies provided, equipment downtime, time spent on the intervention, parts replaced); the date is important because a failure can always occur at the same time of day, period or season .
- □ The operating conditions of the process (type of input material, machine operator, operating parameter values: temperature, speed, flow rate, pressure, vibrations, etc.).

4.4 Management of stock and supply

4.4.1 The stock maintenance

It is the whole of the items stored, necessary has the realization optimal of the maintenance function, that is to say in the best conditions of deadlines, costs and safety (NF X 60-000).

THE stock maintenance East constituted, according to the policy of maintenance of the company :

1) By the **items belonging has the nomenclature of the elements has maintain** according to the maintenance level defined by the company.
2) by the items such that **tools, tools or equipment necessary has the carrying out maintenance work** .

The items of stock maintenance can be classified by example following their nature :

- Consumables : fuses, gaskets, screws, oils, etc.
- Pieces of spare parts : sensors, engines, belts, bearings, jacks, etc.
- Classic tools : common tools of the maintenance agent, lubrication equipment, measuring devices, etc.
- Special tools : lifting equipment, infrared thermography camera, vibration analyzer, etc.

He East necessary to make a distinction at level of the pieces of spare :

- On the one hand, those which are **specific** to a material and which can only be acquired from the manufacturer of the element.
- Else share those Who are **trivialized** , Who can to to go up on several materials and which can be purchased from different suppliers.

The specific parts involved in the safety of people and property must be perfectly identified and subject to rigorous monitoring.

4.4.2 The supply function

The " function supplies » East responsible of the satisfaction of the needs expressed in raw materials, components and supplies necessary for carrying out operations manufacturing and maintenance of the company.

A supply to unfolds generally following the diagram opposite.

All activities related to a procurement must be carried out in a timely manner and with minimum overall cost.

The general structure of the supply function highlights 2 sub-functions: purchasing and inventory management.

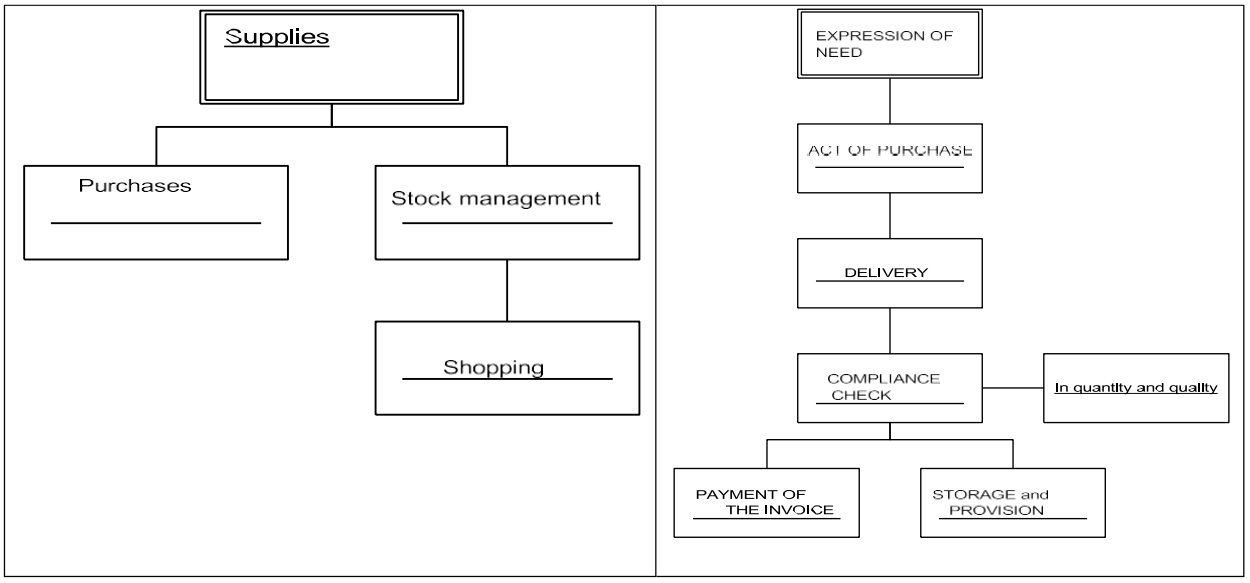

Figure 12 : The procedure of supply

4.5 Planning of the maintenance

4.5.1 Planning of the works of maintenance preventive

Increasing the share of preventive maintenance to the detriment of corrective maintenance makes it possible to plan maintenance activities and to control them instead of suffering them. Daily, weekly, monthly and annual operations are defined in plans of maintenance ; the maintenance daily (lubrication, control…) East instead entrusted to production personnel while annual maintenance, generally consisting of heavy and highly technical operations, is rather carried out by maintenance personnel. Planned maintenance allows production to organize manufacturing taking into account maintenance shutdowns planned in advance; the two activities, maintenance and production, are no longer competitors but partners for the use of the line. Planned maintenance allow also a better management of stock of pieces of spare : these born are supplied that at moment wanted for perform the intervention.

4.5.2 Planning of the charges

It is an annual distribution homogeneous for all the stops, except the annual stop and the stop of end of production, in order to respect the personnel resources available for production (workshop load capacity).

The planning will have to hold into account of the constraints following :

- The actual charge for all the work defined in each work sheet preventive maintenance;
- The frequency of operations;

- The actual duration of working time (6 hours per shift);
- The terms intervention such that accessibility, the location, the rules security;
- The policy of the maintenance, production or company department.

4.6 Paintings of edge

4.6.1 Definitions

The dashboard characterizes the state and evolution of the equipment and the maintenance service. It must be able to measure the effectiveness of the maintenance policy and thus justify the implementation of preventive maintenance. This summary tool is composed of the following elements:

- Indicator: quantifying value of a situation, a result or a state, for a given period;
- Ratio: relative indicator or ratio of an actual value and a reference value. It is expressed as a percentage;

4.6.2 Need of indicators and of paintings of edge :

The importance of quantifying maintenance, as with other major positions in the company, must lead maintenance managers to choose and use characteristic and significant indicators in order to know the situation (financial, material and personnel) of their department and to justify all past, current and future actions; these indicators must be based on explicit data .

The use of these indicators must therefore make it possible to set objectives at the economic, technical and human levels and to monitor the results in order to assess the gaps and analyse them. The indicators therefore constitute essential tools for effective management of the production tool and the maintenance function:

- Improving productivity
- Maintaining and justifying objectives
- Put in evidence of the points weak
- Help has the decision during of changes of materials
- Etc.

4.6.3 Manage the maintenance has leave of paintings of edge :

4.6.3.1 *Principle and bet in shape :*

Applied to maintenance, the use of dashboards makes it possible to lead towards controlled availability of equipment and/or towards a reduction in costs through knowledge of events and service activities.

These events and activities being configured and measured at time t1, the dashboard must allow the manager to carry out the analysis at situation t1, to deduce lines of action and then to check at t2 whether they were effective or not.

The dashboard is therefore a tool to help with the objective analysis of the results obtained in the situation of the period t1 for target goals to reach at horizon t2; then for check at time t2 whether these results have been achieved or not. These results are put in the form of indicators facilitating analysis and interpretation.

The formatting of these indicators needed to describe a situation must facilitate the decision-maker's thinking. The indicators must therefore be:

- ☐ Globalized to synthesize the mass information entered then selected
- ☐ Little many, but descriptions of the function has to drive
- ☐ Simple, visuals, clear for be easily understandable And interpretable
- ☐ Goals For give an image indisputable of a situation
- ☐ Structured following the objective has reach
- ☐ Selected : too much of information harm has the analysis but not enough born allow not a complete description of the situation
- ☐ Established on a period of reference identified and significant

4.6.3.2 *THE different forms possible of indicators :*

Let's look at a car dashboard: digital indicators (oil level indicator) sit alongside analog indicators (engine rotation frequency).

A digital indication 0/1 (indicator light) is suitable for describing a status (alarm, threshold) but not for a situation analysis.

On the other hand, any analogue measured value is an indication of the situation. : n = 7500 rpm. She becomes so more interesting has interpret as soon as it allows a reflection drawn from a drift in relation to a reference value (n maxi = 6000 rpm) or a temporal evolution put into evidenced by a graph.

The phenomenon “the engine rotation frequency is higher than the maximum frequency admissible" deserves a diagnosis followed by corrective measures. In other words, the analog indicator "measured value" does not have a great meaning in absolute value, but becomes interesting in relative value:

- Below shape of percentage (that's the interest of the analysis Pareto)
- Below shape of average (by treatments statistics or probabilistic)
- By comparison to a reference (derivative) or to a standard
- By comparison to himself in the time (evolution)
- By comparison has others indicators of similar nature

The is therefore a definite interest in using the "visual" tools of descriptive statistics to process a sample of N values. These graphic tools are preferable to tables of values which are less easy to interpret.

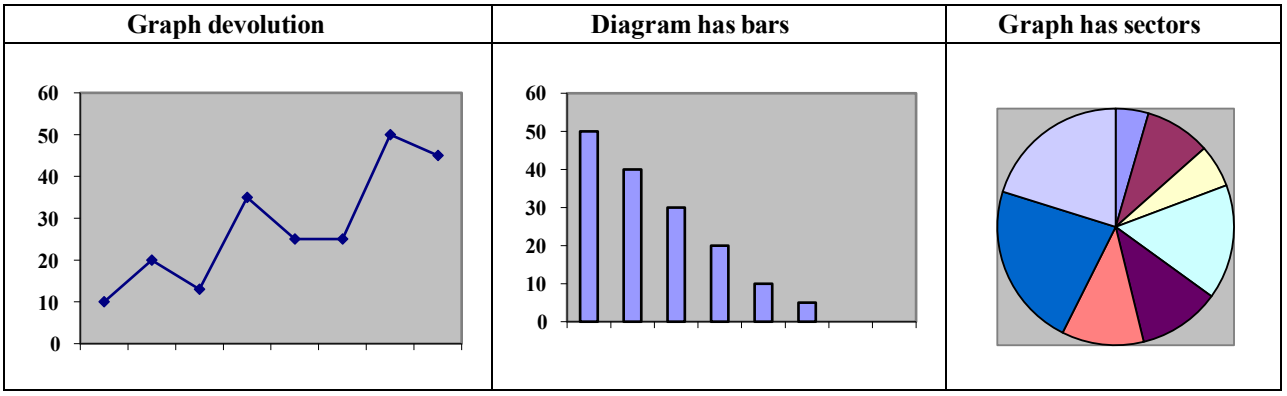

Figure 13 : The graphic tools

4.6.3.3 ***Qualities of a indicator :***

Relevance: The indicator aims at informed decision-making. Relevance allows easy interpretation of the phenomenon studied and effective decision-making.

The loyalty : the indicator must return a image without distortion of the phenomenon.

Accuracy and stability: the indicator must give an exact (centered) and stable (renewable and repetitive) image.

Accuracy and sensitivity: significant variations in the phenomenon must be reflected by readable variations in the indicator.

Consolidation: it can be useful in order to carry out syntheses or analyses, to aggregate (to bring together all distinct elements into one), of to accumulate or to consolidate (present results in a synthetic manner) quantified indicators.

Communication assistance: when multiple populations with different concerns are interested in the interpretation of an indicator, it must facilitate dialogue.

4.6.4 The ratios :

Indicators can also take the form of ratios: a conventional ratio of two quantities without a direct link, but having an evocative force facilitating reflection and comparisons .

Ex: number of liters of fuel consumes on 100 km ; the number of breakdowns by ton of steel produced; maintenance cost per liter produced, etc.

4.6.4.1 *Ratios standardized :*

The ratios of the pages following are excerpts of the standard NF X 60-020. They born are not limiting. In addition, each company may have its own ratios.

Indicators of maintenance and performance general of the company	
$R\,1=\frac{\text{Maintenance costs}}{\text{Value of element has maintain}}$	Allows the economic requirements of the property concerned to be assessed and, in particular, decisions to be made of investments or of choice of a Technology given.
$R\,2=\frac{\text{Maintenance costs}}{\text{Added value produced}}$	He allow of the comparisons inter-company in identical sectors.
$R\,3=\frac{\text{Costs of maintenance}}{\text{Figure business relative has the production}}$	It is A indicator financial.
$R\,4=\frac{\text{Costs of maintenance}}{\text{Quantity produced}}$	Allows you to measure the evolution of short-term maintenance costs and judge proper use or of the element maintenance of a material .
$R\,5=\frac{\text{Costs of maintenance + Costs unavailability}}{\text{Turnover relating to production}}$	Indicator of the evolution of the economic efficiency of maintenance.
$R\,6=\frac{\text{Costs of failure}}{\text{Costs of maintenance + Costs of failure}}$	Indicator devolution of efficiency maintenance technique.

Indicators of maintenance And management of the elements sustainable : analysis of the costs maintenance	
$R\,7=\frac{\text{Value of Or of the elements has maintain}}{\text{Quantity produced}}$	Indicator of evolution of operating cost per unit produced.
$R\,8=\frac{\text{Costs of the maintenance outsourced}}{\text{Total maintenance costs}}$	
$R\,9=\frac{\text{Preventive maintenance costs}}{\text{Costs of the maintenance preventive + corrective}}$	Importance relative of the costs preventive maintenance.
$R\,10=\frac{\text{Cost of maintenance}}{\text{cost of replacement}}$	Equipment replacement decision indicator .
$R\,11=\frac{\text{Costs of the tools and of the equipment of maintenance}}{\text{Costs of intervention personnel}}$	Evolution of the importance of the tools by report to corresponding means of manpower.

$R\ 12 = \frac{\text{Costs of the documentation technical}}{\text{Costs of maintenance}}$	
$R\ 13 = \frac{\text{Costs consumables}}{\text{Costs of staff intervention + Costs of the consumed}}$	Current expenditure indicator. Choice between rapid replacement policy for spare and wear parts, and in-depth repairs of material by the staff of maintenance.
$R\ 14 = \frac{\text{Value of stock maintenance value}}{\text{of the elements has maintain}}$	

Indicators of maintenance and management of the elements sustainable : follow up of the activities of maintenance	
$R\ 15 = \frac{\text{Active maintenance times Time}}{\text{effective of availability}}$	Anticipation of intervention personnel costs in relation to to forecasts of availability .
$R\ 16 = \frac{\text{Time assets of maintenance conditional}}{\text{Time assets of maintenance preventive systematic + condition}}$	Importance of the conditional maintenance in the Nonperiodic active tions of Maintenance preventive.
$R\ 17 = \frac{\text{Time assets of maintenance corrective}}{\text{maintenance active times}}$	Importance of the corrective maintenance In the operations Active of maintenance.
$R\ 18 = \frac{\text{Time annexes of maintenance corrective}}{\text{Corrective maintenance time}}$	Importance of all the time of implementation of operations corrective maintenance (administrative time, Logistics, technical, preparation).
$R\ 19 = \frac{\text{Time of preparation of work}}{\text{Active maintenance times}}$	Importance of work preparation activities in relation to interventions Effective on the element.
$R\ 20 = \frac{\text{Time of prepared work}}{\text{Time assets of maintenance}}$	Share of the interventions prepared In all the interventions carried out on the elements.

Indicators of maintenance And management of the elements sustainable : follow up of the performances And of exploitation durable elements.	
Measure of the availability elements .	
$R\,21 = \frac{\text{Time required}}{\text{Time total}}$	It is the rate of commitment element .
$R\,22 = \frac{\text{Time effective availability}}{\text{Time required}}$	Indicator for assessing the operational availability of assets.
$R\,23 = \frac{\text{Operating time}}{\text{Time effective of availability}}$	It is the rate of use of the property called again TRS or rate of Yield synthetic.
$R\,24 = \frac{\text{Time of element functioning}}{\text{Time required}}$	Allows a comparison of the operating performance of the property.
Measure of unavailability For maintenance	
$R\,25 = \frac{\text{Time own of unavailability for maintenance corrective}}{\text{Time required}}$	Expression of the unavailability penalty suffered by the user f o r perform the maintenance corrective.
$R\,26 = \frac{\text{Time own of unavailability for maintenance}}{\text{Actual availability time}}$	Highlighting the causes of unavailability due to maintenance compared to those inherent to of the external causes or Independent of the maintenance actions themselves.
$R\,27 = \frac{\text{Time own of unavailability for maintenance}}{\text{Operating time or quantity produced}}$	Anticipation of maintenance personnel load compared to has of the forecasts of Functioning Or of production.
$R\,28 = \frac{\sum \text{Time of Element Operation Number}}{\text{of failures}}$	MTBF : average operating time between 2 Failures . The reverse given the failure rate
$R\,29 = \frac{\sum \text{Time assets of maintenance corrective}}{\text{Number of failures}}$	TMRS: mean time before return to service = MTTR.

Indicators of management of staff of maintenance : training staff .	
$R\,30 = \frac{\text{Time or costs of training maintenance}}{\text{Effective maintenance}}$	$R\,31 = \frac{\text{Time or costs of training maintenance}}{\text{Time or costs of training business}}$
$R\,32 = \frac{\text{Training costs}}{\text{Mass salary}}$	

Indicators of management of staff of maintenance : evolution of the workforce maintenance .	
$\text{Variation} = \frac{\text{Effective of the period P}}{\text{Workforce for period P-1}} .100$	$\text{Rotation} = \frac{\text{Effective replaced during the period P}}{\text{Average workforce for period P-1}} \times 100$
$\text{Staff temporary} = \frac{\text{Nb of hours of staff temporary}}{\text{Nb of hours totals worked}}$	

Indicators of management of staff of maintenance : security people .	
Nb of accidents of work by month with or without stopping.	Nb of " almost accidents » by month by non-compliance with instructions or by No awareness instructions .
$\text{Rate of frequency of the accidents} = \frac{\text{Nb of accidents with stops x } 10^6}{\text{Nb of hours worked}}$	
$\text{Rate of gravity of the accidents} = \frac{\text{Nb of days lost x } 10^3}{\text{Nb of hours worked}}$	

Indicators of management of staff of maintenance : absenteeism and presenteeism.
$\text{Presenteeism} = \frac{\text{(Number of people) x (Number of hours of actual presence)}}{\text{(Number of people registered) x (Nb of hours standard planned)}}$
$\text{Absenteeism} = \frac{\text{(Number of people) x (Number of hours of actual absence)}}{\text{(Number of people registered) x (Nb of hours standard planned)}}$

4.7 Availability And reliability of the equipment

4.7.1 Definition of reliability

The reliability of a system is expressed by the probability that this device will perform a required function under conditions of use and for a specific period of time (AFNOR). It is therefore a quantity between 0 and 1.

Let us recall that the lifetime of a system is a measure of the quantity of service provided. Depending on the system studied, it is expressed in terms of time, kilometers, operating hours or other.

4.7.2 Definition The availability

Availability is the ability of an asset to be in a condition to perform a required function under given conditions, at a given time or during a given time interval, assuming that the provision of external resources is ensured. Resources other than maintenance logistics

(personnel, documentation, spare parts, etc.) Do not affect the availability of an asset.

Availability is translated as " Availability " and is often denoted by A(t). Only intrinsic downtimes, called also " time stop clean » And characterized by the MTI (average of time unavailability), will be surveys for assess the availability operational of a system .

The figure below watch the three factors of influence of the intrinsic availability Di.

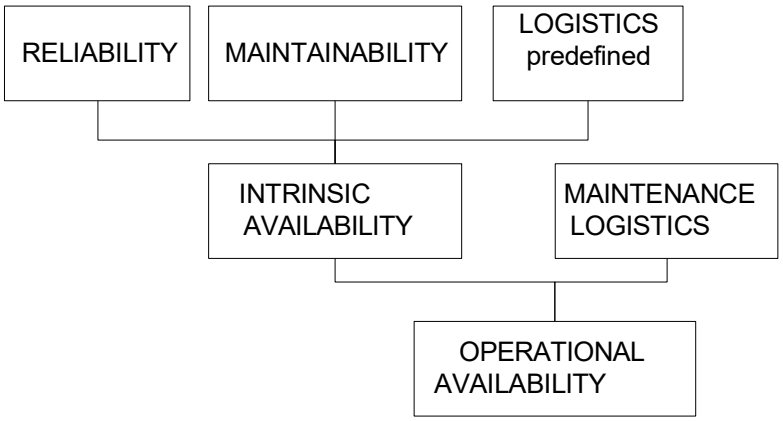

Figure 14 : The factors of influence of the intrinsic availability

4.7.3 Definition the maintainability

Under given conditions, maintainability is the ability of an asset to be maintained or restored to a condition where it can perform a required function, when maintenance is carried out under given conditions, using prescribed procedures and means.

It is also the probability of restoring a system to specified operating conditions, within desired time limits, when maintenance is performed under given conditions, using prescribed procedures and means.

Maintainability = be quickly repaired

HAS from these definitions, we distinguish :

- **Intrinsic maintainability:** it is “built” from the design phase based on specifications taking into account maintainability criteria (modularity, accessibility, etc.).
- **Predictive maintainability:** this is also “built”, but based on the availability objective.
- **Operational maintainability: this will be measured based on** intervention histories .

Noticed :

We can improve the maintainability in :

- Developing the documents help has the intervention
- Improving the machine's ability to be disassembled (modifications that may be costly) Dear)
- Improving interchangeability of the parts and below together.

4.7.4 Maintainability And maintenance

For a maintenance technician, maintainability is the ability of equipment to be restored when a need for maintenance arises. The idea of "ease of maintainability" » is materialized by measurements taken from intervention durations.

It is therefore essential that maintenance knows how to define its needs and integrate them into the specifications of new equipment so that it can be easily maintained.

Maintainability is a characteristic of the system and is defined in terms of probability. In revenge, the maintenance east an action performed by the technicians of maintenance on the system to restore it.

4.7.5 Maintainability And availability

The diagram above recalls the components of equipment availability. It highlights:

- That maintainability is one of the levers for action to improve the availability and therefore the productivity of equipment.
- That reliability and maintainability are two parallel concepts of equal importance (and whose analysis approaches are similar).

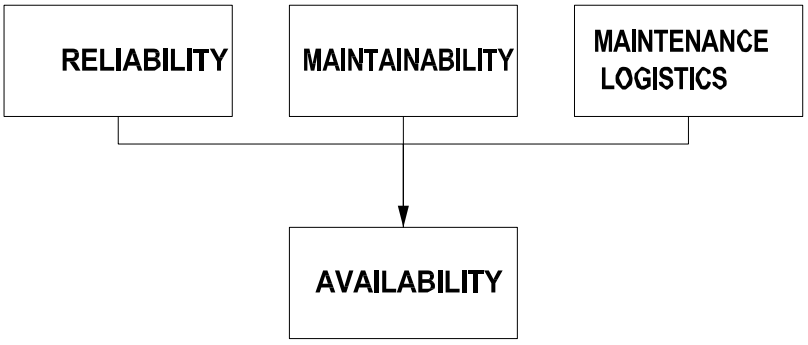

Figure 15 : Maintainability and availability

Chapter 5: The Environment of maintenance

5 Chapter 5 : The environment of the maintenance

5.1 Introduction

It follows that the maintenance department must organize prevention by taking into account its environment, such as environmental risks, personal safety and energy and fluid management. In this context, this chapter gives an overview of the relationship between the maintenance department and its environment.

5.2 Protection of the environment

Regular maintenance of machines and equipment is not only essential in terms of health And of security workers And of the public, but can also contribute greatly to the preservation of the environment and the reduction of direct or indirect pollution levels .

Some types of machinery can cause serious damage to the environment if not properly maintained, for example by emitting toxic fumes that exceed specified limits. Although they may be operating properly, the damage caused to the environment is not acceptable and is likely to be a breach of legislative regulations, not to mention the fact that they are likely to pose a health and safety hazard to anyone in the vicinity as they breathe in the noxious fumes.

It should be noted that maintenance which limits the scrap rate and maintains high efficiency will by definition have a favourable effect on the company's results since it allows for a reduction in the consumption of raw materials and energy. Concern for the environment can even in some cases lead to the production of high-quality products: this is the case for cement plants, where better filtering of fumes allows extremely fine and therefore high-quality cement to be recovered from the filters, provided of course that regular maintenance maintains the efficiency of the filters. The result for the environment is visible, since we no longer see landscapes around cement plants entirely powdered with white, as in the past.

5.3 Security of the people

Poor attention to compliance with safety rules and machine operation leads to accidents. Sometimes a person's mistake leads to fatal accidents of people. Work accidents have a great influence on financial, production and above all human, man is the happiness of the family, he is also the constituent element of society, let us protect him first.

Business managers should not underestimate work safety and should take of the measures For decrease the frequency And the gravity of the accidents in the company. The are a number of devices, instructions and so-called safety regulations for this. Preventive work cannot be the sole responsibility of company managers. It is absolutely necessary to give all staff a real safety mindset that will allow them to plan and act effectively in all circumstances.

5.3.1 Rules basic of security

Each accident of work results from a neglect of someone. We can avoid the accidents through the contribution and involvement of safety managers, engineers and technicians who must ensure:

- The best terms possible of security of work ;
- Continuous training of workers in safety methods. For that, he exists

of the instructions has organize for the workers such that :

a. **General instructions :** These instructions are intended for all workers without exception and they include knowledge of the company, the order and organization of work, the most dangerous and harmful places and locations.

b. **Job Post Instructions:** These instructions are intended for new workers or those who are in charge of work stations or workshops. They are noted the parties dangerous equipment, the rules appropriate safety precautions to be followed with respect to the equipment and the workshop.

   It is also necessary to organize regular periodic seminars to review and remind people of general and workstation-specific safety instructions.

c. **Personal protection instructions** : In addition to these two instructions mentioned above, he east necessary also of remind the protection individual of the

Workers , it is absolutely necessary and can save the worker from serious infirmities.

- ☐ The helmet protects the skull against impacts and its wearing is mandatory in the workplace;
- ☐ Goggles protect the eyes from dust, grinding particles, acids, electric arc rays, etc. The type of goggles to be worn must be suitable for the type of work to be carried out;
- ☐ Masks prevent the installation of dust or gases, the consequences of which are sometimes disastrous for health;
- ☐ Gloves protect hands from abrasions and diseases such as skin diseases;
- ☐ Reinforced shoes provide protection against falling materials, shocks, penetration by spikes, etc.;
- ☐ The apron is used when the is a risk of burns from hot or corrosive bodies;
- ☐ Ear protectors or noise stoppers are used in workshops where noise is intense, exceeds the standards. Its use prevents deafness;
- ☐ Welding filter glass screens protect the eyes from radiation.

5.4 Control of the installations

Effective maintenance practices require comprehensive control over the environmental conditions in which installations operate. This control is critical for ensuring the safety, efficiency, and longevity of machinery and equipment. An optimized environment helps prevent unexpected failures, reduces wear and tear, and enables smoother operations, all of which contribute to better overall system performance.

Key Elements in Controlling the Environment

- **Temperature and Humidity Regulation**: Maintaining optimal temperature and humidity levels is crucial, especially for equipment sensitive to temperature fluctuations. Overheating can lead to malfunctions, while high humidity may cause corrosion and degradation of electrical components.
- **Air Quality Management**: Dust, chemicals, and other airborne particles can interfere with machinery, especially in environments like factories or workshops. Implementing filtration systems and regular cleaning protocols helps maintain air quality and reduces the risk of contamination.
- **Vibration and Noise Control**: Excessive vibration and noise can affect both equipment and personnel. Control measures, like installing vibration dampers and using

soundproofing materials, protect sensitive machinery and create a safer work environment.

- **Lighting and Accessibility**: Adequate lighting enhances precision during maintenance tasks, while well-designed layouts improve accessibility, reducing the time needed for repairs and inspections.

Benefits of Environmental Control

Controlling the environment in which installations operate leads to numerous benefits:

- **Increased Equipment Reliability**: Maintaining stable conditions minimizes the likelihood of faults.
- **Reduced Maintenance Costs**: By preventing environmental-induced issues, facilities can cut down on repair costs.
- **Enhanced Safety**: Proper control measures protect personnel from hazards associated with poor air quality, noise, and other environmental factors.

In conclusion, managing the installations environment in maintenance is essential for maximizing equipment performance, ensuring safety, and achieving long-term cost savings. Regular monitoring and adherence to environmental standards can effectively mitigate risks and support sustainable maintenance practices.

5.5 Management technical centralized

The management centralized of the maintenance or all the maintenance East assured by A only service. The advantages are:

- The standardization methods , of the procedures and of the means of communication
- Possibility to invest In of the materials expensive grace At grouping
- Vision global of the state of park of the materials has manage
- Management more easy And more flexible of the means in personnel

- Rationalization of material resources and optimization of their use (faster depreciation)
- Decrease quantities of parts of spare available
- Communication simplified with the others services grace has its centralized location

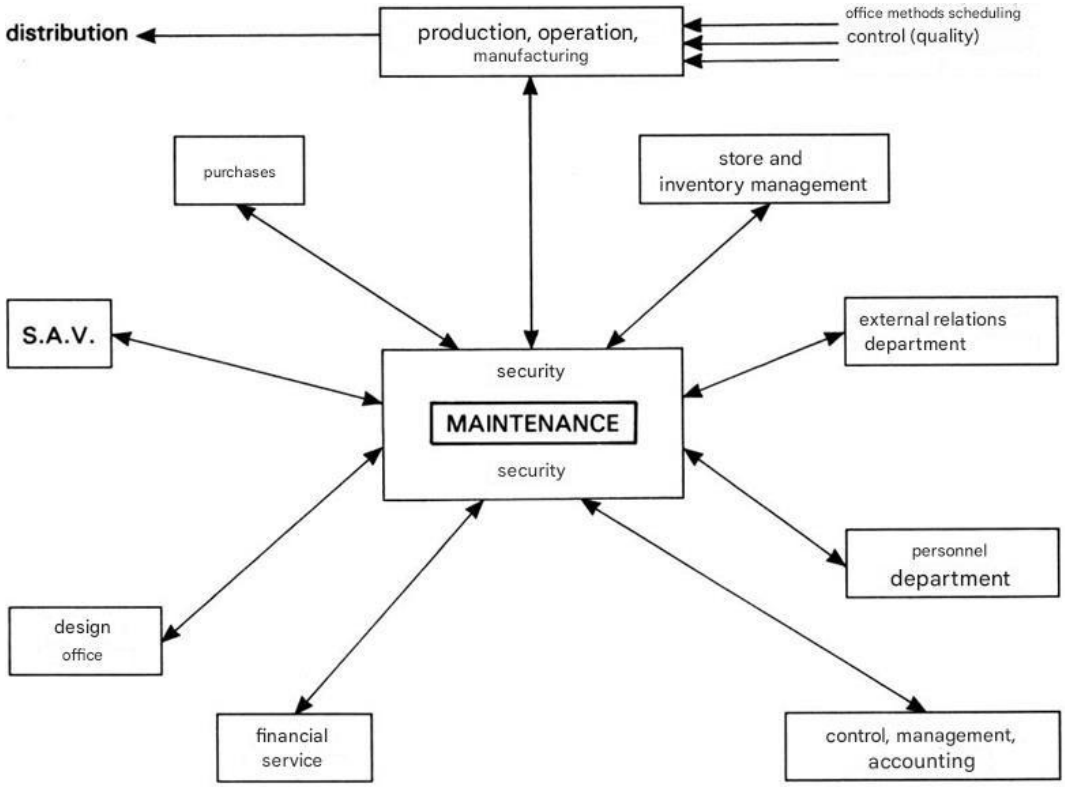

Figure 16 : Management centralized of the maintenance

In This case, the service maintenance has a alone direction who manages all. HAS this effect we have the following disadvantages:

- Heavy and poor communications and relationships within the maintenance department, and also with other departments.
- Staff more important In the service maintenance
- Reactivity diminished facing a problem
- Bad awareness of the materials
- Management administrative very heavy

5.6 System integrated of production

Face has competition worldwide, the companies must reconcile :

- Improvement of the quality of their products and of their services,

- Reduction of the time limit and flexibility,
- Decrease of the costs and improvement of their profitability.

Total Productive Maintenance TPM fits well with this notion of continuous progress. It can be defined as:

A global approach improvement of production resources which aims the economic performance of the company.

The resources of production understand the equipment element on, but also people and the organization that allows them to achieve maximum efficiency.

Some people forget that TPM is a global approach that meets the objectives of total quality and the still present of manner plotted. The TPM is not not a new method of Maintenance, nor a tool such as the 5S or the maintenance of first level, no more than the application to equipment of quality circles.

One of the main objectives of TPM is to improve the performance of production resources, performance which is measured by the OEE: Overall Effectiveness Rate created in 1970 by JIPM.

The TRG is the ratio between the quantity of element Products manufactured and the quantity of products that could have been manufactured in the ideal conditions .

In many companies, the TRG is in the range of 40 to 60%. A TRG equal to 40% means that more than half of the investment is not used; while its depreciation on its total value is well included in the industrial cost price. Having a TRG of 40% also means that the company has, without having to invest, a second equipment For produce more, but Also For be more flexible And For be able to meet deadlines.

The TPM has For goals :

- To obtain the yield maximum of system of production,
- To optimize the operating costs of equipment throughout its lifespan (notion of Life Cycle Cost),
- To improve the know-how of each for create a process continuous improvement of company performance.

5.6.1 The 16 causes of losses of performance

These 16 causes of losses can to be classified in 3 large families :

- The losses due at lack of reliability of the equipment,

- The losses due to deficiencies of the organization,
- The losses due to methods and processes used.

5.6.1.1 ***Losses due to the lack of equipment reliability***

These losses concern the stops due to :

- Breakdowns - disappearance or degradation of the function,
- Adjustments - adjustments during series production that should not exist if the process used was capable and stable.
- Start-up losses - machine preheating time, parts lost before process stabilization.
- Micro stops and idle running - companies have gotten into the habit of calling all stops of less than 5 or 10 minutes this way. But the are other much shorter stops, not always detectable and which really deserve the name micro stops. They are often the cause of chronic failures in the face of which maintenance departments have very often given up. They represent the main causes of problems met by the operators, This are them Who prevent the automatic operation of equipment.
- Below speeds - drop voluntary of speed, because than to the speed nominal on encounters reliability or quality issues.
- Scrap and rework - equipment has been used for nothing (scrap) or longer than necessary (rework).
- Shutdowns - equipment shutdowns for actions that could be described as essential in the proper use of production resources. These are shutdowns for cleaning, preventive maintenance, inspections, meeting times (5-minute meetings or end-of-line meetings). In general, these times are deducted from the work schedule to obtain the opening time that serves as the basis for calculating the OEE. But just because these shutdowns have been described as essential does not mean that they should not be measured and sought to be reduced.

5.6.1.2 ***Losses due to deficiencies of the organization :***

This are all losses generated by the deficiencies of management such that :

- Manufacturing changeover time - time from obtaining the last element part of the ending series to obtaining the first element part of the next series.

- Operator Activity - lack of skill, training, know-how, efficiency of the Operator.
- Travel and handling - time spent by Operators handling products or materials following equipment failure.
- Job organization - delays in the sequence of tasks due to travel or various problems.
- Defects of logistics - lack matter, lack tools, lack of personnel.
- Over-measurement - losses due to poor control organization, lack of confidence in the process, quality diagnostic expectations.

5.6.1.3 ***Losses due to methods and processes :***

These losses born can not always enter directly In the calculation of TRG; they correspond:

- At yield of the materials
- At energy efficiency
- Overconsumption of tools and accessories - additional expenses for replacing worn or broken tools and accessories. Overconsumption of oil also falls into this category.

5.6.2 Improvement of TRG :

The goal of TPM is to reduce the 16 causes of loss to ZERO to improve performance of the resources of production and get efficiency maximum of the Men, equipment, materials and energy. Which requires, according to the classification we have adopted:

- Of delete the causes of losses due to deficiencies of the organization,
- To improve the reliability (intrinsic And operational) equipment ,
- To improve the methods And processes of manufacturing.

5.6.3 THE 5 principles of development of the TP M

TPM is structured around 5 principles (5 principles which will translate into 8 pillars) which make them:

An approach global of management of the resources of production having For objective the economic performance of the company.

Principle No. 1 : Reach efficiency maximum equipment

For reach this efficiency maximum he East first of all essential :

- **To respect the basic conditions of use of the equipment** and therefore to eliminate all causes of chronic losses and forced degradations (external aggressions and non-compliance with normality conditions). This mainly concerns production personnel (quality of driving, adjustment, respect of the features nominal, respect of the equipment, cleaning, ...). In addition, since the operators are closest to the equipment, they will be called upon to detect the first signs of anomalies in the equipment as early as possible (it is more important to transform the operators into "reliable detectors" than into maintenance technicians).

The TPM will have for goals of give back responsible the operators of the quality of their equipment by using it correctly and detecting any changes as early as possible. In the condition or behavior of their equipment.

This action will be carried out using the 1st pillar of TPM: **AUTONOMOUS EQUIPMENT MANAGEMENT**

- **Of DELETE THE causes of losses of yield due has the organization** . It is of course this action which will bring financial gains. But we cannot hope to detect the real problems as long as the resources are not used in the conditions for which they were intended and as long as the staff, from the operator to the management, are not involved in the process.

The deletion of the causes of losses will do the object of 2nd pillar : **THE IMPROVEMENT AT CASE BY CASE.**

- **To prevent natural failures.** As long as the are causes of Forced degradations Preventive maintenance is ineffective and costly . Only when the basic conditions are met can the maintenance department set up an organization that allows:
  - Of prevent the failures natural due to phenomena wear,
  - To detect and seek possible improvements regarding the reliability and maintainability.

This action will be the subject of the 3rd pillar of TPM: **PLANNED MAINTENANCE .**

- **To improve the knowledge and the know-how of the operators and of the technicians maintenance**. The previous pillars are essential to obtain maximum equipment efficiency, but their implementation and sustainability require to improve the knowledge and the know-how of the

Operators , maintenance technicians but also direct management of the staff.

From where the 4th pillar : **IMPROVEMENT OF KNOW-HOW AND KNOWLEDGE**

Principle No. 2 : Start new products and new equipment as quickly as possible

Mastering production resources will enable production and maintenance managers of to work effectively with the services developments and engineering to design products that are easy to manufacture and equipment that is easy to use and easy to maintain.

TPM is in line with the concept of simultaneous engineering and aims to no longer accept modifications to the product or equipment after the pre-industrialization phase.

This principle is will translate speak pillar No. 7: **MASTERY OF THE DESIGN**

Principle No. 3 : Get efficiency maximum of the services functional

The technical and administrative services must aim to provide production with the information and support necessary to improve its competitiveness, All in decreasing the tasks administrative and in simplifying the procedures "over-generated" by the certification procedures.

This principle to will translate by the pillar No. 8: **APPLICATION OF THE T P M IN THE OFFICES**

Principle No. 4: Stabilize the 5 M to a high level

Get the zero breakdown, the zero default, the TRG maximum, in word get the Maximum performance of production resources requires achieving and maintaining the 5 causes (Materials, Equipment, Environment, Means, Workers) at a high level. That is to say, implementing implements the preceding principles:

- Arrange of equipment or born remain that of the deteriorations natural,
- Prevent the natural failures ,
- Apply the TPM to new products and equipment,
- To have of the operators and of the Technicians of maintenance very competent.
- To have of the suppliers Who to consider as partners of the quality of the company.

The pillar corresponding will be the pillar No. 6: **MASTERY QUALITY**

Principle No. 5 : *Mastering safety, working conditions and respect for the environment*

The performance of production resources also depends on these requirements, which are now reflected in the ISO 14001 environmental certification and soon in the safety and working conditions certification. It also means making work less difficult, less dirty, less dangerous.

5.7 Management of energy and of the fluids

Oils have high performance, especially for difficult purposes and service conditions. However, they are expensive to produce and their availability worldwide is limited. In addition, the choice of a synthetic lubricant depends on the problem at hand.

Mixtures of base oils of different origins are sometimes possible, however a so-called "synthetic" oil must contain less than 15% mineral oil.

Below a few families of oils of synthesis :

Table 3 : A few families of oils of synthesis

Polyglycols	Element lubricating properties, high flash point. High viscosity index: 150 to 200, low volatility, element thermal stability, incompatible with mineral oils. Examples of uses : Water-soluble poly glycol: flame-retardant fluid, Poly machining fluid glycol insoluble : fluid of brake, lubricant engine, lubricant gear ...
Esters	Low volatility, element cold properties, element thermal resistance, element solvent properties and element shear resistance. Examples of use : fat, turbine has gas, aviation, used as additive (high lubricating power).
Synthetic hydrocarbons (polyalphaolefins)	High cold behaviour, high viscosity index. Depending on the chain length, element thermal properties. Examples of uses : lubricant of gears, compressor ...
Silicone	Chemically inert, high resistance to heat and oxidation. Hydrophobic, high viscosity index (up to 300), element cold properties. Chemical incompatibility with many additives. Very poor lubricating power. Examples of uses : fat, fluid hydraulic ...
Glycol	Used In THE compressors (air, refrigerated) For the cleanliness of the valves, compatibility with refrigerants, heat transfer fluids...

5.7.1 Choice of the lubricants :

The choice of a lubricant must take into account the functional conditions of the mechanism to be lubricated and in particular its operating temperature, pressure forces, relative movement speeds, environmental conditions.

The manufacturers of oils and of fats are the better placed for determine the kind of lubricant to use depending on the mechanism to be lubricated.

However, the standard NF ISO/TR 3498 given of the recommendations for the choice lubricants for machine tools.

5.7.2 Storage of the lubricants :

For put in place the security in the storage and the use of the products, he must first of all, know the risks that these products represent. This knowledge is acquired by obtaining data on the product(s).

5.7.2.1 *A few rules general for the storage :*

Safety rules aim to manage the organization according to the type of storage and the type of products and quantities held. The products are stored in fixed tanks or in mobile containers according to their quantities and use.

Storage in tanks fixed (aerial) Or buried) :

- Compliance: tanks containing pressurized gases must comply with the regulations on gas pressure devices (decree of January 18, 1943, as amended).
- Corrosion resistance: the material constituting the tank or cistern must be chosen to resist corrosion by the product it contains.
- Marking: fixed tanks and reservoirs must be identified using a sign bearing indelible characters the indication in full of the product stored. It is also advisable to report, on the tank, its volume and the black symbol on an orange-red background of the labeling. The pipes that leave the tank must also be identified by different colors or symbols. A display near the tanks reminds of the ban on smoking and the use of devices producing flames, sparks, etc.
- Filling control: each tank or cistern must have an indicator allowing the filling level to be easily checked.
- Vent: each tank or cistern must have a vent of sufficient section, the outlet of which is directed towards the inside of the retention area in a direction such that the is no danger to people.
- Put has the earth : all the tanks or tanks fixed must be connected has the earth.

- Retention basin: in the event of a leak from the tank or cistern, the liquid must be retained on place by a device making bowl of retention, in material resistant to the stored product. Provide a low point in the retention basin to facilitate pumping in the event of a leak and to evacuate rainwater. If products present a risk of dangerous reaction if mixed, the retention basins must be separated.
- Tank protection: fireproof materials are now accepted for the protection of above-ground tanks of liquefied combustible gases. For these same storages, placed under embankments, the application, under specific conditions, of a geomaterial is now recognized as providing mechanical and thermal protection equivalent to the thickness of inert materials recommended by the texts in force.

Containers mobile :

Mobile container storage describes a set of products packaged in drums, various containers, rigid or flexible packaging, stored in an outdoor area or in a room. The movement of mobile containers is carried out using manual or motorized devices.

- **Rules of implantation :**
  - Separation of products: Products that may react violently with each other should not be stored in the same place. This will keep combustible products away from oxidizing products, such as oxygen or peroxides .
  - Storage floor: The floor must be impermeable, chemical resistant and slope gently towards a drainage channel connected to a recovery pit or treatment plant.
  - Ways of traffic : The ways of traffic fitted out in the warehouses must be large enough to provide easy access to storage, whether for unloading products, carrying out checks or responding to danger or fire.
  - Ventilation of the storage site: If storage is carried out outdoors, a canopy is recommended for shelter it bad weather and sun; if the storage is realized in

Premises , this must be ventilated (a mechanical ventilation system will be preferred).

- Electrical compliance: electrical equipment, lighting, electrical appliances (including heaters), handling equipment, used in a warehouse of flammable chemicals, must comply with the regulations concerning areas at risk of fire and explosion.
- Marking: a display near the packaging reminds people of the prohibition on smoking and using devices producing flames, sparks, etc.

➢ **Fashion of storage**

- Storage without accessories (stacking): The maximum storage height must be chosen so as to avoid any damage to the containers in the event of a fall. Special accessories are used for flexible containers which must not be stacked on top of each other.
- Storage on racks: The racks used for high storage must be designed and installed to prevent falls. They must also include protection systems against handling trolleys. The storage area must be easily accessible to transport and emergency vehicles. It must be away from any work or living area (distances to be respected). It must be organized into separate product zones, identifiable without risk of confusion.

5.7.3 Organization of lubrication :

In maintenance preventive, on must :

➢ Elaborate cards of lubrication by material who must define :

- The material to maintain (photos, drawings)
- The kind of operation of lubrication
- The quantity of lubricant has fill
- The nature and the features lubricant has use
- The frequency operations of lubrication
- The points of lubrication and/or of filling
- The organs to be lubricated
- The material has to use

➢ Establish A planning visits

The NF E 60-201 standard provides all the necessary information. This standard concerns “LUBRICANTS FOR THE LUBRICATION AND THE ORDER OF THE MACHINE TOOLS » and precise the " SHEETS INSTRUCTIONS OF LUBRICATION AND THE LOCATION ".
This lubrication plan must take into account the recommendations of the machine manufacturer (information given in the machine file) and the company's experience (history).
The establishment of the lubrication plan can be facilitated by a specific module within the CMMS.

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