

An approach to audit the maintenance function

MOKHLIS Ahmed¹, ELMORTADA Asmaa², ELFEZAZI Said³, BOUAMI Driss⁴, AZIM Azzeddine⁵

¹ National School of Applied Sciences (ENSAJ_UCD), El Jadida city, Morocco
Higher School of Technology (UCA), Safi city, Morocco

² Higher School of Technology (Cadi Ayyad University), Safi city, Morocco

³ Higher School of Technology (Cadi Ayyad University), Safi city, Morocco

⁴ Mohammadia School of Engineering, Rabat city, Morocco

⁵ National School of Applied Sciences (ENSAJ), El Jadida city, Morocco

ABSTRACT

Continues improvement of maintenance management system can't be reached without identifying weeks and forces of the existing system. Several studies have been carried out in the field of maintenance audit and many companies have developed their own internal audit methods of their production systems. However, only few studies have published a methodology to have the audit maintenance referential. In this context, the present work is related to develop one methodology of maintenance audit in manufacturing companies. It consists to decompose maintenance function into a set of rubrics, decomposed in turn, into sub-rubrics which will constitute an exhaustive representation of this function. Thus, we are led to develop an audit referential and a quantitative questionnaire to evaluate the company's maintenance function. Then, we present our approach results after its application in in chemical industry company.

Keywords: Maintenance, audit, diagnostic, maintenance level, referential.

1. INTRODUCTION

The increase in competitiveness in relation to requirements regarding quality, availability, safety and service has contributed to demonstrating the need to change the concept of maintenance from a tactical issue to a strategic subject in companies. In order to evaluate the efficiency and effectiveness of the maintenance area, it is essential to carry out an audit that detects and diagnoses the problems that could develop, provides solutions to these dysfunctions and adapts the function of maintenance to the specifications of the standard ISO 9001[2]. Therefore, manufacturers have production systems increasingly complex and sophisticated that are both more efficient and more fragile [7], [1]. Nowadays it's became evident that maintenance is important throughout all the process life cycle of equipment. Moreover, it has experienced the long of industrial developments evolution. we can quote: systematic preventive maintenance, conditional preventive maintenance, predictive maintenance, integrated maintenance to the design, the overall cost life cycle, total productive maintenance, maintenance based on reliability, aided computer maintenance, expert systems to aid in diagnostic, or again the audit of maintenance [7], [8], [14], [13], []

The audit approach is used to represent the differences between goals and results using referential tools to evaluate deviations and define action plan to improve the subject audited. Several maintenance audit studies have been developed. Many companies have developed their own internal methods. However, few works have been published. We especially retain in this context works of the audit Y.LAVINA [13], and those of l'ADEPA and of CETIM [12], [5], [4], [6]

In this work, we aim to propose steps to make maintenance audit referential as follow:

Maintenance function will be decomposed into a set of rubrics that will, in turn, be divided into sub-rubrics. There will be a comprehensive cartographic presentation of the global maintenance function, and a set of efficiency indices will be defined to assess the performance of the maintenance function.

2. METHODOLOGY

2.1The audit approach

The proposed audit approach consists of three levels (*figure 1.*):

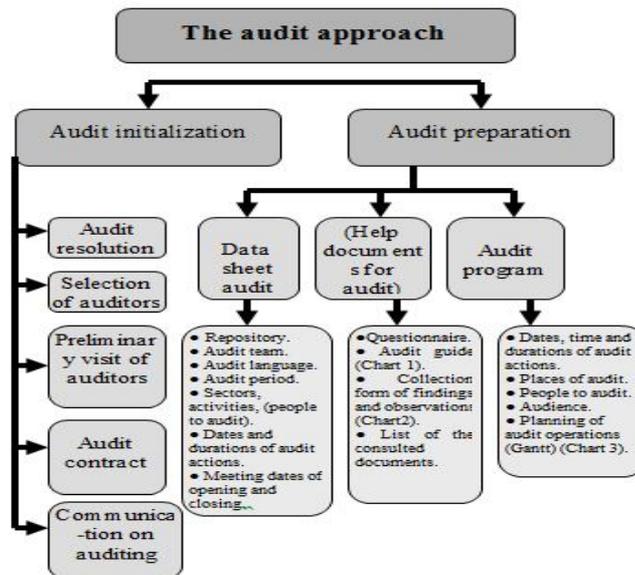


Figure 1 The proposed audit approach (a)

Audit questions	Answers	Remarks
...
...
...

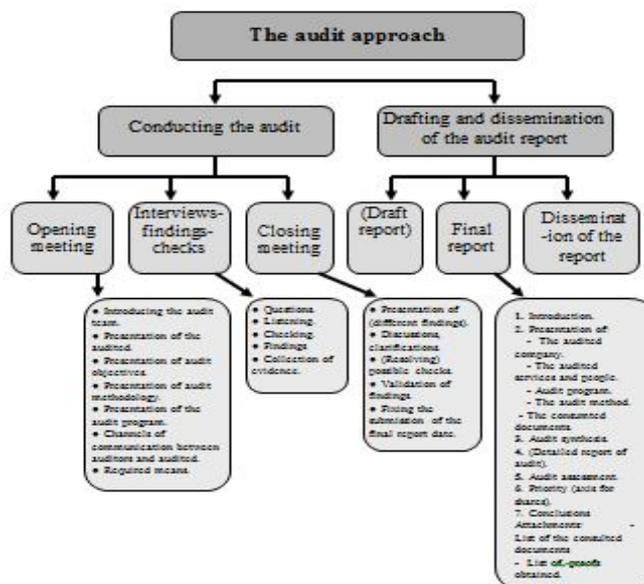


Figure 1 The proposed audit approach (b)

1st level : it describes the four main steps in the conduct of the audit :

- Audit initialization;
- Audit preparation ;
- Conducting the audit ;
- Drafting and dissemination of the audit report;
- 2nd level: it specifies exhaustively the activities relating to each main stage.

- 3rd level : it gives the supports, records and useful details to the conduct of each audit activity (examples : charts 1, 2, 3).

Table1. Example of the Audit Guide

Audit questions	Points to be checked	Collecting evidence
- Are the critical equipment identified? - Are the failures identified? - Are failure costs determined?	Identification of critical equipment in terms of failure cost.	- Sheets of critical equipment. - List of critical failures. - Failure costs. ...
...
...
...

Table2. Collection form of observations and answers

Table3. Audit planning

Audit process	J 1	J 2	J 3	J 4	J 5
Organization, Policy and Strategy					
Inventories, Consolidated Law and					
Documentation					
...					
Feedback and Analysis					
Ameliorative Studies					
Computer-assisted maintenance					

2.2 Management system of the maintenance: the proposed approach

Our approach is to divide the maintenance management system into 16 sections. These are all the essential components which make it (Figure 2).

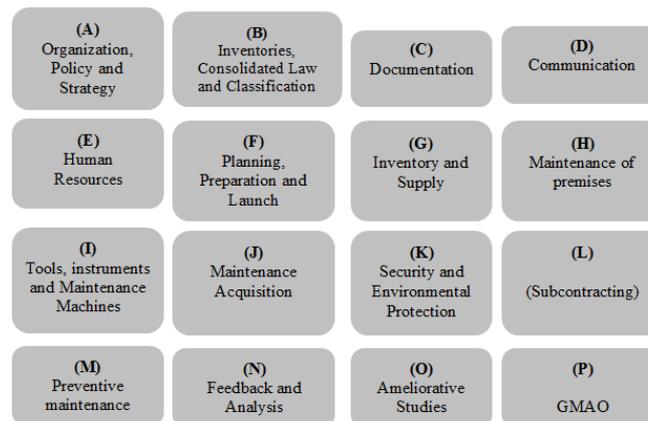


Figure2. Constituent sections of the maintenance function

Each rubric is, in turn, divided into a set of sub-rubric. They will provide a detailed and comprehensive representation of the logical flow of their related maintenance activities. In the following, we present as examples developed subtopics for registration. **Feedback and analysis (N) and Preventive maintenance (M)** (figures3, 4)

2.2.1 Feedback and analysis (N) :

- Intervention traceability report
- Lubrication plan record
- Round record
- Operating Maintenance Record
- Historic
- Accounting
- Periodic analysis
- Determination of technical indicators: TRS, (Failure rate), MTBF, MTTR, (Turnover of stock)...
- Determination of economic indicators: direct costs and indirect costs for equipment, (design), workshop, factory...
By specialty, for maintenance strategy, stock value, consumption value...
- Development of dashboards (technical and economic)
- Benchmarking
- Actions:
- Optimization of frequency response
- Ameliorative studies
- Modification of Maintenance strategy
- Changing procurement policy
- Trainings.
- Changing operators
- New acquisitions

2.2.2 Preventive maintenance (M):

- Identification of critical equipments in terms of cost of failure
- Systematic maintenance outside the annual revisions
- Maintenance of operations
- Predictive Maintenance
- Rounds
- Maintenance of exploitation or of conduct
- Maintenance strategy selection procedure for each critical component
- Maintenance Plans
- Records revisions : Maintenance Studies AMDEC and the manufacturer's recommendations to define the preventive work which to be done

- Range of maintenance
- Plans of greasing and lubrication
- Work planning by Gantt or Pert
- Load Optimization
- Preparation of important works
- Resource reservation: Men, machinery, tools, local,
- Maintenance Consultation Operation for Planning

So we will have a total of 246 sub-rubrics (referential). They will be establishing a global representation of the shares of the maintenance function as a description of its internal mechanisms every time this latter is activated as part of the fulfillment of its mission within the company.

The referential thus formulated, it is up to the auditor initially to ask relevant questions in order to understand the reality to understand the reality of the maintenance function through capturing and processing of the collected information. Then, compare the reality to our repository, set a finding of compliance and assess differences. Our approach can also be applied for positioning relative to a prior situation, as part of a process of continuous improvement of the maintenance function.

During our audit approach, the auditor is free to ask useful questions to estimate the reality (progress, performance ...) of each sub-rubric. He can therefore add or subtract other issues. These latter may differ in situation from one company to another. They depend on the history, implementation, sector of activity and peculiarities/specificities of the company in question.

2.3 Evaluation of the audit

2.3.1 Evaluation of the rubric:

- 1- We have assigned to each sub-rubric a mark **N_i** between 0 and 10. It constitutes an estimation of its degree of realization with respect to the reference. The determination of this mark is set through a questionnaire on the implementation of sub-rubric in question.
- 2- We have assigned for each sub-rubric a weight **P_i** between 1 and 3; it constitutes an estimation of its degree of importance.
- 3- We determine the evaluation of the efficiency degree of the rubric in question by calculating the (global average) of the sub-rubrics that form it (**Chart4**):

$$M = \frac{\sum(N_i * P_i)}{\sum P_i} \quad (1)$$

Table4. An example of the scoring grid of sub-rubric

Sub-rubric	N	P	NP
N1			
N2			
...			
N12			
Rubric score N			

2.3.2 Evaluating the maintenance function :

For evaluating the effectiveness of the global maintenance function, we proceed as follows:

- 1- We determine for each rubric its degree of implementation (efficiency) by calculating its average **M_i** with the previous method. It constitutes an estimation of the efficiency of its progress.
- 2- We assign to each rubric a weight **K_i** between 1 and 3; it constitutes an estimation of its degree of importance.

3- We determine the degree of the efficiency of the progress of the global maintenance function by calculating the global average of the average of the rubrics which make it up (**chart5**):

$$MG = \frac{\sum(Mi * Ki)}{\sum Ki} \quad (2)$$

Table5. Scoring grid rubrics

(Rubric)	N	P	NP
A- Organization, Policy and Strategies			
B- Inventories, Consolidated Law and Classifications			
...			
O: Ameliorative Maintenance			
P: Computer-assisted maintenance management			
Score of Maintenance System			

These various coefficients as calculated, will allow us to evaluate the performance of the maintenance function in the manufacturing companies and estimate the **deviation from (gap???)** the reference. They also allow to assess the effectiveness of flow of each of these internal components.

Finally, a representation by graphic radar allows us to trace the profile of each rubric and determine thereafter, the position of the company in terms of maintenance (maintenance profile).

3. RESULTS AND ANALYSIS

3.1 Implementation of the audit approach in a company

Table5. Results of the questionnaire

Studied Topic	Percentage %
A- Organization, Policy and Strategies	76
B- Inventory, Consolidated Law and Classifications	64
C- Documentation	50
D- Communication	60
E- Human Resource	54
F- Planning, Preparation and Launching	59
G- Stocks and Supplies	58
H- Local maintenance	84
I- Tools, Instruments and Maintenance machines	92
J- Maintenance Acquisition	70
K- Security and Environmental protection	65
L- Subcontracting	63
M- Preventive Maintenance	56
N- Feedback and Analyzes	71
O- Ameliorative Studies	62
P- Computer-assisted maintenance management	54

3.2 Graphical representation of results:

In the following, we take as an example of the graphical representation that of the rubric N (Feedback and Analyzes). The twelve branches of the next polar diagram represent the ten sub-rubric of this rubric. We (bring forward) on each axis the corresponding result.

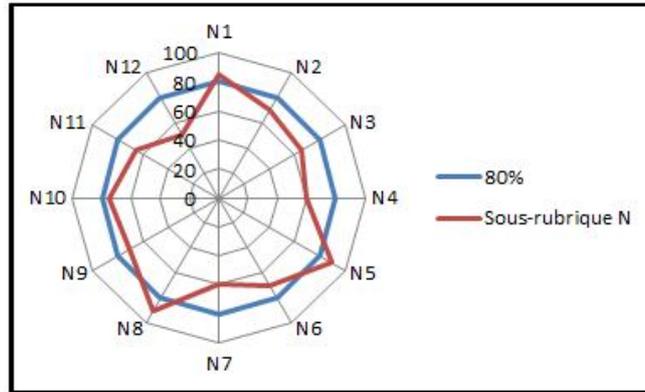


Figure5. Rubric profile (N)

3.3 Polar diagram of the maintenance profile:

Similarly, the polar diagram of the maintenance profile represents sixteen (sections) which (bring forward) in each case the corresponding result.

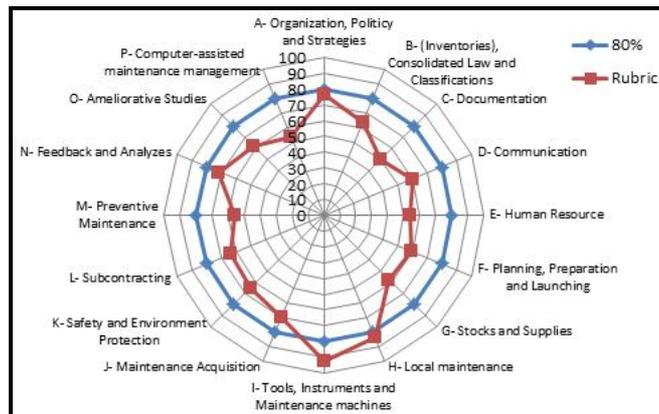


Figure6. Maintenance profile

3.4 Some comments on the results:

3.4.1 Organization, Policy et Strategies : Obtained score : 76 %

This (rubric) is among the best rated, but there some remarks to be retained:

- The absence of job descriptions for each of the performers;
- Operators do not have instructions to perform first-level maintenance tasks;
- The partial absence of maintenance objectives or of their deployments;
- The absence of formalized methods of employment;
- The absence of some printed Flowcharts
- Interventions are quite private and are improved by (performers).

3.4.2 Stocking, Consolidated Law and Classification Obtained score: 64 %

The score for this rubric is very low, several weaknesses have been spotted:

- The (facilities) on the site are not all clearly identified by more suitable codes on each (setup) ;
- The absence of (correspondence tables) of maintenance codes, stores and manufacturers;
- The lack of equipment classification to determine them Criticality according to:
- Quality

- Cost
- Time
- Quantity
- The absence of codification procedures, deleting and editing the code;
- The (fixtures) are not each accompanied by its own technical file;
- The lack of information concerning the gears' cost;
- The information related to the history is not exploited.

3.4.3 Planning, Preparation and Launching Obtained score: 59 %

The findings for this (rubric) are:

- Operators are not directly involved in the first-order works maintenance;
- The absence of the procedure which determines works to be prepared and the level of preparation;
- The lack of preparation procedures ;
- The lack of a permanent knowledge of the billfold workload;
- The lack of a (monitoring) program of preventive interventions. These programs are not made for any (prospective) adjustments.
- A lack of preparation procedure.
- Poor management plans and scales of preventive maintenance.
- Insufficient management of work requests (DT).
- Insufficient management of preparation records.
- The lack of certain procedures and (printed launching) of works (Work order (WO) and Good working (GW));
- The absence of the use of Gantt or Pert for planning;
- Consultation (scheduling)-production is insufficient.

3.4.4 Stocks and supplies: Obtained score: 58 %

For this (rubric), we can notice:

- The absence of monitoring gears for spare parts consumption ;
- The actual value of the replacement stock cannot be easily creditable;
- The thresholds of supplies are to be set;
- The (consolidation) of stocks (elimination of (unnecessary events), duplicates, ...) is insufficient;
- The absence of (correlation tables of maintenance codes), store, manufacturer;
- A lack of commutable identification;
- Application procedures for deleting items (obsolete, (not compliant), deteriorated...) is not systematic;
- The lack of use of anticipation techniques of consumption;
- Insufficient data analysis, dashboards development and reporting;
- Insufficient inventory optimization studies and supplies of standardization;
- The lack of communication on the objectives and results of the Inventory Management and supplies;
- The (issuance) of order is too slow;
- The lack of coordination between the purchasing department and maintenance department during the various negotiations with suppliers.

4. CONCLUSION

Continually faced very severe constraints of cost, quality, deadlines, safety and environment, industrial production systems are becoming more complex and sophisticated. This imposes on the maintenance function a daily confrontation with very complicated problems whose solution requires a set of concepts, tools and methods for optimizing and improving the maintenance function. And thus, our work presents a practical approach to audit the maintenance function as part of a continuous improvement process. This is an original approach that led to the determination of all the (action) situations and the development of a (repository) audit of the maintenance function. The use of this approach has the merit of placing us at the heart of the operation of each component of the maintenance function to detect and correct malfunctions, prevent errors, optimize the use of resources, to have a dynamic continuous improvement and thus have significant gains in terms of performance, deadlines and costs.

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AUTHORS



Ahmed MOKHLIS is a professor researcher at the Higher School of Technology of Safi (EST_UCA) and at the National School of Applied Sciences of El jadida (ENSAJ_UCD). Prof.Mokhlis's research interests in the area of measuring the performance of industrial processes, and industrial indicators.



Asmaa ELMORTADA is a member of the Research Team in Industrial Engineering at Cadi Ayyad University, her research focuses on human resources management within industrial enterprises. Asmaa ELMORTADA is the corresponding author.



Said ELFEZAZI is a professor in the Department of Instrumental Techniques and Quality Control at the Higher School of Technology. He is currently responsible for the Research Team in Industrial Engineering at Cadi Ayyad University. Prof.Elfezazi's research interests in the performance of industrial processes, project management, industrial indicators, and logistic.



Driss BOUAMI is a professor in the mechanical department at Mohammadia Shool of Engineering. His researches interest in the fields of maintenance, quality and security.



Azzeddine AZIM is Director of the National School of Applied Sciences of El Jadida (ENSAJ) and a professor researcher within its educational team. He is interesting in materials and manufacturing engineering.