

Design of the New Competences Relative to the New Policies of the Industrial Maintenance

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Abstract-- *In this paper, we will display the successful mutation of the industrial maintenance. Besides, the agents' evolutions in terms of competence of the industrial maintenance. Also, we will represent and analyze the academic referential of competence of the industrial maintenance, and more specifically competence related to the New Information and Communication Technologies (N.I.C.T.).*

Keywords—industrial maintenance, NICT, Competence

I. Introduction

The industrial maintenance, which is primarily engaged to ensure the proper functioning of the tools of production, is a strategic task in the business. This service is closely related to the regular technological progress, to the emergence of new modes of management, to the need to reduce production costs, it is in constant evolution. Its role today is no longer limited to repair the errors but also to anticipate and avoid the malfunctions, and even remotely control the production chains. Over the course of these changes, the activity of the staff of maintenance has also evolved to join the technological, organizational and relational skills.

Practically, this article describes the successive mutations of the industrial maintenance as well as their impacts on the evolution of the agents of maintenance dexterity, on the basis of a repository of trades and skills.

II. The function of maintenance: diverse and substantial developments

A. The history

Maintenance is a set of the technical, administrative and management actions carried out during the life cycle of a machinery tool and designated to maintain or to restore a state in which it can perform its required function [1]. Maintenance has long played a curative role whose sole objective was to reduce the downtime of machines. This curative maintenance was focused on the short term but failed to resolve the problems related to inevitable degradation. The rampant competition and the race for competitiveness lead companies to search for a total quality in particular the reduction of costs.

Maintenance has thus become one of the primordial functions in the business. It is therefore hardly intended to repair the working tool and to anticipate its malfunctions. The technical problems in, or the abnormal functioning of the tool of production, and the non-compliance with the deadlines follow and cause additional costs that companies can no longer stand. The company should no longer be loose with these incidents; it must anticipate them and analyze their effects on the long term. Previously curative, protective maintenance becomes and contributes to improve the reliability of the equipment and the quality of the products.

This preventive maintenance is vacillated in the definition of plans of actions and interventions on the equipment, by the replacement of certain parts in degradation pathway in order to limit wear, by the lubrication or the regular cleaning of some working tools.

These preventive actions were in a previous time carried out in a systematic manner according to predefined timetables. They allowed us to anticipate the faults, but at the cost of a significant increase in maintenance fees. Thanks to the evolution of methods of diagnosis and control, a new kind of maintenance has been created. It has been using techniques of forecasting faults such as the analysis of vibration or oils. This preventive maintenance labelled "conditional" allows the agent to substitute the parts just before being broke. The choice between the different aspects of maintenance is not done only in terms of economic costs, but also of the skills and abilities of the maintenance staff and the competitive position on the market. MONCHY presented the various aspects of maintenance shown in the Figure.1 [9]:

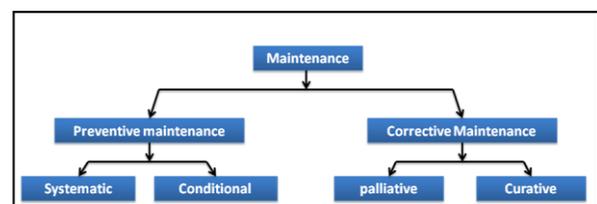


Fig.1: The different aspects of maintenance

B. Development of maintenance:

In the way of competition development and the race to competitiveness that drives the search for total quality, and especially the reduction of costs as well as complexity and automation of production processes, maintenance has become

one of the strategic functions of the company. Far from being stabilized today, maintenance has been evolving with the latest information and communication technologies I.C.T., the introduction of new methods of management, the technological development of the tools of production, particularly in the areas of the measurement and control of operation and the systematization of progressive of the use of standards and procedures. All of these factors changed not only the modes of organization of the maintenance function but also the activities of technicians and workers who operate in this field.

B.1. Total productive maintenance (T.P.M.):

The Total Productive Maintenance refers to maintenance, modification and improvement of machinery and equipment [5]. With this concept, maintenance is no longer seen only as an activity non-value-added, but as an important process of improvement of the overall productivity.

The purpose of the Total Productive Maintenance is to reduce as much as possible the urgent stops of activities due to maintenance, improve overall productivity by involving all staff. Metaphorically, the T.P.M. is as important for equipment and machinery as medicine is to the human beings. The figure.2 presents the home of the T.P.M.:

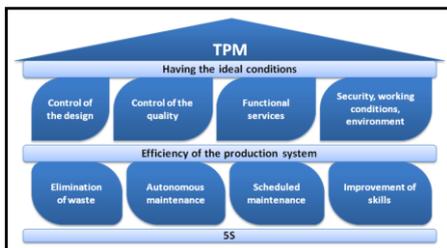


Fig.2: the T.P.M.'s home

This concept is also employed to maximize the performance of equipment, the availability and quality of equipment with the participation of all the staff of the productive unit in question.

B.1.1.Objective:

BUFFERNE according to [5], the T.P.M. has the objective to:

- Acquire a better control of human, material and financial resources.
- Reduce costs and increase the reliability of the equipment with a maximum availability.
- Empower the operator in relation to the machine / product and it could lead to the search for the improvement of performance, by proposing solutions to get rid of the repetitive failures and improve the quality of the manufacture.
- Increase the skills of the operators and their know-how and security.
- Relieve the service jobs that do not require special skills.
- This will enable the service to be devoted to its essential role which is: (high-level intervention, failure analysis,

implementation of advanced technologies and optimization methods and procedures for maintenance).

The T.P.M is directly and permanently on the go of core competencies of the company development through the three main factors shown in the following figure.3 [7]:

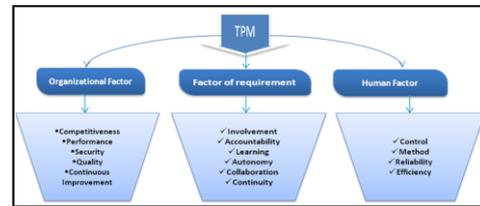


Fig.3: Influence of the T.P.M. in the enterprise

The ultimate objective of the T.P.M. is to reduce the causes of losses approximately to zero degree, in order to improve the performance of production resources and obtain the maximum efficiency of persons and the effectiveness of equipment.

This is a change on the principle that cannot decide unilaterally, but which is built in the time and with all the actors or the staff of the company. That is to say, a T.P.M. approach is long and never even completed since it is based on the continuous and permanent improvement.

B.2.The expert systems (E.S.):

An expert system is a computer application able to make decisions or solve problems in a specific area; it is a program using artificial intelligence. A database is designed on the basis of the knowledge of an expert earlier than being integrated into a program [4].

The E.S. used in maintenance allows you to:

- Address the various aspects of maintenance for a family of given equipment.
- Guide gradually the intervener to the most reachable manner of lower cost by a careful integration of the corresponding know-how and of observed facts.
- Take into account easily the adaptations that may be necessary.
- Resuming possibly and strengthening the "Troubleshooting flowchart" which can be enhanced by making it more accessible.

The E.S. is a program that brings together knowledge. It is used in a manner similar to those of the specialists; it cannot be done without difficulty. However, the human-machine dialog is currently the main obstacle to the use of expert systems as well as the limitations vacillated in the exploitation of non-systems originally designed for micro-computers.

Expert systems can help the industry to solve problems involving the specialists. They cannot replace them in their entirety, duplicating their knowledge and taking advantage from a greater number of users and the skills and the know-how of the so-called "experts". And these systems must contain all the knowledge of the area and be able to have a method of resolution similar to the human reasoning.

To improve maintainability, it is necessary to facilitate the diagnosis of faults and to reduce the downtime. In this context, the expert system is a helpful resource.

The E.S. offers the advantage of being based on the methods of the human reasoning and being also able to be enriched depending on the user's experience. It must be then able to:

- Solve the problems (find causes of the failure)
- Explain the results.
- Benefit from the experience.
- Restructure its knowledge.
- Breaking a rule.
- Judge the relevance of a data.
- Judge its ability to solve a problem.

B.3.The technology of C.M.M.S.:

The information used in different applications of the field of maintenance has been changing according to the evolution of information technologies and in function of the increasing complexity of the industrial environment. In the past, this information has been entered manually on paper (plans, schematics, manuals) and exchanged verbally between operators. The information was not formal enough in order to share the paper form, because the need was not to be considered. Today, however, the information has become totally different. It is structured and formalized in order to be manipulated by the computer systems.

The call for the C.M.M.S. package (Computerized Maintenance Management System) will meet the needs of businesses with regard to the exchange of information and procedures and the analysis of maintenance activities and archive them.

The C.M.M.S. is characterized by four standard features (figure.4)

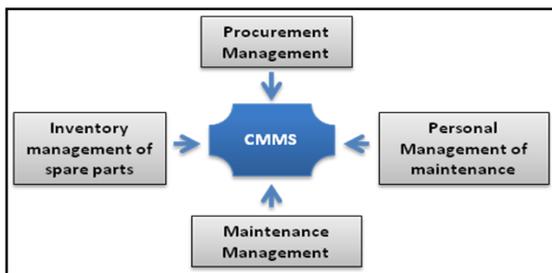


Fig.4: The characteristics of the C.M.M.S.

- The management of maintenance concerning the preventive or curative interventions on the industrial equipment.
- The management of the maintenance staff in charge of schedules, assignments, and management of training.
- The management of the stock of replacement parts, control inventory in the store, alert on the threshold, receipt of parts.

- The management of procurement in everything that concerns the addition of commands, the management of suppliers and their price, and the billing.

The C.M.M.S. is a part of a project for the improvement of productivity thanks to the following actions.

- Improvement of the availability of equipment.
- The extension of the life of machines.
- Improvement of the charging rate of the maintenance team.
- Improvement of the information sharing and removal of the "key person".
- The improvement of the safety of the equipment.
- Controlling the costs of maintenance.

According to an analysis carried out by the French Association of Engineers and responsible for Maintenance [1], the effects of the C.M.M.S. in the companies having been implemented are the following:

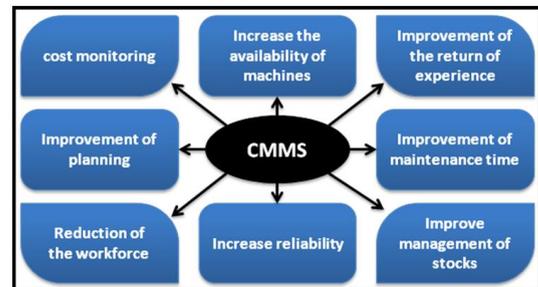


Fig.5: the effects of the C.M.M.S

B.4.The remote maintenance:

Businesses are looking to improve the current system of maintenance through two strategic levels:

- The first level is aiming to strengthen the service of maintenance in the company itself, i.e. at the level of internal resources (internalization of the maintenance function.)
- The second level appeal to external resources of the enterprise through a sub-contractor (reduction of maintenance service) - we are talking here about the outsourcing of the maintenance function.

The current trend is to outsource, in part, the maintenance function. The Outsourcing process brings us to evolve in a domain which is distributed and has changed the information systems as well as the practices of the company. The new technologies of the information and communication (I.C.T.) have helped establishing these new practices and making them to change. Thanks to the N.I.C.T., to the emergence of Web technology and the Internet, the tasks of maintenance services and controls can be performed automatically to distance and with the aid of various appropriate devices implanted within the firms.

Therefore, the emergence of the concept of services offered through architectures of maintenance can lead autonomous systems to entrenched systems or cooperation and collaboration which are vital to any operation. The birth of the remote maintenance on the technologies of access, treatment of data,

information or of knowledge and exchange between actors at a distance, appears to solve the problem of the limited number of service personnel with the skills, the versatility and the know-how in the business. Hence, the new forms of maintenance tend to expose the staff to a rapid access to information.

They also allow you to directly benefit from the assistance of experts to distance in case of need. In remote maintenance, the states of devices are discovered on the spot thanks to sensors or local operators, and then routed via a network and forwarded to the intended recipient. As such, two main architectures of remote maintenance exist:

- The remote maintenance.
- The e-maintenance.

B.4.1. The remote maintenance:

AFNOR according to [2], the remote maintenance is defined as "Maintenance of a goods implemented item without physical access of personnel to the working tool."

The remote maintenance therefore aims to allow the staff performs, quickly and at a distance, a large number of operations. The main component of a system of remote maintenance is the network on which it relies for the flow of information. A system of remote maintenance is usually consisted of at least two distinct parts:

- The center of expert maintenance, also called the center of competence.
- The sites of maintenance.

ZERHOUNI presents the architecture of the remote maintenance shown in the figure.6 [11]:

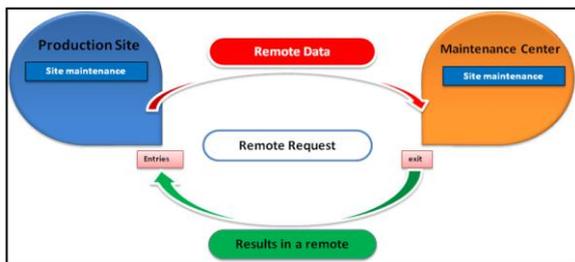


Fig.6: The architecture of the remote maintenance

B.4.2. The E-maintenance:

The e-maintenance is also an evolved form of maintenance with the advent of the Internet and of the new information and communication technologies (N.I.C.T.), and which allows for the sharing of knowledge and work with actors. The e-maintenance is associated with the concept of intelligent service since it allows access to knowledge outsourced, of e-service (electronic service via the Internet). It allows you to make available for remote resources; these resources can be hardware (spare parts, tools ...) or intangible (human or computer...). The outsourced resources are accessible through the Internet network, to tools for communication, exchange and access to information that can be

grouped under the term of e-service [11], ZERHOUNI gives an overview of the activity of e-maintenance (figure.7):

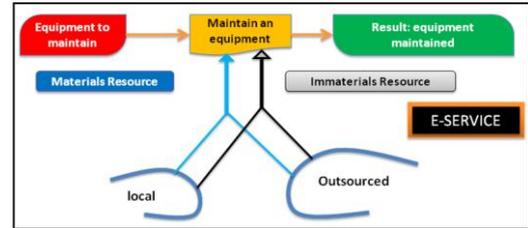


Fig.7: The activity of E-maintenance

The architecture of e-maintenance is done via a web-based network which allows you to cooperate, to exchange, share and distribute this information to the different systems partners in this network. The principle is to integrate all of the different maintenance systems into one information system [11]. The systems offer different formats of information which are not always compatible for sharing data which requires the coordination and cooperation between the systems to make them interoperable. ZERHOUNI presents the architecture for E-maintenance (figure.8):

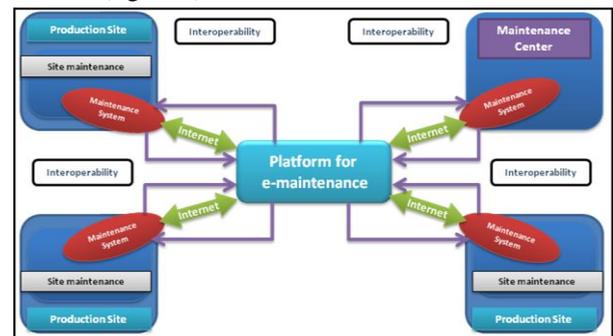


Fig.8: The architecture of the E-maintenance

III. The repository of skills in maintenance:

A. Overview:

The creation of the repository of trades and skills allows us to have:

- A better consideration of the institutional and professional developments in the trades.
- An identification of current and future employment to develop a contingency management jobs and skills.
- A permanent adaptation of the training to the developments of the trades.

The repository of trades and skills will be used to identify the main components of trades in regard to the activities of the business as well as the skills relating to the person who practice this profession [6].

B. The structure of the repository of competence:

A repository of trades and skills must begin with:

- The action of the business:* it defines the business, its purpose and reason.

-*Activity*: defines the set of actions that help to achieve the mission, the emphasis is on the activities that determine the specific circumstances of a business.

-*Skill*: it is characterized by the implementation in situation of professional capacity to carry out properly an activity; this includes the capacity required for the realization of a professional activity and the entire professional behavior to a mastery of this activity.

-*Indicator of competence*: this is the proven capability to exercise the profession that encompasses the knowledge (conceptual competence) and the know-how (technical skills).

-*Autonomy and responsibility*: measure the latitude and the initiative at the disposal of the practicing of the business from a grid to five levels, the following table presents the specification of each level:

Table.1: Levels of autonomy

Level	Specification
Level 1 (Concept)	This skill is somehow mobilized in the post. The agent must have a basic knowledge.
Level 2 (acquisition)	This skill is required to fill the position. The agent must have in-depth knowledge.
Level 3 (master)	This skill must be perfectly integrated into being indispensable to occupy the post. The agent must be able to facilitate the transmission of this competence
Level 4 (specialist)	This skill must be perfectly integrated and indispensable to fill the position. The agent in this area must be able to promote the transmission of this jurisdiction; he must be able to remedy all kinds of problem.
Level 5 (expert)	This skill must be perfectly integrated into being indispensable to occupy the post. The agent expert in this field must be able to promote the transmission of this jurisdiction; he must be able to participate in the development of his activities.

C. The repository of trades and skills of an agent of maintenance:

Table.2: repository of trades and skills:

<p>Action of the business: The agent of maintenance ensures the maintenance of industrial equipment, be it curative or preventive, he ensures the availability and reliability of his equipment according to a physical access (direct maintenance), or without physical access (remote maintenance).</p> <p>Activities</p> <ul style="list-style-type: none"> ❖ Check the proper operation of industrial equipment ❖ Diagnose a malfunction on the industrial equipment ❖ Organize an intervention ❖ Control the technologies of the N.I.C.T. in the maintenance of industrial equipment

Activities	Competences	Levels	Indicator of competence
Check the correct operation of industrial equipment	-Monitor, measure, run the tests mechanical, electrical, electronics, -control, hydraulic, pneumatic...)	*	Observe the safety instructions by inspections, measurements and tests - Adapt each control or measure or test in terms of caliber and accuracy
	- Know the methods of malfunction	*	On the functional plan: Know the type of failure (control, electrical, mechanical ...) On the sequential plan: -Test of control systems -Analyze the automatisms, position them On the plan hardware: -Test components (from simple to more complex) -Test the failed components
Diagnose a malfunction on the industrial equipment	- Collect the information to enable to drive in a logical manner to the identification of the malfunction	*	- Know the different types of maintenance
	- Knowing the types of maintenance that should be executed (curative or preventive)	*	- Observation, control, readings
Organize an intervention	- Know the types of interventions (troubleshooting, installation, replacement, reassembly)	*	Hardware -Prepare -Calibrate Part - Identify the parts by contribution to the plan and patterns
	-Prepare the equipment and parts before the intervention.	*	-Separation of sources of energy of the tool -follow the safety instructions -The master of environmental hazards (chemical, pollution ...)
	-The safety of the area of the intervention	*	

Control the technologies of the N.I.C.T. in the maintenance of industrial equipment	Treat a document	*	- Produce a simple textual digital document. - perform and manage functional documents.
	Search for information	*	- Find the information in a context known - Find and manage information tailored to his needs
	Communicate	*	-Send and receive messages using a device known - Manage their email
	Get a service	*	- Obtain an essential service with a known device - Use any type of device providing the same service

Concerning the experience of the agent of maintenance at the level of knowledge and know-how, he may be evolved to a position of responsible for maintenance. The latter is called to organize and manage the technical activities of the company. He must prove the characters beneficiaries of his activity regarding the improvement of the availability of production equipment and also improving the performance of his service (exploitation of quality tools ...).

He must have significant experience of technologies implemented in the production system of the company. In effect, the access to this post is done more by internal promotion than by recruitment. The responsible for maintenance must have an organizational competence regarding the control of the activities of agents. These agents are placed under its responsibility, the planning of preventive activities or the tools of interventions during the shutdown.

Not to mention his ability to manage budgets and his capacity to investment in hardware maintenance, material of investigation, computing capabilities as well as the formations or the recruits. He must also justify the financial profitability of his service using encryption methods and the ratios which are useful to maintenance.

His relational and decision-making role is to lead and motivate the various departments and teams, he must ensure the level of their skills, and he must demonstrate the ability to listen to and negotiate the production circle or the customer [1].

Thanks to the birth of information and communication technologies I.C.T., the maintenance manager must be able to know methods and techniques for the servicing and maintenance processes related to the C.M.M.S; however, he must also control the packages of intelligent, analyze activities and reliability, diagnose and remote-control the actions of maintenance of the equipment that he manages.

D. Analysis:

According to a study conducted by the aid of a questionnaire which was sent to the various sectors of industry in France,

having the purpose to define the different functions of the agent of maintenance related to the field of I.C.T., we have been able to presume that these skills can be summed up in four strategic functions mentioned in the previous table and grouped in the following figure:

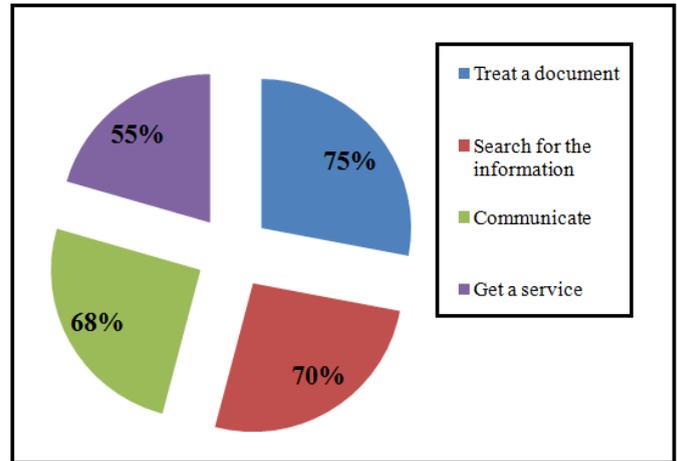


Figure.9: Classification of the major functions for the use of N.I.C.T. in industrial maintenance

Note. - The maintenance agent must have in a prime time as nearly required from fundamentals in the different areas of technologies such as computer science the telecommunications....

According to the poll that we have been able to do, each strategic function has two levels of weighting or of autonomy:

- The level 2: have the extensive knowledge
- The level 3: mastering his knowledge.

D.1. Treating a document:

For the second level, the maintenance agent must be able to produce a simple textual digital document to describe the type of anomaly and the archive (document management).

While in the third level, the maintenance agent must realize and manage functional documents; in the same vein, he must be able to archive and manage his files, use a sheet of simple calculation (summons, product, ...) or complex a text (rate of malfunction of a machine, M.T.B.F., M.T.T.R; for example).

So he is ready to edit a document (report) complex text based on mathematical calculations and graphs narratives.

D.2. Searching for the information:

For the second level, the maintenance agent must find information in a context; which means, he must be able to know the use, the interest, and the limits of the internet, discover the architecture of a graphical user interface (web site, C.M.M.S. software or other) and identify the invariants of the graphical interfaces and the specificities of presentation.

The third level leads the maintenance agent to find and manage information tailored to his needs. Equally, he must be able to develop a critical aspect vis-à-vis the internet, use of search engines, filter and extract the information suited to his needs and finally download a file (document, video...).

D.3. Communicating:

For the second level, the maintenance agent must send and receive messages with a known device. Likewise, he must know (the use, the interest, the limits of e-mails, discussion forum...), exchange and share information on a forum or a network.

For the third level (masters), he must be able to create a box mail to facilitate the sharing of information, manage his contacted, send and receive messages developed with a complex procedure and finally archive his messages

presents the different functions of the agent of maintenance, and we have analyzed the skills which are related to the field of N.I.C.T.

D.4. Getting a service:

For the second level, the maintenance agent must be able to obtain a desired service of a communication device (phone, fax, computer...) or an application of industrial maintenance (C.M.M.S. or of more intelligent software diagnostic).

For the third level (masters), he must be able to use any type of device that is providing all the preferred services to diagnose the anomaly to distance, starting goods from a distance, archive all information...

IV. Conclusion

Therefore, this article has tried to describe the mutation of the maintenance function; it has begun by a reminder of the history of the maintenance function, and then the gradual evolution of this feature in passing by the T.P.M., expert systems, the C.M.M.S., the remote maintenance and the e-maintenance. We have presented later a repository of trades and skills which

References

- i. A.F.I.M. French Association of Engineers and responsible for maintenance, "production maintenance" C.M.M.S. guide - second edition - review of the A. F. I. M., Paris, September 2004
- ii. A.F.N.O.R NF EN 13-306, "Terminology of the maintenance", Edition A.F.N.O.R, Paris, 2001.
- iii. A.F.N.O.R X 60-00, "Industrial Maintenance - maintenance function", Edition A.F.N.O.R., Paris, 2002
- iv. Blanc M., Charron E., Freyssenet M., The "development" of systems-experts in business, Cahiers of research of the G.I.P "Industrial Change", No. 35, November 1989, 84 p. Digital edition, freyssenet.com, 2007, 800 kb.
- v. Jean BUFFERNE "The T.P.M.: a production system", Technology (SCEREN - CNDP) - French magazine of industrial management, Paris, April 2008.
- vi. Catherine FRENOT "Repository of trades and skills", direction of the judicial protection of the youth D.P.J.J./SDRHRS department of justice, update July 2008.
- vii. Daoud AIT KADI, "Maintenance and Quality" department of Mechanical Engineering, University of Laval, CANADA, 2007.
- viii. M.E.F.I., Ministry of the economy of finance and industry "trades of the industrial maintenance" mode of employment, edition of the industry, Paris 2001.
- ix. Monchy F., "Maintenance, Methods and Organizations" Edition. DUNOD, Coll. The Factory, New Series Industrial Management (2nd edition), Paris, ISBN 2-10 -007816-5, 2003
- x. Muller A., « On the concept of e-maintenance review and current research», reliability Engineering and System Safety, 93 (8), p. 1165-1187, 2008.
- xi. Zerhouni N., "Classification of different architectures of maintenance" 7th international Congress of Industrial Engineering - June 5-8, 2007 - Three-Rivers, Quebec (CANADA)