Optimize the maintenance activity with computer application

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Abstract. The paper contains a few knowledges about the maintenance activity to establish an optimal maintenance strategy with computer application. Maintenance activity is theoretically analyzed by finding a logical scheme for implementing a maintenance strategy and a brief description of the advantages of implementation a computerized maintenance management software.

1. Introduction

Maintenance is the set of technical, administrative and management measures taken during the lifecycle of an equipment, intended to maintain or restore it to a state in which it can perform the function necessary to ensure that the system functions as efficiently as possible. The term "maintenance" has multiple definitions, which try to highlight different aspects. The most important task of maintenance is to ensure the availability of long-term equipment.

The best ways [1], [2] to support the maintenance process are:

• Team work;
• Productivity oriented on contractors;
• Total integration with spare parts and services provided by suppliers;
• Management support;
• Proactive planning and programming;
• Continuous improvement of the maintenance process;
• Continuously improving the procurement process of materials and services;
• Integrate the maintenance process into the organization.

Maintenance activity [2], [3] includes several professions and targets all sectors of activity. Occupational diseases and maintenance-related health problems (asbestosis, cancer, hearing deficiencies and musculoskeletal disorders) are predominant. Maintenance workers are at risk of a whole series of accidents, are more exposed to heat in the summer (44% compared to 19% among other professions), cold in winter (44% compared to 17 %) and a humid atmosphere (25% compared to 13%), hazardous substances, vapors and emissions.

Maintenance workers are at risk of a whole series of accidents. It is estimated that about 15-20% of total accidents and 10-15% of total fatal accidents are related to maintenance operations.

The cost lifecycle of a piece of equipment includes all the resources needed to develop the product, produce, distribute, use, recycle, and remove it. Maintenance activities are managed over time.

Figure 1 shows the rate of occurrence of a fault depending on the operating time.
A new equipment is likely to fail in the first week since commissioning due to installation issues. After this period, the probability of a defect is relatively reduced over a long period of time. After this period, called the life cycle, the probability of failure increases rapidly with the elapsed time. Maintenance management should take this statistic into account when planning work.

2. Maintenance strategy

The maintenance strategy [2], [4] selected for a machine must effectively use the following types of maintenance, individually or cumulatively. Figure 2 presents schematically the types of maintenance strategy approach.

The role of maintenance strategy [2], [4] is to achieve and maintain the following:

- optimal availability of production facilities and auxiliaries to maintain the company's production capacity at the established performance level;
- optimum operating conditions for production / ancillary equipment / systems;
- efficient use and maximum capacity of maintenance resources;
- extending the life of equipment / systems;
- rapid reaction in case of defect.
3. Algorithm for optimally select the type of maintenance

All equipment or installations requiring maintenance must be related to the amount of revenue or its importance. As long as the equipment are different importance, the type of maintenance chosen for them should not be the same. The maintenance strategy determines the position of equipment (value and importance) to achieve a minimum lifetime cost, with maximum reliability and maximum availability. The efficiency of maintenance work depends on the type of maintenance and the strategy for doing this.

A good management of maintenance activity is to optimize the activity by finding an algorithm for the choice of the maintenance strategy of the electrical installations in buildings. By applying the obtained results it can increase the performance in the maintenance activity. The main performance indicators are reducing maintenance costs and increasing availability of equipment.

Figure 3 shows an algorithm that can be used to optimally select the type of maintenance for a specific equipment.

![Algorithm for optimal selection of maintenance type](image)

Figure 3. Algorithm for optimal selection of maintenance type

4. Efficiency indicators

In article “Efficiency indicators for maintenance activity” [2], [5] are presented these indicators and they role. The role of efficiency indicators is to “quantifying the quality of the service provided by the maintenance team”. Indicators that express the efficiency of maintenance activity are numerous,

a) Technical indicators
- number of interventions
- the use of the equipment over its lifetime
- availability of equipment
- stock of spare parts

b) Economic indicators
- the specific cost of maintenance
- the specific cost of using spare parts stocks
- share of repair cost in total cost
- productivity indicators
c) Time indicators
   - average response time
   - average repair time
   - planned maintenance time

5. Maintenance management
The Maintenance Framework [2], [6] describing the maintenance management as the leadership and organization, planning and scheduling, preventive maintenance, condition monitoring, execution of maintenance repairs, root cause failure analysis and spare parts management.

Maintenance management [2], [6] can be used to achieve improvements in safety and reliability, improvements to operating procedures and strategies and the establishment of capital and operating regimes. Successful implementation of a maintenance management system can lead to improvements in cost effectiveness, asset reliability and availability complemented by a comprehensive understanding and management of risk.

The maintenance activity must be managed to pass from corrective maintenance to reliability-based maintenance. It must prevent malfunctions, not repair the failure.

When failures can’t be prevented by maintenance actions should be developed strategies to minimize effects.

The predictive maintenance is the first step to implement an efficient maintenance management.

Figure 4 shows the diagram of the occurrence of a defect [2], [7]. It is possible to observe the moment of occurrence of a fault - O, the moment when it can be detected - P and the moment of damage - F.

The P-F interval is the interval between the point at which a potential failure becomes detectable and the point at which it evolves into a functional failure. The fault detection and diagnosis process requires access to certain significant system size / parameters that give information on its status at all times.

Figure 4. Early Identification of a defect

To extend the life of a equipment, point P must be eliminate from P-F curve. This can be made by training maintenance personnel, effective work procedures, etc.

Tackling maintenance issues, establishing procedures and maintenance strategy for a system should therefore take into account both the monitoring and diagnosis of each component, but also the influence of the variables. The most well-known monitoring and diagnosis techniques are: vibration monitoring, thermography, lubricant fluid analysis and electrical system specific methods (Impedance Measurement, Insulation Resistance Measurement, Phase Harmonic Range Analysis).
6. Computerized maintenance management software

Computerized maintenance management system (CMMS) [2], [8] is a software package that maintains a computer database of information about an organization's maintenance operations. This software help managers of maintenance to optimize their activity and to do right decision. CMMS data [8] may also be used to verify regulatory compliance and allows for record keeping, to track completed and assigned tasks in a timely and cost-effective. A CMMS offers multiple core maintenance functionalities [8]. With improved technology and increasing competition, more and more companies are switching to CMMS vs using manual methods to track and organize information. The different components of a CMMS [8] include but are not limited to:

- Equipment data management
- Preventive Maintenance
- Work order system
- Scheduling/Planning
- Vendor Management
- Inventory Control
- Purchasing
- Budgeting

CMMS packages [2], [8] may be used by any organization that must perform maintenance on equipment, assets and property. Some CMMS products focus on particular industry sectors, other products aim to be more general. CMMS packages [2], [8] can produce status reports and documents giving details or summaries of maintenance activities. The more sophisticated the package, the more extensive analysis facilities have available.

Many CMMS packages [2], [8] can be either web-based, meaning they are hosted by the company selling the product on an outside server, or LAN based, meaning that the company buying the software hosts the product on its own server.

Although most CMMS products contain similar modules and features, some vendors boast a variety of unique services, special functionality, different pricing schemes [9]. From this list of feature and cost differences, the process of finding the right software to meet the budget and needs is hard to realize.

Needs Assessment Process [9] can be broken down into four main quadrants:

- Objective
- Feature Search
- Functionality
- Budget

MM@EI application software

MM @ EI is an Maintenance Management application developed by the authors in the research for the PhD thesis dedicated to the electrical installations in buildings (civil and industrial). The application is web-based and used the HTML and Microsoft Excel spreadsheets.

Entering the application is done by pressing the "START" button, after which a login page opens in OPERATION or ADMINISTRATION mode. Access in each of the two modes is through a user name protected with the access password. For the first login, a username and an initial password are configured which will be customized by each user.

After entering OPERATION or ADMINISTRATION mode, the page with the main menu for the selected mode opens. The two pages have similar menus, except that in the ADMINISTRATION mode the user has access to the modification of the main data (equipment, the importance of the installation, definition of task lists), and in the OPERATION mode the user has access to complete the maintenance execution data.

The identification data and characteristics for each installation as well as its inventory value are introduced into the application. There is a section where the importance of the installation or
equipment (low/normal/high) is introduced. Using the algorithm, the optimal type of maintenance is chosen for each installation or equipment, after which the activity is scheduled in time and the necessary reports for the maintenance are printed.

Figure 5 shows the start page of the application.

![Figure 5](image)

**Figure 5.** Application of the Management of the Maintenance Activity of the Electrical Installations

Figures 6 and 7 show two examples of electrical installations for which the operation of the maintenance type selection algorithm has been verified.

![Figure 6](image)

**Figure 6.** Algorithm for optimal selection of maintenance type: lighting installation
For a lighting installation (Figure 6) which is not a critical equipment and the cost of repair is acceptable (checking lighting fixtures and replacing lamps) corrective maintenance was chosen.

For AC installation (Figure 7) which is a critical equipment and the cost of repair is not acceptable and monitoring techniques is profitable, the result of the algorithm was predictive maintenance.

![Algorithm for optimal selection of maintenance type AC installation](image)

**Figure 7.** Algorithm for optimal selection of maintenance type AC installation

The performance indicator analyzed in the MM@EI application is MTBF [10] - average time in which there are defects - it is a complex care indicator when it is possible for the average to operate between two failures for a peak of equipment or to use a certain period of time. The indicator of use values is calculated as the ratio between operating period (days) and total number of faults:

- operating period (days) = the sum of the number of operating hours for all the equipment of a particular type, in a certain period of time / 24;
- total number of faults = the sum of the number of faults for all equipment of the same type, for the same period of time.

7. Conclusions
The implementation of the concept of management of maintenance activities aims at productive importance, an efficiency by reducing the number of accidental failures of the equipment and of satisfactory customers to implement a continuous culture of trade. To achieve this goal, you need to use practical and modern tools to optimize activities and you need to know the process. The long-term goals of a maintenance department involved in a fully integrated maintenance system can be ambitious: general reduction of equipment emergency situations; reduce purchase costs; improving deposit activities and optimizing stocks; increase maintenance efficiency.

The computerized maintenance management system is an important tool for use in support of the activities required for the management in maintenance activities. CMMS does not have to be complicated or expensive.
With the MM@EI application and using the right equipment for measurements, a high level of performance can be achieved in the maintenance activity of electrical installations. For small businesses and for the vulnerability of inefficient operations and equipment protection, switching to cloud and mobile solutions is a useful investment with costs of maintenance activity reduced of 10% to 30% when they can become familiar with the implemented application.

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