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Proposal of Maintenance-types Classification to Clarify Maintenance Concepts in Production and Operations Management

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Abstract: Due the fact that there are a wide terminologies to define types of maintenance, this paper discuss the some traditional classifications highlighted in the literature and presents a proposal for sorting types of maintenance on the most appropriate terminology, taking into account criteria as: criticality, intervention modes, planning actions, costs and available resources. The proposed methodology evaluated maintenance concepts by multi-criteria analysis and realized a sorting using the ELECTRE TRI outranking method. Initially the main concepts about terminologies for types of maintenance were explored in order to organize classes for terminologies sorting. In sequence were defined thresholds for the classes, identifying the borders in what each type could be allocated. Finally an experiment with a numerical application was built, considering the terminologies adopted by some authors of the maintenance management area. The results obtained indicate a pattern scientifically organized for these concepts, supported by multi-criteria analysis. This approach contributes significantly to clarify maintenance concepts linked to Production and Operations Management.

Key words: multi-criteria analysis; maintenance types; maintenance concepts

JEL codes: L20

1. Introduction

There is still great confusion in the maintenance management regarding terminologies used for types of maintenance, mainly in the industrial sector, not only Production and Operations Management but also correlated literature. This can be a barrier for the definition of a standard terminology and it occurs due the fact that there is:

- Incorrect conceptualization or dissemination of the adopted names for types of maintenance, not always in a good way or satisfactorily explained or understood, but which are local or particular habits,
- Neologism, often derived from translations of foreign languages,
- Definition of particular names by different authors and from specific scenarios.

The terminology may even vary, but it is necessary that the concept is well understood. Careful standardization is appropriate in order to enable a clear concept to assist the maintenance decision maker to choose the most appropriate type for a piece, equipment, installation or system. Consequently, in the industrial

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organizations, the economic aspects will be affected by these definitions. The evolution of maintenance concepts is according to the productive sector expectations and related to the techniques used to meet emerging maintenance needs for this moment. Currently, there are philosophies such as: maintaining reliable and available systems, shutting down for maintenance, sensing and monitoring parameters that indicate the best time to perform maintenance in order to anticipate failures. Other concepts such as projects to ensure the reliability/maintainability and Terotechnology come as reinforcements to anticipate maintenance actions, still in the design phase. For decision making assertiveness, it is necessary to apply a maintenance technique effectively. Therefore, knowing the concepts of the most suitable types to be used is essential to do it. Even the combination of two or more types of maintenance should be well conceptually clarified; because knowing where an application ends and another begins is essential to plan and manage efficiently the industrial maintenance. In fact, both literature and the applications published in scientific articles, are constantly presenting new terminologies and assignments for maintenance types, with little variation when compared to traditional concepts, but which receive different names and end up causing confusion and shaded concepts.

This work through the multi-criteria analysis technique looks for common characteristics in known maintenance types from the literature, in order to classify these types into main classes, taking into account criteria which are common among these traditional concepts. The multi-criteria decision-making methodology derives from the fact that in most situations where we have to decide, there is not only one goal but also different points of view are considered, which very often conflict with each other. The ELECTRE TRI method was used in a numerical application in this work. The main objective was to recognize a standard for industrial maintenance types, distributed in classes, covering the common characteristics of the various types presented in the literature, after applying the method of multi-criteria analysis. We attempted with this application to find clusters of designations that have common characteristics, allocated in their classes. With this, we can also know the variability of these concepts in a future and more detailed study on these classes and the intrinsic characteristics of the elements of each set.

2. Historical Evolution of the Maintenance

In accordance with Moubray (2000) the evolution of maintenance can be divided into generations and the timeline of these generations was adapted as presented in Figure 1.

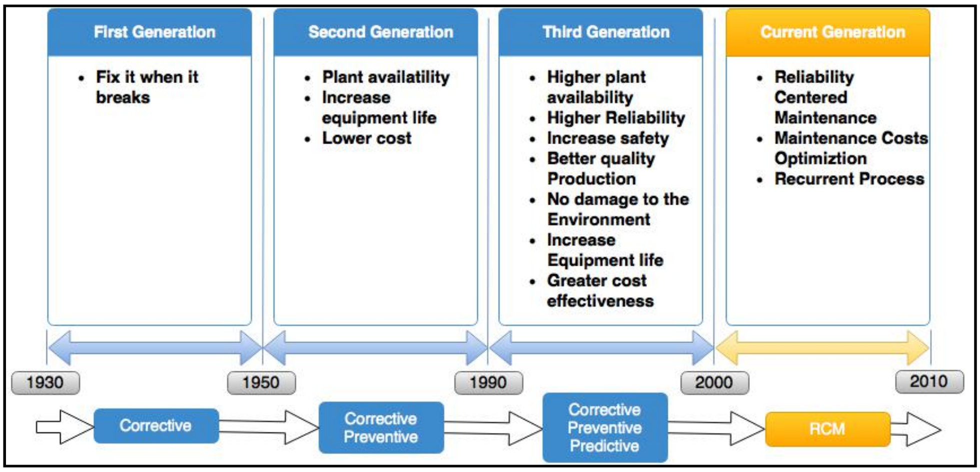

Figure 1 Timeline — Maintenance Generations

This evolution is demonstrated through the industrial needs in each generation, in which the central concepts about the maintenance types and how they could have been classified were highlighted. With the division of maintenance into generations, also concepts about more efficient maintenance types to be applied in the industrial context were developed.

The first generation gave support to the diversification of corrective maintenance concept, such as: scheduled, unscheduled, curative, palliative or repair. The corrective maintenance actually is still "repair after damage" and appeared as the main concept of the first generation. The second generation in turn, brought conceptual elements for the development of preventive maintenance, which is based on scheduled overhauls, planning and control of work systems and the evolution of applied computer science. In the third generation the evolution of condition monitoring techniques, failure analysis and studies of risks brought base to conceptualize predictive maintenance.

The evolution of these concepts was fueled by growing maintenance expectations. These expectations forced the development of new technologies that could help the productive sector to maintain safety, quality, availability and reliability of their equipment and consequently of the production processes. In the current generation, inherited from aerospace industry the RCM (Reliability Centered Maintenance) brought advanced techniques linked with reliability and availability and frequently adapted to industrial systems.

2.1 Types of Maintenance

Traditionally in Europe, maintenance is sorted and performed by time-based fixed intervals, and it is called preventive maintenance, or by corrective maintenance after breakdown. In the preventive type, maintenance is performed in order to prevent equipment breakdown by repair, or components exchange. In the corrective type, maintenance is performed after a breakdown. For some equipment the maintenance must be performed immediately, and for others types the maintenance can be delayed, depending on the equipment's criticality (Bengtsson et al., 2004). In the European Standard of EN 13306, as shown in Figure 2 the preventive maintenance has been sorted into two categories, condition-based and pre-determined maintenance (CBM) (CEN, 2001).

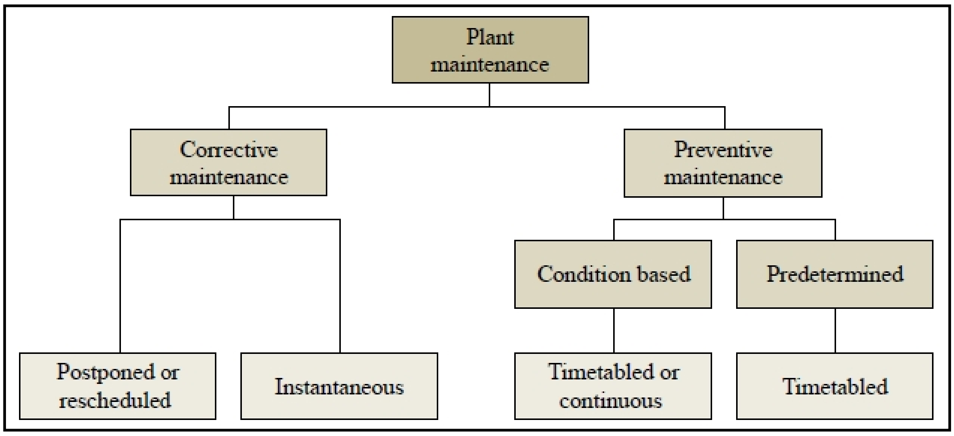

Figure 2 Maintenance Types by CEN (2001)

In Germany there is a specific standard, called DIN 31051, in which "*all measures for maintaining and restoring the target condition as well as determining and assessing the actual condition of the technical equipment in a system*" are performed by a sector called Plant Maintenance. The types are categorized into preventive maintenance, inspection and repairs (DIN, 2003). This categorization is shown in Figure 3.

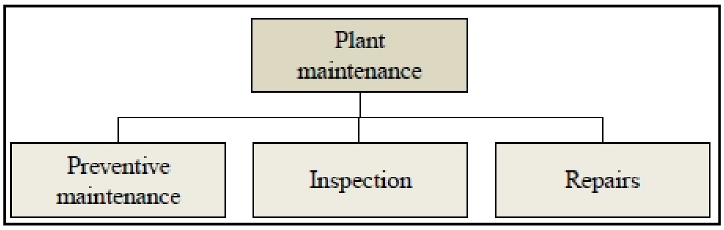

Figure 3 Types of Maintenance by DIN (2003)

According Williams et al. (2002) it is not required to be an engineer or a technician to value the role of maintenance in today's industrialized life that has been largely urbanized around the application of machines in different aspects. Tsang (2002) complements this statement spotlighting maintenance as a necessary expense that belongs to operating budget, and a common item on the hit list of cost-reduction programs in industries.

Around the world, maintenance has been interpreted and classified in too many different ways. In the USA for the US Department of Energy (US DOE) past and current maintenance practices must be performed after it is broken. It underlines the literal meaning of maintenance as "*the work of keeping something in proper condition*" and declares that maintenance should be actions taken to prevent a device or component from failing or to repair normal equipment degradation experienced with the operation of the device to keep it in proper working order. Such an interpretation catalogs four types of maintenance: reactive, preventive, predictive and reliability-centered maintenance (RCM), as presented in Figure 4 (US DOE, 2004).

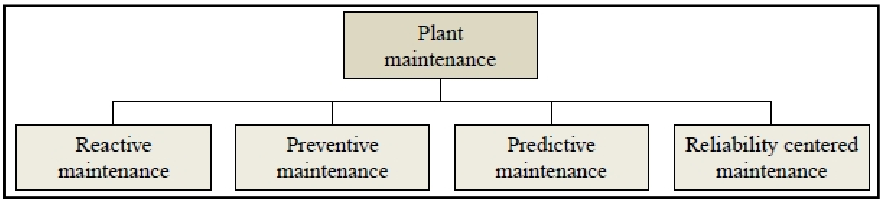

Figure 4 Maintenance Types by US DOE (2004)

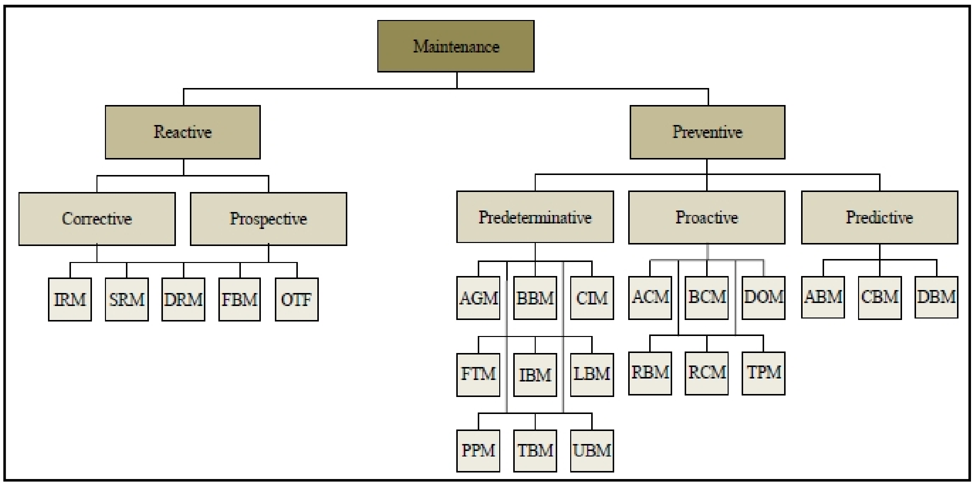

Figure 5 Maintenance Taxonomy by Khazraei and Deuse (2011)

Khazraei and Deuse (2011) proposed a classification based on the tactics regarded with traditional maintenance aspects. Based on this classification, they present two main strategies in machinery maintenance, namely reactive and preventive maintenance and the various tactics linked with the maintenance concepts, as shown in Figure 5 and complemented in Tables 1, 2 and 3. The authors conclude that obviously, each of these tactics can be used by utilizing different methods, techniques and technologies.

Table 1 Reactive Tactics in Maintenance

Abbreviation	Brief description
IRM	Immediate reactive maintenance
SRM	Scheduled reactive maintenance
DRM	Deferred reactive maintenance
FBM	Failure-based maintenance
OTF	Operate to failure

Table 2 Preventive Tactics in Maintenance

Abbreviation	Brief description
AGM	Age-based maintenance
BBM	Block-based maintenance
CIM	Constant interval maintenance
FTM	Fixed time maintenance
IBM	Inspection-based maintenance
LBM	Life-based maintenance
PPM	Planned preventive maintenance
TBM	Time-based maintenance
UBM	Use-based maintenance

Table 3 Proactive Tactics in Maintenance

Abbreviation	Brief description
ACM	Availability centered maintenance
BCM	Business centered maintenance
DOM	Design-out maintenance
RBM	Risk-based maintenance
RCM	Reliability-centered maintenance
TPM	Total productive maintenance

In Latin America, more specifically in Brazil, where the experimentation was applied, some authors present maintenance classification at the same way that European and North American classification, compounding a miscellaneous of these classifications.

According to Viana (2002), the main types of maintenance can be subdivided as follow:

Unplanned corrective maintenance: this type of maintenance occurs after failure or loss of device performance, without time for the maintenance preparation services. This maintenance-type, despite all the trouble, is often practiced still today.

Planned corrective maintenance: it is the correction of lower performance than expected or failure, for managerial decision, i.e., for lower performance from predictive tracking or the decision to operate until breaking (Pinto & Xavier, 2007).

Preventive maintenance: unlike the corrective aims, it seeks to prevent equipment failure. This type of maintenance is carried out in equipment which is not in failure yet, i.e., is still operating with minimum conditions. This type may have two quite different situations: the first, when the equipment is switched off before the need for service and the second situation is when the equipment failed, from incorrect estimate of the repairing period.

Predictive maintenance: this is nothing more than preventive maintenance based on the equipment condition. It is interesting because it allows the monitoring of equipment by measurements carried out when it is fully operational, enabling high availability. The predictive maintenance can be said to predict equipment failure and then to help decide when to make the intervention to repair this equipment; it is actually a scheduled corrective maintenance.

The Total Productive Maintenance or TPM was originated in Japan in the post-World War II period, with a philosophy of work that must be followed by all sectors of the company. Regarding equipment, Tavares (1999) points out that it means promoting the revolution along the production line, through the incorporation of "Zero Break,""Zero Defect" and "Zero Accidents". It is the realization of an "Equipment Management", i.e., administration of the machines through organization. This philosophy also incorporates the concept of Autonomous Maintenance, where operators are motivated and trained to carry out checks, quick checks and maintenance actions on the operating equipment. Tahashi and Osada (1993) reinforce the meaning of the TPM as "a broader preventive maintenance based on lifetime and economic applicability of equipment, dies and jigs that play the most important roles in the production."

The Reliability Centered Maintenance or RCM was related to technological and social processes arising from the Second World War. The benefits of RCM were perceived and quickly the methodology was applied in various sectors: nuclear submarines, electrical industry, construction, chemical, and steel, among others. The generality of the RCM concepts and techniques are applicable today to any system, regardless of technology. In RCM, the objectives of maintenance are defined by the functions and performance standards required for any item in their operating environment and its application is an ongoing process and should be reevaluated frequently, while experience is accumulated (Lima & Castilho, 2006).

According to the French standards AFNOR NF X60-010 and NF X60-011 cited by Monchy (1989) the various types of maintenance can be classified as Corrective Maintenance when Maintenance is performed after failure; Preventive Maintenance which aims to reduce the probability of failure. Preventive maintenance can also be explored as Preventive Systematic and Preventive Conditional. Monchy (1989), complementing definitions of the AFNOR standards, divided the Corrective Maintenance in two modes which are: Curative Corrective Maintenance and Palliative Corrective Maintenance.

The Brazilian standard ABNT, NBR 5462 (1994), classifies the various types of maintenance: Preventive maintenance; Corrective maintenance; Controlled maintenance or Predictive; Scheduled maintenance; Non-Scheduled maintenance; Maintenance in field; Maintenance off-site; Remote Maintenance; Automatic Maintenance; Deferred Maintenance.

The classification adopted by the UN (United Nations) cited by Tavares (1999), covers an interesting feature on the preventive and corrective types of maintenance. They were allocated together in a tree called "planned maintenance". Thus, the UN classification considers the corrective maintenance with some level of planning and maintenance actions are considered while operating, not operating or until it breaks (repair by fatigue). The concept of operation after failure, in this classification is addressed by maintaining a break down or unplanned maintenance.

The authors Mirshawka and Olmedo (1993) adopted a classification that separates the preventive maintenance of the corrective one, but it includes predictive maintenance within the preventive classification, considering it as a prevention based on equipment condition. In this context the corrective maintenance also brought the concept of "repair after damage" and enhanced the concept to the improvement in the implementation of corrective maintenance. The planning criterion is implicit in the concepts adopted by the authors.

Summarizing, the basic conditions to establish maintenance types are:

- the equipment, system or installation should allow some kind of monitoring;
- the equipment, system or installation must have the choice for this maintenance type justified by the costs involved;
- failures must originate from causes that can be monitored and have their progress also monitored.

The Brazilian Association of Maintenance — Abraman (2005) shows a broader concept, seeking to meet the expectations of reliability and maintainability of the third generation of maintenance. Maintenance is classified into three main branches (or types), represented by maintenance: Corrective, Preventive and Predictive. Within these branches, other nomenclatures conceptualize some of the changes adopted in each of these subdivisions.

Although considered irrelevant, as stated by Viana (2002), the changes that occur in the maintenance types create a new terminology and a new "potential concept or type of maintenance", emerging from a specific application, based on pre-defined criteria. The definition of criteria for classification is not an easy task because discussions covering maintenance concepts are constantly arising due to the increasing development of advanced maintenance techniques in various areas of knowledge and industry. Viana (2002) provides elements for at least one criterion that this work addresses, which are the intervention modes on the equipment / instruments. These modes can be initially divided into: Intrusive, Non-intrusive.

2.2 Proposal to Sorting Maintenance Types

The methodology in this paper addresses the sorting problematic in maintenance and proposes to sort the maintenance types in classes, based on collected parameters in the literature and representing the relevant characteristics to be taken into account in the definitions of the criteria and desired limits. The proposed methodology is constructed as a sequence of steps that represent a way to organize and make a most efficient model, placing important information in a sequence that provides a clear view of it. The information that will give relevance for this classification should represent characteristics of maintenance types. These characteristics are defined by the decision maker in the maintenance management area; because he is the one who can to know the problem in its specificity. Then, the data collected can be estimated from real processes or through literature surveys. The definitions shall provide the kind of classes that you want to explain to the decision maker. For example, classes are concentrated where the degrees of criticality involving equipment or even classes that are designed to promote more efficient alternatives for system maintenance, as is the case in this study. The criteria for the evaluation of alternatives should explain whether the decision maker's preference to meet certain minimum parameters for a given alternative fits the expected class and predetermined efficiency.

To calculate the performance of alternatives, some techniques are used, such as the definition of subjective scales and standardization of these scales in a numerical order which is a representation of the criteria true importance. Based on these commonalities, the calculation is performed by the ELECTRE TRI method, so that classification is made, for each alternative presenting numerical characteristics that will be taken into account in the framework of the alternatives in their respective classes. At this stage, the boundaries between the classes to which the alternatives will be subject to the frame should be listed without any doubt.

The relevance to create a methodology to support decision-making with multi-criteria analysis to classify maintenance types also derives from the fact that in this situation we have to define based on only one goal but considering different points of view, conflicting with each other, such as developed in the traditional theory of multi-criteria decision making. Therefore, the decision process should be guided by multi-criteria analysis methods to support the decision maker in the optimization of the alternatives. According to Vincke (1992), there are several methods and multi-criteria techniques, among which one can identify: the additive models, which generate a single criterion synthesis (Multiple Attribute Utility Theory — MAUT; Analytic Hierarchy Process — AHP) and the outranking methods (ELECTRE and PROMETHEE). Those models and methods follow two main lines, the Multiple Criteria Decision Making — MCDM and Multicriteria Decision Aid — MCDA. The adoption of these models is usually justified by arguments dictated by the nature of the problem. One of the known families of outranking methods is the family ELECTRE (*Elimination Et Choice Traidusaint la REalitè*)(Yu, 1992).

The method used in this work, ELECTRE TRI, is a multi-criteria method that allocates alternatives in predefined categories. This allocation of an alternative "*a*" results from the comparison of "*a*" profiles with defined boundaries of categories (Mousseau & Slowinski, 1998; Yu, 1992). Given a set of criteria indices $\{g_1,..., g_i, ..., g_m\}$ and a set of index profiles $\{b_1, ..., b_h,...b_p\}$, is defined $(p+1)$ categories, in which b_h represents the upper limit for the category C_h and the lower category limit C_{h+1} , $h = 1, 2, ..., p$. Two conditions must be verified to validate the claim aSb_h (*a* outranks b_h):

***Concordance*:** for an outranking aSb_h to be accepted, most of the criteria should be for the claim aSb_h.

***Non-discordance*:** when the agreement condition is not met, none of the criteria should oppose the claim aSb_h.

In building *S*, a set of veto thresholds $(v_1(b_h), v_2(b_h), ..., v_m(b_h))$ is used in the discordance test. $v_j(b_h)$, which represents the minor difference $g_j(b_h)$ - $g_j(a)$, inconsistent with the statement aSb_h. Rates of partial agreement $c_j(a,b)$, concordance $c(a,b)$ and partial discordance $d_j(a,b)$ are calculated by the expressions (1), (2) and (3).

$$c_j(a,b) = \begin{cases} 0\,if & g_j(b_h) - g_j(a) \geq p_j(b_h) \\ 1\,if & g_j(b_h) - g_j(a) \leq q_j(b_h) \\ & \dfrac{p_j(b_h) + g_j(a) - g_j(b_h)}{p_j(b_h) - q_j(b_h)} \quad in \quad other \quad cases \end{cases} \tag{1}$$

$$c(a,b) = \frac{\sum_{j \in F} k_j c_j(a, b_h)}{\sum_{j \in F} k_j} \tag{2}$$

$$d_j(a,b) = \begin{cases} 0\,if & g_j(b_h) - g_j(a) \leq p_j(b_h) \\ 1\,if & g_j(b_h) - g_j(a) > v_j(b_h) \\ & \dfrac{g_j(b_h) + g_j(a) - p_j(b_h)}{v_j(b_h) - p_j(b_h)} \quad in \quad other \quad cases \end{cases} \tag{3}$$

3. Proposal Application

For the application of the multi-criteria method ELECTRE TRI 2.0a software was used, the additional Lamsade (Paris-Dauphine University, Paris, France). The problem was structured with the aim to apply the ELECTRE TRI method in a setting for the number of alternatives and weighted criteria to evaluate the classification problem for the types of maintenance efficiency. Some subjectivity inherent feature of the decision-making process was also considered to establish the relative weights for the criteria. Table 4 presents a summary of the study that is organized on the most commonly used maintenance types, based on intervention time.

Table 4 Summary of Research on the Maintenance Types

Authors	Classification related with intervention time			
	Immediate	Short-term	Long-term	Bycondition
UN, (1975)	- Unplanned	- Planned	-	-
	- Emergency	- Preventive	-	-
	- Corrective		-	-
AFNOR, (1985)	- Corrective		- Preventive	- Preventive
			Systematic	bycondition
Monchy, (1989)	- Corrective	- Corrective	- Preventive	- Preventive
	Curative	Palliative	Systematic	bycondition
Mirshawkaand Olmedo (1993)	- Corrective	- Improvement	- Preventive Systematic	- Preventive Conditional
				- Predictive
ABNT, (1994)	- Corrective	- Preventive	- Predictive	- At theplace
	- Unscheduled	- Scheduled	-	- Out ofplace
	-	-	-	- Remote
	-	-	-	- Automatic
Viana, (2002)	- Corrective	- Preventive	- Predictive	-
	- Planned	- Autonomous	- TPM	-
	- Unplanned	-	- RCM	-
Abraman, (2005)	- Corrective	- Preventive	- Predictive	-
	- Scheduled	- Sistematic	- Followup	-
	- Unscheduled	- Reconstructions	- Monitoring	-
	-	- Oportunity	- Measurement	-
	-	- Repairs	- Inspections	-
	-	- Lubrication	-	-
Pinto & Xavier, (2007)	- Corrective	- Preventive	- Predictive	- Maintenance
	- Planned	-	- Detective	Engineering
	- Unplanned	-	-	-

Table 5 Criteria, Classes, Boundaries and Weights Definition

Categories / Classes	Type of action	Boundaries	Criteria				
			Criticality g_1	Intervention g_2	Planning g_3	Costs g_4	Resources g_5
CL_1	Advanced	b_1	90	90	90	25	90
CL_2	Predictive	b_2	60	75	50	55	50
CL_3	Proactive	b_3	40	25	25	90	25
CL_4	Reactive						
Weights			25	15	25	20	15
Direction of Preferences			↑Max	↑Max	↑Max	↓ Min	↑Max
Preference and Indifference thresholds			10	10	10	10	10
			5	5	5	5	5

After the survey, the criteria for evaluation should be set so that the alternatives could be framed properly in classes that represent the action levels of the various maintenance types studied. Table 5 presents the definition of these criteria and their classes, relative weights, directions of preferences and thresholds related with the maintenance classification process, based on some features found in the literature on the subject.

Parameter values try to translate the scale subjective languages into numerical variables, making comparisons, as in this case. Table 6 sets out the numerical scales for the criteria in order to assign values for evaluation. These standard values will support the comparison made by the ELECTRE TRI method and allocations of alternatives in their classes. These scales were considered as subjective values (High, Medium, Low, Planned, Unplanned, etc.) and their respective numerical values (0 to 100) in order to serve as input to the ELECTRE TRI 2.0a software, whose values need to perform calculations for comparisons.

Table 6 Numerical Scales for Criteria

Cr	W (%)	Criteria	Scale	Value
g_1	25	Criticality	LowLow Low Medium Regular High HighHigh	0 20 40 60 80 100
g_2	15	Interven-tionMode	Intrusive NP IntrPlanned On operation NIntrUnPlanned NIntrPlanned	0 25 50 75 100
g_3	25	Planning Level	None Low Medium High	0 25 50 100
g_4	20	Costs	Low Medium High	100 50 0
g_5	15	Resources	Unvailable Unplanned Planned Available	0 25 75 100

In Table 7 the evaluation of 29 alternatives is carried out (maintenance types found in this study), specifically in relation to the listed criteria, and using the numerical scale from Table 3.

4. Results

After applying the ELECTRE TRI 2.0a software, the following results were obtained. Figure 2 shows the results obtained with the classification performed by the software. These results show the ability of the method to present an “optimized” version for the maintenance types exploited by this work. From the classification results, the “optimistic” procedure was adopted, due to the fact that it better represents the purpose intended to reach. It is noticed that in the Advanced class the types of maintenance that require higher planning and investments were allocated: Monitoring (MON); Maintenance Engineering (ME), RCM and TPM. On the other side, i.e., the Reactive class alternatives were linked with the reaction failure concept.

Table 7 Numerical Evaluation of the Types of Maintenance

a_n	MaintenanceTypes	Abbreviation	Criticality g_1	Interv. mode g_2	Planning level g_3	Cost g_4	Resources g_5
a_1	At the place	AP	80	50	25	50	0
a_2	Automatic	AUTO	100	50	50	50	75
a_3	Autonomous	AUT	60	75	25	50	25
a_4	Byopportunity	OP	20	25	50	50	50
a_5	Conditional	CON	60	75	50	50	75
a_6	Corrective	CORR	0	0	0	100	0
a_7	Corrective Curative	CC	20	0	0	100	0
a_8	Corrective Palliative	CP	40	25	25	50	25
a_9	Detective	DT	60	75	25	50	25
a_{10}	Improvements	IMP	20	50	50	50	75
a_{11}	Inspections	INS	60	25	50	50	25
a_{12}	Lubrication	LUB	40	50	25	50	25
a_{13}	Maintenance engineering	ME	80	50	100	100	100
a_{14}	Measurement	MEA	20	75	50	50	25
a_{15}	Monitoring	MON	100	100	100	50	100
a_{16}	Out of place	OUTP	60	25	25	50	0
a_{17}	Planned	PL	40	50	25	50	50
a_{18}	Predictive	PRED	60	75	100	50	75
a_{19}	Preventive	PREV	40	50	25	50	25
a_{20}	Preventive by condition	PCOND	60	75	50	50	50
a_{21}	Preventive Systematic	PS	40	50	25	50	25
a_{22}	RCM	RCM	100	100	100	25	100
a_{23}	Reconstructions	REC	60	25	25	50	100
a_{24}	Remote	REM	20	50	50	0	25
a_{25}	Repairs	REP	0	25	25	100	25
a_{26}	Scheduled	SCH	40	25	25	50	0
a_{27}	TPM	TPM	100	100	100	0	100
a_{28}	Unplanned	UPL	0	0	0	100	0
a_{29}	Unscheduled	USCH	20	0	0	100	0

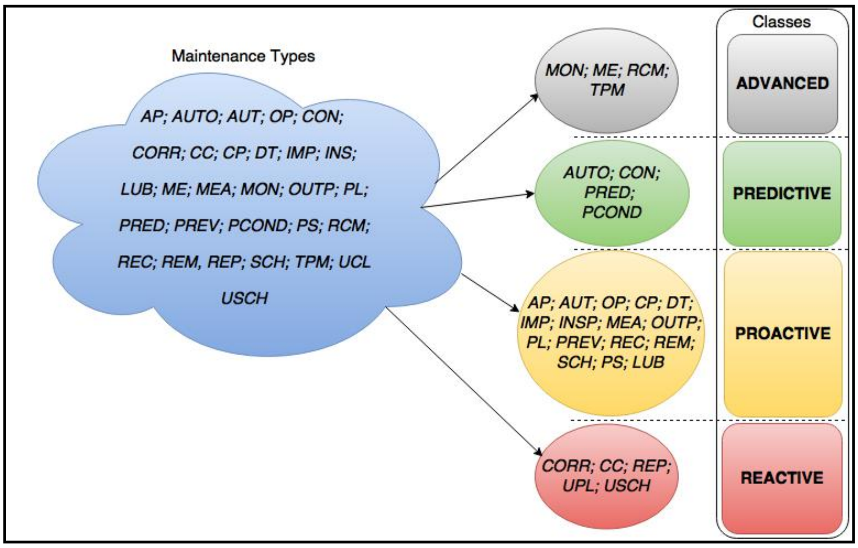

Figure 6 Proposed Classification

In the intermediate classes (Proactive and Predictive) the allocation of preventive and detective maintenance was revealed, among others which have common characteristics with respect to criticality, planning, costs and availability of resources. The results achieved demonstrated consistency in the classification and followed compatible logic with the concepts studied.

5. Final Remarks

The maintenance management over the years has become an important ally for the optimization and efficiency of production processes. Understanding the concepts and their specificities is vitally important to the decision maker at the moment he decides to adopt techniques to help increase efficiency and industrial productivity by managing maintenance.

This paper attempts to make a contribution to traditional concepts of maintenance by consolidating similar terminology in performance classes of the various techniques known about the types of maintenance currently used. The use of multi-criteria analysis associated with the use of the ELECTRE TRI method, enables the classification of types for maintenance to be seen from an innovative point of view, in which the maintenance area manager may decide on the basis of an expert study on these types characteristics.

After the development of this study it was possible to see the similarities that so far caused doubts in the understanding of the concepts on the classification of maintenance types. The classes defined as: Reactive, Proactive, Predictive and Advanced now group types of maintenance that once brought confusion in understanding. Certainly the characteristic variations of each context will still exist, but now they are listed under concepts that give comprehensive and clear guidelines on each type developed by various authors in the field.

One can also envision some future work to recognize these variations within each class presenting classification proposals. These variations could also be individually treated in their specificity and further clarified through the development of maintenance over the years

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