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Audit Proposal for Maintenance, Reliability and Warranty Management Process

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ABSTRACT: Management effectiveness in maintenance and warranty assistances can be assessed and measured by the analysis of a wide variety of factors. These factors together constitute the contribution of such technical assistances to the production system. The results of audit technics applied to the assessment of technical assistance effectiveness (whether maintenance or warranty tasks) may help to improve the profitability of the production system, reducing uncertainty in the decision making process management. This article describes the importance of the audit process in the area of maintenance and warranty support, describing some of the techniques most used to evaluate the performance of its management.

1 INTRODUCTION TO THE PROCESSES OF AUDIT

Management effectiveness in maintenance can only be assessed and measured thorough the analysis of a wide variety of factors which taken together, constitute the contribution of maintenance to the production system. This assessment procedure is known with the term “audit”, which can assess the compliance of rules or objective criteria that these systems should follow [1]. The implementation of an audit process must go through a number of stages following a specific logical order. Figure 1 presents a basic procedure of implantation of an audit [2].

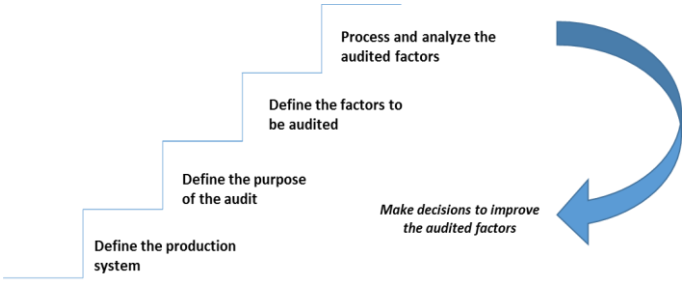

Figure 1. General procedure for implementation of an audit

It is important to note that there are no simple formulas to "measure" maintenance, nor are there fixed or immutable rules with endless validity and for all those cases. The results of the auditing techniques applied to the diagnosis of the effectiveness of maintenance should help to improve the profitability of the production system and to reduce the uncertainty in the decision-making process of management of the maintenance [1], [2]. Audits of maintenance and warranty support must have as the main objective to assess the most important processes of management. Therefore, one of the aspects of greatest relevance in the development of this type of audit is related to the definition of the key objectives to be audited. Below are cited, as an example, some of the most common key objectives of these areas [3], [4]. Once determined the key objectives of the management process in the technical assistance in both maintenance and warranty, organizations should identify the areas of greatest opportunity to be evaluated within the developed audit (González, 2004). Taking as a reference the 8-phase maintenance management model (MMM) (see Figure 2), and its adaptation to the case of assistance under warranty (see Figure 3), this article related to the techniques of audit in the management of technical assistance would be part of phase 1. In the following sections are the procedures for implementing some of the mostly used techniques of auditing to evaluate maintenance and warranty management processes, including the audit to the integrated maintenance management process shown in Figure 2.

2 EXAMPLES OF TECHNIQUES

Some of the mostly used techniques of auditing will be evaluated below that are also applicable and adaptable to the case of warranty assistance.

2.1 *Audit technique called "Asset Management, Operations, Reliability & Maintenance Survey"*

This audit called AMORMS (Asset Management, Operations, Reliability & Maintenance Survey) [7] allows to evaluate the 8 stages of the maintenance management model proposed in Figure 2. The process of implementation of this audit should be executed from supervisors´, engineers´, superintendents´ levels up to managers´ levels. The process of analysis of the 8 areas to diagnose is performed based on a questionnaire guide of 150 questions.

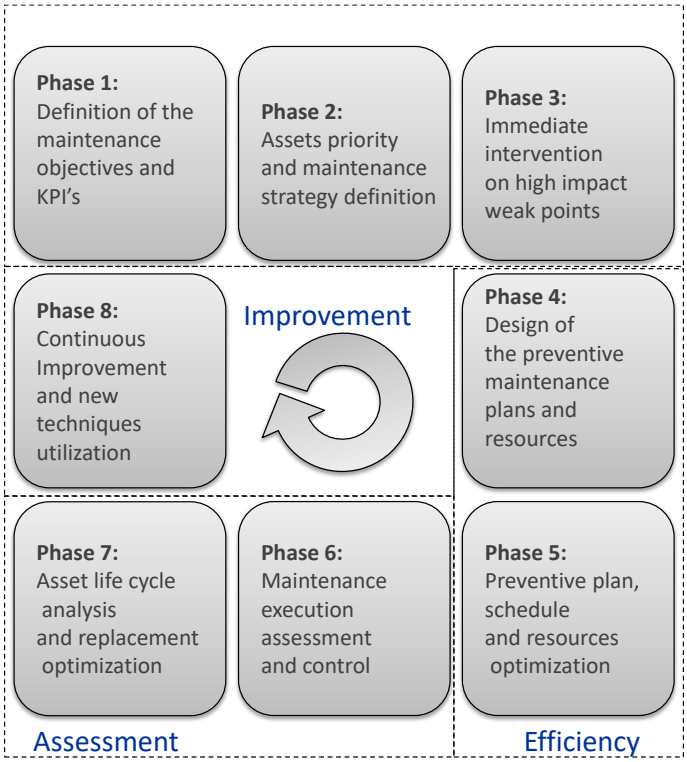

Figure 2. Model of the maintenance management process [5]

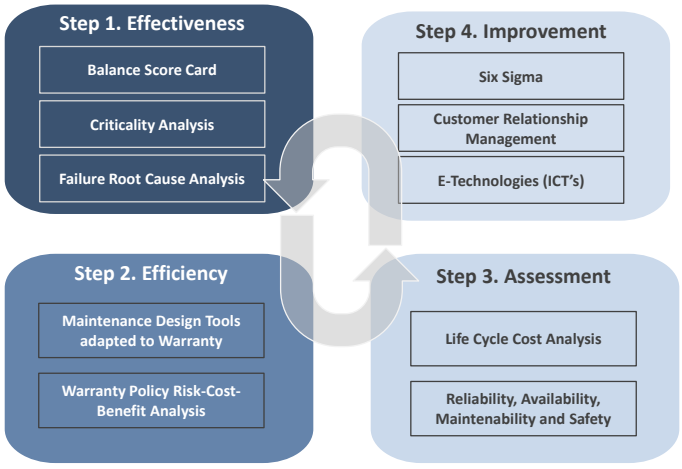

Figure 3. Frame of reference for the warranty management process [6]

Each participant assesses each of the questions posed, assigning scores from 1 to 5, according to the following scale (Figure 4):

1. Very poor process
2. Process below average
3. Average standard process
4. Process with very good practices
5. Process at world class level

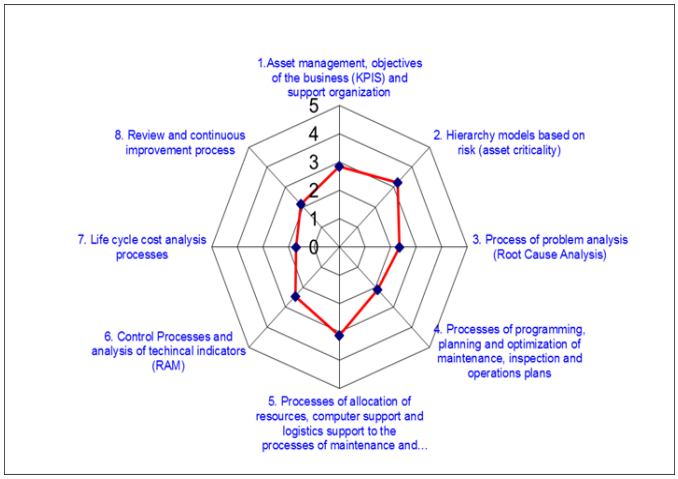

Figure 4. Example of audit results: AMORMS [7]

2.2 *Audit technique called "Qualitative Matrix in Maintenance Excellence"*

The Qualitative Matrix in Maintenance Excellence (QMME) is based on reference [8] and its axes are constituted by:

- Horizontal axis: corresponds to the 5 stages of improvement, in this case, the technical assistance: uncertainty, awareness, understanding, maturity and excellence
- Vertical axis: corresponds to the factors of management of the maintenance and warranty to evaluate:
  i. Competence of senior management
  ii. State of the technical assistance organization
  iii. Technical assistance costs / total costs
  iv. Forms of solving the problems in maintenance and incidences in warranty
  v. Qualification and training of the technical assistance personnel
  vi. information Management and decision making
  vii. Position of the Organization in relation to maintenance and warranties

The implementation process of this audit is carried out at the management personnel level and it is common to develop it through a brainstorm technique (it is recommended to apply the matrix questionnaire to the largest possible number of participants to minimize the uncertainty of this technique). The process of quantification of the areas of maintenance and assistance under warranty to diagnose is carried out by taking the results of each assessment of each participant and by averaging them. An extract of the questions to be evaluated in the QMME is shown below (Table 2).

Table 2. Qualitative Matrix in Maintenance Excellence (QMME)

Stages Criteria	Stage 1 Uncertainty
Management Competence	There is no concept of prevention – it is corrected only when necessary
State of the maintenance organization	REACTIVE: work on the equipment when they fail unexpectedly - repair when it breaks
Total maintenance costs / Total production costs	30 + %
Ways to solve the problems	Problems are solved as they emerge
Qualification and training of the maintenance personnel	Poor-quality work is accepted, training is considered unnecessary, absence of procedures, tools in poor condition
information Management and decision making process	No record of maintenance is managed - the little data collected are of very low quality
Position of the Organization in relation to maintenance	We have no clue why the equipment breaks. Operations continuity is very low, but for us maintenance is not an important factor

2.3 *Audit technique called "Maintenance Effectiveness Survey"*

The Maintenance Effectiveness Survey (MES) is an audit proposed by the Marshall Institute [9] based on a questionnaire of evaluation of 60 questions divided in 5 areas of maintenance. The answers to each question are limited to five possible options. The areas of maintenance assessed are:

- Management resources
- Information management (technical assistance management software)
- Preventive maintenance techniques and team
- Planning and execution
- Support, quality and motivation

The audit implementation process occurs at the management, supervision, operations and maintenance personnel levels, and it is recommended to make a minimum of 8 participants work on the questionnaire. The chosen individuals evaluate the 12 questions developed for each area (total: 5 areas / 60 questions) based on a scale from 1 (very poor) to 5 (excellent). Each area to be evaluated is considered to have the same level of importance. Total scores are added together and averaged based on the number of people surveyed. Finally, the position of technical assistance is estimated on the basis of the following ranges:

- 300-261: "World class" category /level of excellence in technical assistance
- 201-260: "very good" category /level of good practices in the technical assistance
- 141-200: "above average level" category / acceptable level in the technical assistance
- 81-140: "below average" category /not a very good level of technical assistance, with opportunities to improve
- Less than 80: "well below average" category /a very bad level with many opportunities to improve technical assistance

An extract of the 60 questions developed for each of the 5 areas to be evaluated (12 questions by area) are appended below (Table 3).

Table 3. Summary of the questionnaire for the MES audit

QUESTIONS BY AREA	VALUATION				
MANAGEMENT RESOURCES	**1**	**2**	**3**	**4**	**5**
1. Do you think that the technical support department is capable of doing their job?					
2. Does the complete maintenance structure seem to be logical and foster the fulfilment of maintenance activities?					
3. Does the organization contribute to eliminate the barriers that the maintainer encounters is in their work and on which they have no control?					
4. Does the management encourage maintenance to achieve production goals?					
5. Does the management encourage production to help maintenance in their activities?					
6. Are work teams developed (maintenance and production) to resolve issues involving both departments?					
7. Does the management encourage the maintenance personnel (mechanics, electricians...) and operators to work together on the resolution of problems affecting the availability of their processes?					
8. Do the maintenance personnel have the necessary skills to perform their jobs?					
9. Have the workers in general received the right training in their areas of work?					
10. Does the management involve the maintenance personnel in the definition of their objectives and goals to achieve?					
11. Does the management review and make follow-up on the objectives of the plant during work meetings with maintenance and operations personnel?					
12. Are the objectives of the maintenance aligned with the vision and mission of the business?					

2.4 *Audit Technique called "Maintenance World Class Survey"*

The MWCS (Maintenance World Class Survey) is an audit based on a questionnaire of evaluation of 105 questions divided into 9 areas of maintenance which, similar to the previous cases, also found its adaptation to the cases of assistance under warranty. The answers to each question are limited also to five possible options [10]. The areas evaluated are:

- Organization of the department of technical assistance (18 questions)
- Work environment (10 questions)
- Means of technical support for the assistance (14 questions)
- Development of plans for maintenance and warranty (7 questions)
- Relationship between the maintenance schedule and the corrective maintenance (10 questions)
- Development of procedures for the implementation of the technical assistance (7 questions)
- Generation of work orders and information tool support (12 questions)
- Management of spare parts for maintenance and warranty (12 questions)
- Management of technical indicators of maintenance and warranty (15 questions)

Again the process of application occurs at the management, supervision, operations, maintenance and after-sales personnel level and the total scores (from 1 to 5) are added and averaged by the number of people surveyed. Finally, the position of maintenance and/or assistance in warranty is estimated according to the following ranges:

- 525-470: "World class" category /level of excellence in technical assistance
- 469-370: "very good" category /level of good practices in the technical assistance
- 369-270: "above average level" category / acceptable level in the technical assistance
- 269-170: "below average" category /not a very good level of technical assistance, with opportunities to improve
- Less than 169: "well below average" category /a very bad level with many opportunities to improve technical assistance

An extract of the 105 questions developed for each of the 9 areas to be evaluated is shown below (Table 4).

Table 4. Summary of the MWCS audit questionnaire

AREA TO ASSESS		QUESTION
Organization of the department of maintenance (18 questions)	1	Does the chart of maintenance ensure the presence of maintenance personnel prepared when needed, in the fastest possible way?
	2	Are there personnel that can be considered “essential” whose absence affects the normal activity of the maintenance area?
	3	Does the organizational chart warranty that there will be personnel available to perform the scheduled maintenance, even in the case of an increase of the corrective maintenance?
	4	Is the number of overtime hours that is generated in the maintenance area usually higher than the legal maximum permissible?
	5	Is previous qualification required of the personnel of the maintenance area adequate?
	6	Is an initial effective training provided when a new worker is incorporated into the area of maintenance?
	7	Is there a training plan for the maintenance personnel?
	8	Does this training plan make that the knowledge in the maintenance of the business to improve?
	9	Does the training plan make that the knowledge in other areas of the business (operations, security, environment, administration, etc.) to improve?
	10	Can the mechanical maintenance personnel do simple electrical or instrumentation tasks?
	11	Can the mechanical maintenance personnel do specialized electrical or instrumentation tasks?
	12	Can the electrical maintenance personnel do simple mechanical tasks?
	13	Can the electrical maintenance personnel do specialized mechanical tasks?
	14	Are the maintenance personnel trained to work in other areas (operations, security, chemical control, etc.)?
	15	Are both clock-in and clock-out schedules kept?
	16	Is break-time granted?
	17	Is the average of non-productive downtimes adequate?
	18	Do intervention times conform to the estimable theoretical duration that could be performed?

2.5 *Audit technique called "Comprehensive evaluation for Warranty management"*

On the basis of the framework for the management of warranties (Figure 3) and in view of the previous techniques an audit called CEWM (Comprehensive evaluation for Warranty management) was prepared which allows to evaluate the critical aspects of such a process, as well as those aspects of reliability and maintainability to be analyzed from a practical after-sales service perspective. Similarly to other techniques, in this case each participant also evaluates each of the questions posed, assigning scores from 1 to 5, according to the following scale:

1. Very poor process
2. Below average process
3. Average standard process
4. Process with very good practices
5. Process at world class level

You can see that similar questions are made in a random fashion in order to review consistency in the answers by the responding members of personnel. In

addition, it is preferable that this query is carried out separately by Department, in such a way that for a global computation of the result a different weight would be given on each stage according to Department:

- Logistics Department
- Manufacturing Department
- Management or governing body
- After-Sales Department
- Quality assurance Department
- Purchasing Department
- Engineering Department
- Customer

The weight that is proposed to each area by phase [11] is shown in Figure 5, where:

* Department little involved in the corresponding phase of the framework

** Department partially involved in the corresponding phase of the framework

*** Department highly involved in the corresponding phase of the framework

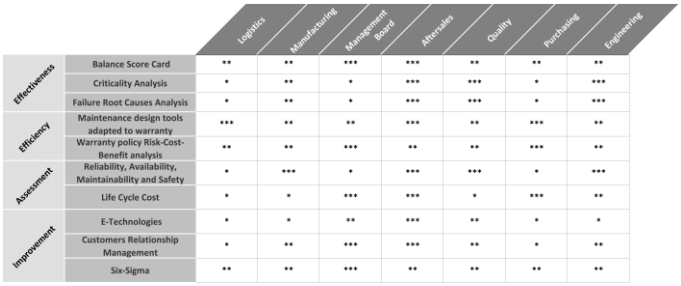

Figure 5. Involvement degree or weighing proposal by Department to the answers of each phase

It is observed that in the previous figure the client's case has intentionally been removed, while their outcome should have a separate and independent analysis that is contrasted with that one retrieved internally by the organization. Figure 5 tries to summarize the different degrees of participation that the different departments involved have in the phases described according to the framework proposed in Figure 3.

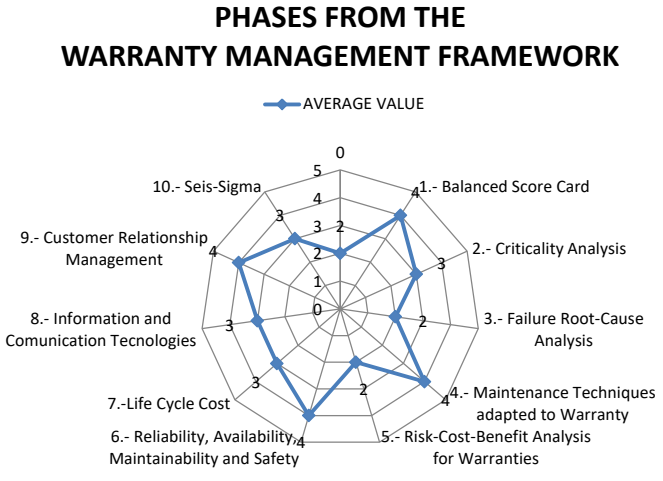

Figure 6 Example of audit results: CEWM

In any case, these degrees of participation will depend of course on the company's policy for its program of warranty management and on the vision that each employee has of their own area in relation to the company as a whole [6]. Also, in order to show the results of this audit, it is useful display them in a type "Radar" diagram in which the average values obtained for each one of the 10 evaluated phases or for each of the 4 blocks (Figure 6) are presented. At the same time, it can be shown on a global basis, or well according to the perception by Department of the company. An extract of the questions developed for the CEWM audit, are here shows (Table 5).

Table 5. Summary of the questionnaire for the audit of assistance under warranty

QUESTIONS BY AREA		**VALUATION**				
EFFICIENCY						
Phase	**Initial stage**	**1**	**2**	**3**	**4**	**5**
1. Score-card	Are decisions anticipated to the emergence of problems?					
	Are there an after-sales strategy and action plans?					
	Is the strategy related with medium / long term objectives?					
	Is the management behavior proactive?					
	Do managers take a proactive action to avoid the emergence of problems?					
	Are the results periodically reviewed?					
	Are progresses quantified?					
	Are the changes necessary in the Organization taken into account?					

3 CONCLUSIONS

To conclude this section, it is important to mention that this paper has made reference only to five audit methods. However, in the literature, a significant number of methods may be gathered in addition to those here presented and equally adaptable to cases of maintenance management and assistance under warranty, which will also serve to evaluate and diagnose the various processes related to such management. The audits of diagnosis of the management of technical assistance are designed to make the companies more profitable each time within the scenarios of high competitiveness. Audits identify in a detailed and objective way the State of maturity and capacity of a company in the management of its physical assets regardless of their size or economic activity, becoming an advantage and a strategic tool that defines the success of a company. Audits include a comprehensive set of measurable

elements used to assess the implementation of best management practices, where opportunities for improvement are identified and the basic line for the implementation of techniques for engineering support of maintenance and reliability as well as in warranty assistance and after-sale service are identified. Whatever the target of the Organization it must audit its performance level on the key aspects of management supported on the standards, and best practices applied in the industry, which will result in actions to follow and the optimal resources to develop in accordance with the objectives set. This set of actions must be prioritized and consolidated in a work plan framed in the cycle of continuous improvement that also brings economic benefits, an approach that allows the organizations to address their efforts of improvement in the critical aspects of the business [12]. Lastly, the Organization must convert these control techniques into normal work practices, i.e., into a process of continuous improvement that will help to optimize decision-making within the management of the technical assistance process.

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