Analysis of a maintenance strategy to be implemented in electric transmission companies

Análisis de una estrategia de mantenimiento a implementar en empresas de transmisión eléctrica

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Abstract

Maintenance management guarantees the life cycle of assets. The objective was to implement a tool to verify the relevance or not RCM (Reliability Centered Maintenance) estrategy for a company. With the agreement between the specialists, the effectiveness of the tool was approved because the reliability indicators of the survey are good. The results obtained, from its application in an electric transmission company, showed that it had in the first variable, based on the RCM, a reliability of 92 % considered excellent and of 72 % in the second variable, preparation of the company for its implementation, rated as acceptable, both obtained using Cronbach's Alpha. In addition, it was possible to establish the relevance of this strategy and it showed that the entity was not prepared to be able to assume it without first making changes.

Key words: diagnostic; reliability-centered maintenance; survey; maintenance strategies.

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Resumen

La gestión del mantenimiento garantiza el ciclo de vida de los activos. Este trabajo tuvo como objetivo implementar una herramienta para la comprobación de la pertinencia o no de una estrategia de RCM (*Reliability Centered Maintenance*) para una empresa. Con el concierto entre los especialistas fue aprobada la eficacia de la herramienta debido a que los indicadores de confiabilidad de la encuesta son buenos. Los resultados obtenidos, de su aplicación en una empresa de transmisión eléctrica, expusieron que tuvo en la primera variable, basada en el RCM, una confiabilidad del 92 % considerado de excelente y de 72 % en la segunda variable, preparación de la empresa para su implementación, calificada de aceptable, ambas obtenidas mediante el Alfa de Cronbach. Además, se pudo establecer la pertinencia de esta estrategia para este campo de investigación y demostró que la entidad no estaba preparada para poder asumirla sin antes realizar cambios.

Palabras claves: diagnóstico; mantenimiento centrado en la confiabilidad; encuesta; estrategias de mantenimiento.

Introduction

Industrial maintenance, is currently breaking down the barriers of the past. Nowadays, maintenance managers in companies should see the maintenance as an investment, instead of seeing it as an expense. The transformation that is happening in the maintenance area requires an important and sustained improvement of the operational and financial results of the companies, through the implementation of a philosophy or an organization system that is feasible according to their context [1].

The electric transmission companies are responsible for operating, maintaining and managing all the high tension electrical networks, substations, equipment and machinery of the electrical transmission system. They have a structure containing substationsand electrical lines divided into different transmission networks, which are located

in different areas. The infrastructure maintenance management is responsible for the correct functioning of the assets [2].

The reliability-centered maintenance is a methodology of systematic, objective and documented analysis applicable to any industrial facility and it is very useful for the development or optimization of an efficient preventive maintenance plan. It is a structured procedure to determine the most appropriate maintenance policy for each physical asset of an industrial plant, according to its operational context [3].

It is used to know what should be done to assure that a physical asset carries out its desirable functions in its operational context based on a safety warranty, minimizing the risk to the environment and human lives, the impact on the environment, the impact on production and the reduction of operating and maintenance costs [4, 5].

The RCM proposes, as general criteria, the maintenance of the components that are considered as critical for the correct operation of the facility, leaving the non-critical components work until there is a failure; then the correct maintenance is applied.

Some of the RCM tools are steady improvement teamwork, systems definition, operational functions and contexts, criticality establishment and differentiation, root cause analysis, documentation of decision sheets for planning tasks. The details explained previously show the importance of the implementation of this philosophy in electrical transmission companies.

In 2013, Pablo Viveros [6] presented the basis for the implementation of a maintenance management model. The model takes elements from a RCM, where is stated that it is necessary to start with a diagnosis, but the constituent elements are not stated.

The objectives of this study were to design a survey oriented to identify if it was possible to implement a Reliability-Centered management system in an electrical transmission company and to determine whether it was possible to implement it at the time of this study. It was a case study.

Data collection was made using a survey, containing two variables, each one with different dimensions and indicators. The reliability test was done using Alpha de Crombach method, showing the result of the level of concordance [7, 8].

Methods

Analysis of a proposal to select a maintenance system

Regarding the facts previously stated, the feasibility of the implementation of a RCM as a management system was done. For this reason, it was necessary to know the potentialities the company has for the implementation. In order to find out this information, a survey was made [9, 10].

Questionnaire main parameters

The survey was made using the criteria stated by Hernández Sampieri R and others [11] in the book.

Study Type

It was a descriptive study. The aim was to find out the important properties of the analyzed phenomenon [6], that is, the possibility of implementing RCM in electrical distribution companies, and identify whether the company selected for the diagnosis was ready for the implementation.

Sample

In the process of selecting a sample, first it was necessary to identify the analysis unit, which was the possibility of implementing a RCM in electrical transmission companies. Nonprobability sampling was used for this study because the selection of the participants did not depend on the probability. It was not mechanic and it did not follow any formula, nor was related to the characteristics of the investigator. It was responsibility of the decision taking process of the experimenter.

The type of sample used was the subject sample, which is the correct one for cases of exploratory studies or qualitative research, like this study. The type of sample shows the same characteristics of the expert type, but in this case, the instrument was executed not only on this specialization level of the interviewed, but other type of specialists were taken into consideration.

Survey analysis method

The method developed by Rensis Lickert or Lickert Method was used. It consists of a set of items presented as affirmations or statements, in which the reaction of the interviewed is measured [12].

Questionnaire evaluation

For the analysis of the results of the study, the measures of the indicators they represent were taken as indicative values, using a range, according to the value criteria of the specialists. It does not mean that they are preestablished values, but a range that gives a criterion for measuring the behavior. It will be taken as follows:

- Values under 2,8 will be taken as a bad value and the need of implementing the strategies that present solutions to the analyzed problems.

- ▪ Values with ranges between 2,81 and 3,4 are considered as regular and the strategies will be corrected so that the problems detected can be solved.
- ▪ For values over 3,41 there should be detected any element that is feasible to correct to keep a good functioning of the organization.

Results and Discussion

It starts with an introduction with the general basis that the interviewed will receive.

Output or performance variables

1. If the improvement program based on the RCM can be implemented at the electrical transmission company.
2. If the electrical transmission company management is ready to implement it at this moment.

In table 1, a summary of the structural elements of the survey, for each indicator is shown:

Table 1: Elements for the evaluation of the survey. Source: authors

Element	Ítems
Indicator I: Implementation of the diagnostic tool	
D 1.1: Steady improvement teamwork technology usage	1 - 5.
D 1.2. System, function and operational context definition	6 - 15
D 1.3. Criticality establishment and differentiation	16 - 22
D 1.4. Root cause analysis. (*RCFA-Root Cause Failure Analysis*) ACR	23 - 24
Indicador II: Impact Conditions	
D 2.1. Impact on people's safety	25 - 28
D 2.2. Impact on the environment safety	29 - 32
Indicator III: Information treatment	
D 3.1. Indicators análisis	33 – 39
D 3.2. Diagnostic technologies usage	40 – 44
Indicator IV: Human Resources Treatment	
D 4.1. Training	45 – 48
D 4.2. Integration of management with workers	49 – 50

Sample:

The questionnaire was answered by 9 specialists with long time of experience in the subject of study. In table 2, the selection of specialists interviewed is shown.

Table 2. Specialists interviewed. Source: authors

Activity	Quantity	Area of work	Professional experience
Electrical maintenance specialist	3	Electrical engineers	15 years
			10 years
			9 years
Area Manager	1	Electrical engineers	20 years
Brigade leaders	2	Electrical engineer	8 years
		Electro Mechanical Engineer	12 years
Maintenance planner	1	Industrial engineer	9 years
Maintenance workers	1	Electrical engineers	11 years
Industrial maintenance specialist	1	Mechanical engineer, Master's degree in engineering	27 years

Results of the evaluation

Table 3 shows the results of the survey collection and evaluation based on the responses of the 9 experts interviewed in the company chosen as the field of research. The results of all indicators and dimensions that were evaluated are also presented.

Variable 1: If it is possible to implement an improvement program based on RCM in electric transmission companies.

Tabla 3. Results of variable I. Source: authors

Indicator/Dimension	Value
I. Implementation of diagnostic tools	
D 1.1._ 1, 3	3,11
D 1.2._ 7, 9, 11, 13, 15	4,36
D 1.3._16, 17, 18	4,48
D 1.4._ 23	4,33
Indicator Value	**4,07**
II. Impact Conditions	
D 2.1._ 25, 26	4,50
D 2.2._ 29, 30	4,39
Indicator Value	**4,44**
III. Información tratment	
D 3.1._ 36, 37, 38, 39	4,56
D 3.2._ 40, 41, 42	4,22
Indicator Value	**4,39**
IV. Human Resources Value	
D 4.1._ 45, 46	3,78
D 4.2._49, 50	2,44
Indicator Value	**3,11**
Variable value	**4,00**

Regarding the results obtained, it is clear that the implementation of a RCM as a methodology is feasible for the institution selected. The result of the variable was 4,00, which is considered as good [12]. On the contrary, the indicator that showed the worst result was Human Resources Treatment, stated as regular.

Variable II: If the management of the company selected is ready for the implementation of the RCM at this moment. The results are shown in Table 4:

Table 4. Variable II results

Indicator/Dimension	Value
I. Diagnostic tools implementation	
D 1.1._ 2, 4, 5	2,07
D 1.2._6, 8, 10, 12, 14	3,00
D 1.3._ 19, 20, 21, 22	1,47
D 1.4._ 24	1,22
Indicator Value	**1,94**
II. Impact conditions	
D 2.2._27, 28, 31, 32	3,28
Indicator Value	**3,28**
III. Information treatment	
D 3.1._ 33, 34, 35	2,19
D 3.2._ 40, 43,44	4,26
Indicator Value	**3,22**
IV. Human Resources Treatment	
D 4.1._ 47, 48	2,39
D 4.2._ 49, 50	2,44
Indicator Value	**2,40**
Variable value	**2,71**

The total value for this variable in the company selected for the study was 2,71 which is a result close to regular but stated as bad [12]. This result shows that this company was not ready for the implementation of the RCM. The negative result for this variable was mainly due to the results of the indicators Diagnostic tools implementation and Human Resources Treatment, but anyway the all the other indicators were evaluated as regular. Therefore, in order to implement the RCM, a program must be designed to mitigate the problems detected in order to obtain results that validate this possibility.

Reliability analysis and coefficient of concordance according to the experts

The total reliability value of the data collection tool, according to Alpha de Cronbach coefficient was 0,9220, it means a 92,2 % reliability, considered as excellent. The analysis of the variable I shows a reliability of 0,9243, which is considered as excellent (92,43 % of reliability), whereas the variable II showed a result of 0,7574 according to Alpha de Cronbach coefficient, it means a reliability of 75,7 %. The result of variable II is not as good as **variable I**, but it is considered as acceptable.

Regarding the concordance among the interviewed, the Kendal coefficient and its signification test was used. In table 5, the results obtained of the survey data processing, using Minitab V.16 software are shown.

Table 5. Elements of the Kendall coefficient of concordance. Source: authors

Coefficient	Chi square (Chi-Sq)	Freedom Degree (DF)	P Value
0,817673	360,594	49	0,0000

In the previous table, a concordance coefficient of 0.82 approximately is obtained. It is considered a high value. The following hypothesis test is used to determine the significance of this coefficient:

H_0: no concordance (W = 0)

H_1: there is concordance (W ≠ 0)

Since the value p for the test is zero, H_0 is rejected. Therefore, there is concordance among the interviewed.

Conclusions

A tool was designed to estimate whether it was possible to implement a reliability-based maintenance organization philosophy in electrical transmission companies and to determine whether the company is ready for such implementation at the time of the study.

From the application, the relevance of the tool was validated since the reliability indicators of the survey are good and there is concordance among the specialists.

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Conflicto de intereses

The authors declare that there are no conflicts of interest

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