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The bus availability through preventive maintenance.

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ABSTRACT: This research paper is about the bus availabilitythrough a plan maintenance in a small company with years of experience. The importance of a maintenance plan is essential,to achieve the objectives of the company, in general, any company seeks to make money with fewer resources and in an efficient way.Part of achieving an efficient process is through successful operation of your equipment, this should work uninterruptedly and allocate time to resolve any problem that may prevent proper operation.

KEYWORDS:Preventive maintenance, buses, service, OEE, availability.

I. INTRODUCTION

Companies always seek to do more with less, frequently the environment is changing in a way that is more demanding, in this paper preventive maintenance can be seen as a basic tool for operational and financial success. Maintenance could be conceptualized as a series of steps accompanied by logistics in search of availability and reliability with the highest performance, previously it was given in a forced way due to basic needs that arose without prior organization.

[1]. Maintenance can be defined as a process that, through given techniques, can preserve equipment and facilities for longer than possible, resulting in high availability and reliability together with higher performance. It is constituted by techniques and methodologies that allow predicting any breakdown through scheduled reviews (Medrano, 2017).

[2]. Preventive maintenance is an integral process in which maintenance activities can be planned through synchronized procedures with the objective of having a constant and adequate performance of the machines that involve the production process, preventing possible deviations that may occur during their activity (Torres, 2017).

[3]. The bus is one of the most used means of public transport in the world because it is accessible to anyone and has different destinations that allow you to reach any corner. This transport must have the characteristic of having operability and availability whenever it is in service, that is, providing customers with a trip without interruptions in the estimated time, this is achieved through maintenance (Rodríguez, 2010).

[4]. A preventive maintenance plan allows you to manage the expenses that a failure implies, it is especially when it is operating because they are expenses not contemplated, for example a repair, replacement of a part, interruption of operability and among others. In order to have a maintenance plan, it is necessary to have indicators that help measure the relationship between quality and productivity of a process or machine, analyzing the behavior and operational performance (García, 2012).

The Overall Equipment Effectiveness (OEE)it is an indicator that represents the real capacity for a product or service to perform and have availability in the process in the teams that are involved.The OEE is considered by many specialists as one of the most effective evaluation tools for making decisions regarding the production system.

It is possible to confuse, but effectiveness differs from efficiency in the sense that efficiency refers to the best use of resources, while effectiveness refers to the ability to achieve an objective, even if in the process it has not been done. the best use of resources, that is, it does not matter if we were efficient in the process carried out to achieve the objective and be effective (Álvarez, 2016).

For the calculation of the OEE, it is necessary to know the availability, efficiency, and quality, as can be seen in equation 1.

$$\text{OEE} = \text{availability} * \text{efficiency} * \text{quality} \quad \text{Ec. (1)}$$

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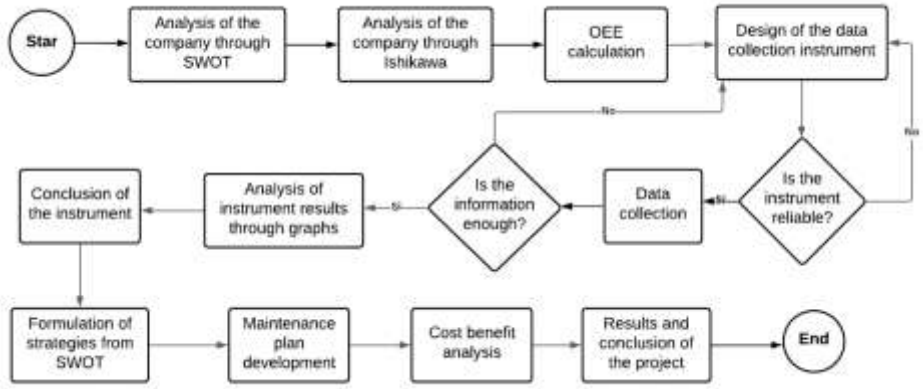

Figure 1, Investigation Methodology

Individually each component of equation 1 can be calculated as follows:

$$\text{Availability} = \frac{\text{productive time}}{\text{available time}} \quad \text{Ec. (2)}$$

$$\text{Efficiency} = \frac{\text{actual production}}{\text{productive capacity}} \quad \text{Ec. (3)}$$

$$\text{Quality} = \frac{\text{actual capacity}}{\text{total capacity}} \quad \text{Ec. (4)}$$

Regarding the above, the impact of adequate preventive maintenance planning is observed, specifically in the transport sector. In this research, it primarily seeks to prevent high-cost mechanical failures and life-risk strategies duringequipment based on a preventive maintenance plan in order to improve maintenance operating costs of buses, favorably reducing unnecessary expenses, bringing with it a favorable demand for the company.

II. METHODOLOGY

This research is defined as descriptive, exploratory, quantitative, qualitative, explanatory, and propositional. From this, the methodology that is observed in figure 1 was determined, which essentially has three phases, the first is to know the current situation with the existing resources, the second is to investigate the general situation with the personnel and finally to propose the plan. through strategies for the primordial area,the mechanics and for the part of comfort.

III. DEVELOPMENT

As part of the first stage, there are several observations such as the lack of organization in the records, the records are a fundamental part of an organization because through these areas of opportunity can be detected and current performance improved, in this case they did not have logbooks or records where you can have control of the incidents that have occurred or basicactivities such as oil changes cannot be programmed logically according to the time the bus has worked.

It can be concluded that the first phase did not achieve a specific objective due to the lack of information, in the second phase information was obtained through personal interviews with the maintenance manager and the owner of the buses, and a survey with the drivers.

The second phase gave results making it clear that the company's current process regarding maintenance is corrective, derived from the fact that there is no logistics in the review activities that allow detecting or predicting some incidents. Corrective maintenance has not been enough because it generates higher costs and times for a company, for example, the availability of buses isaffected by not generating revisions and necessary changes in time.

The company manages a strategy that the driver of each bus is the same during the useful life of the bus, which allows the main incidents of the unit to be known precisely with respect to time, according to the correlation of variables (the correlation of the variables was obtained using Minitab), in the survey of drivers, through means of each variable for each interviewee in figure 2, it is observed that the relationship between maintenance and training is the lowest among all the variables that are available.

The relationship between failures and training is high, leaving as a result that by improving one of them, such as training, failures will no longer be an occasional problem.

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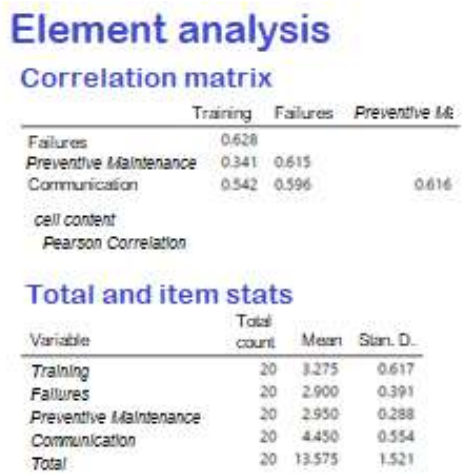


Figure 2, Correlation of Variables

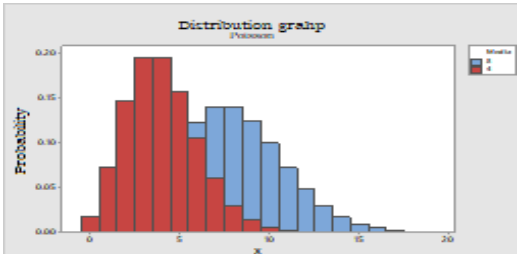
As a conclusion of the second phase, it is that the company does not have any protocol regarding the maintenance item, decisions are made regarding a meeting, implying higher expenses, lost time and poor coordination of activities, being the result of poor communication and old practices.

The table 1 shows the failures registered, the engine overheating and gearbox problems are the most common, and in the graph 1 made with Minitab, there is a distribution graph with the means obtained from the monthly failures in the last six months.

Month	**1**	**2**	**3**	**4**	**5**	**6**
Failures (Mechanical)						
Engine overheating	4	3	5	3	4	3
Gearbox	2	3	2	2	3	3
Retarder overheating	1	2	1	0	2	1
Braking difficulties	1	0	1	0	0	2
TOTAL	8	8	9	5	9	9

Table 1, Monthly Failures.

In graph 1, the blue curve represents the current situation where there is an average of 8 failures per month, which has generated money losses in a trip of $12,000 Mexican pesos, at least with some changes in maintenance management or a reduction of 4 failures per month, indicated in the red curve and gradually looking for failures to be scarce.



Graph 1, Distribution of Current and Desired Faults

From the information obtained in phase two, it was established through a SWOT tool, that with the help of the EFI matrix, with a result of 2.88, indicates that the internal position is maintaining a neutral position that does not advance, and the EFE matrix with a value of 1.47 indicates that they are not responding to opportunities and threats with the current strategies of the company, indicating a need to promote new strategies.

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Subsequently, using an Ishikawa diagram, the factors involved in not having availability in its entirety are determined, of which communication, training, records, organization and mainly the maintenance plan.

With the OEE indicator, adapting the equation 1 to evaluate the service, because evaluation for a service and a process is different.

$$\text{Availability} = \frac{960\text{ h} - (144\text{ h} + 30\text{ h})}{960\text{ h}} = 0.82 \quad \text{Ec. (5)}$$

$$\text{Efficiency} = \frac{10{,}752\text{ h/u}}{18{,}600\text{ u}} = 0.7 \quad \text{Ec. (6)}$$

$$\text{Quality} = \frac{768\text{ h} * 14\text{ u}}{960 * 20\text{ u}} = 0.56 \quad \text{Ec. (7)}$$

Obtaining the individual values, the calculation of the OEE gives the following result

$$\text{OEE} = (0.82 * 0.7 * 0.56) * 100 = 32\% \quad \text{Ec. (8)}$$

OEE	Assessment
0% - 64%	Deficient
65% - 74%	Regular
75% - 84%	Acceptable
85% - 94%	Good
95% - 100%	Excellent

Table 2, Interpretation of the OEE, Adapted from Álvarez, 2016.

According to table 2, the value calculated for the OEE indicates that there are significant economic losses with low competitiveness, indicating the urgent need to improve this indicator of the company's comprehensive use. If the result of each value that makes up the OEE result is analyzed, the current quality is the lowest result of the three, but this is the result of the previous two, which will improve its value by optimizing availability and efficiency.

IV. PLAN PROPOSAL

The proposal will be shaped by the strategies from the SWOT, they will be developed throughout the plan. The plan is divided into two parts, the first part consists of attending to the mechanical part of the bus and the second part is made up of the internal part to seek comfort for passengers.Below is just a section of what makes up the preventive maintenance plan for both parties.

The first part of the plan consists of quickly attending the way in which they handle the records, proposing the use of an Excel file with the information of each bus, so that the reports are recorded on time and that everyone has quick and easy access when they need it, in that way they can also schedule periodic reviews, for example, oil and filter change, tire rotation, crosshead greasing, lining change, retarder oil change, braking and damping system review, all will be carried out based on the kilometers that have been worked, programming the time so that they are carried out while they are not in service. For example, brake lining change every 200,000 kilometers, the cooling system filter change every 10,000 kilometers, oil change every 33,000 kilometers and crosshead greasing every 15 days worked.

Maintenance staff and drivers will be given training annually in maintenance topics to cover basic concepts of each type of vehicle, general characteristics of the cabins, operation of the steering systems and brake. Procedure's manuals will be created according to each make and model of bus, with the purpose of having the necessary information so that they can carry out basic inspections and know the situation prior to the time they must go into service.

The driver and maintenance staffwill have to sign an inspection sheet prior to the trip, where themust check the conditions of the tires, the level of oil, brake fluid and coolant are evaluated, ensuring that they have the necessary conditions for the trip to be made and deliver to the administrative staff at the time they receive the guide.

In the second part of the plan, the aim is to mainly address an area that is not considered important to condition whether the bus is available to go to service or not, in this part the conditions of the seats will be reviewed with respect to the functionality of reclining properly through the lever, before each trip, the cleaning of the entire bus will be scheduled, especially the bathroom part, inspecting that it is working at one hundred percent, adding complete sanitization before departure.

It will also be added as a protocol to turn on the air conditioning once the bus is in motion, this optimizes the useful life of the filter and adjusts the temperature to the lowest level, at the same time turning on the fan.

V. CONCLUSION

There are only some regulations included in the plan, all in search of the availability of buses and efficiency in the service, the company currently has an old work mechanism where they do not

evaluate the advantages of having a maintenance system adequate to the needs of the environment and of the same company, the dimension of losing a day of work where if you had three trips on that day is the equivalent of the cost of four tires, is where the importance of making the company aware of considering an investment in time and money that is minimal to the investment of these currently.

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