Improvements to the Preventive Maintenance Process Performance at a Pharmaceutical Company

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Abstract *— An analysis of the current performance of the Preventive Maintenance (PM) process was conducted for the four main areas of a pharmaceutical company: Manufacture, Utilities, Laboratory, and Facilities. The current performance of the PM process was found to be out of the expected target. Trends and detonating factors were identified, and four alternatives were implemented to improve the PM process performance. These alternatives included: cross training, improvements to the planning process, updating current procedures, and a continuous improvement and monitoring strategy to sustain the optimized performance. A significant improvement in the percentage of on-time PM completion has been observed. A continuous improvement strategy is in place to sustain the optimized performance.*

Key Terms *— Continuous Monitoring, Equipment Lifespan, Equipment Optimization, Pharmaceutical Company*

Introduction

Extending the lifespan of equipment and systems contributes to the success of manufacturing processes. Establishing a maintenance program is one of the tools employed by organizations to fulfill this purpose. Optimal processes are one of the goals of many manufacturing industries, including the pharmaceutical field. This project evaluated the Preventive Maintenance (PM) performance on a pharmaceutical company that has a mass production of intravenous solution bags.

The company presented a low percentage of PM completion, compared to the target of 100% in its four main areas: Manufacturing, Laboratory, Utilities, and Facilities. Therefore, the objective of this project was to improve the percentage of on-time completion for the PM process. To achieve this objective, data from the process was obtained, analyzed, and trended. Strategies from the results obtained were generated and implemented to improve the process. A continuous monitoring was set in place for the process after the implementation of the strategies.

Literature Review

To sustain the performance of the manufacturing processes, industries have established a series of maintenance strategies including PM. This strategy focuses on the mitigation of risks such as equipment malfunctions, process downtime, equipment replacement, among others [1]. There are different methods to implement the PM strategy. The most commonly known are the ones based on the use, based on specific times, the ones scheduled before a failure is observed, and the ones that analyze the what, when, and why of the failures [1]. Some of the benefits of implementing PM strategies are the reduction of unexpected maintenance, extend or sustain the equipment lifespan, and benefits manufacturing by reducing downtime [1].

Nonetheless, PM cannot repair the assets to their original condition. There will always be a decrease in the performance based on asset wearing and aging [2]. This scenario is considered imperfect PM and which creates the need of implementing the PM in the proper frequency [2]-[3]. There are different methods developed to evaluate the proper frequency of PM for an asset and the impact of not completing them on time. Software-based algorithms are used to establish PM frequencies from models that evaluate the worst-case scenarios of failure, trend the type of failures found, and the type of PM performed to the asset [4]-[5].

Another important factor to consider under the PM strategy is its implementation itself. Identifying the worst-case scenarios of defects and failures and finding the proper PM frequency is not enough if the process is not properly followed. This means that deficiencies in the planning strategy of the PM will translate to the failure of the whole maintenance strategy [6]. The coordination underneath the planning process is essential to satisfactorily perform the required preventive maintenance on time and avoid failures that have been previously identified. Tracking the performance of the PM process provides a better understanding of the planning areas that need to be improved to achieve the success of the maintenance strategy [6].

Optimization of the PM strategy is a continuous process that involves the understanding of the factors that are impacting the performance of the processes based on assets failures [2],[4]. Therefore, a monitoring strategy and evaluation are essential in this process. Most preventive maintenance strategies are beneficial to the industries when well planned, structured, and implemented.

METHODOLOGY

Three monthly reports from the Maintenance platform, process evaluations and interviews to maintenance personnel were the source of information required for the data gathering. An analysis of the current performance for the PM process was conducted based on the data gathered from these resources. The following data was obtained from the maintenance reports:

- Work order (WO) number and description
- Maintenance group owning the WO and supervisor
- Area or department owning the asset
- WO status
- PM classification
- Target date, completion date, and days late
- Overdue status

Data was segregated and analyzed for the four main areas of the company: Manufacture, Laboratory, Utilities, and Facilities. To evaluate the performance per area, the amount of work orders issued per month and per area were listed, as shown in Table 1. As expected, the areas of Manufacturing and Utilities have significantly more PMs than the Laboratory and Facilities at an approximate ratio of 2:1 respectively.

Table 1
Preventive Maintenance Assigned and Completed per Area/Department

Area / Department	PMs Assigned*	PMs Completed on Time
Manufacture	100	85
Laboratory	50	35
Utilities	120	96
Facilities	60	45

*Approximate PM work orders assigned per month.

A detailed evaluation was performed to identify possible variables that impact the performance of the PM process. The PMs assigned per area are classified in three (3) categories: Critical, Major, and Regular. Critical are those that a failure will impact the product and/or process. Major are PMs that include multiple assets and involve a process interruption. The Regular cover preventive maintenance that will increase the asset's lifespan. Therefore, Critical PMs are considered the priority when competing with other maintenances. Completion of PMs per classification are included in Table 2.

Other criteria evaluated for the performance of the PM process was the number of overdue days from the target date per area. The maintenance program in place establishes a target day for the PM to be completed and a frequency. The frequency established is based on recommendations from the assets' manuals or evaluation performed by the reliability team. Data for the overdue dates per month are included in Table 3.

An additional criterion evaluated is the personnel involved in the PM process. There are four (4) maintenance crews that work on these PMs: Electrical (Site), Mechanical 1 (Manufacture), Mechanical 2 (Site), and Laboratory. Because the data collected was not conclusive to determine the reasons behind the delays on Preventive Maintenance, a series of interviews were performed to gather information from these crews. The following factors impacting the PM process performance were identified from the interviews:

- Expertise of maintenance personnel
- Competing dates and priorities
- Inadequate headcount
- Not completing documentation on time or following procedures to complete the PMs

Table 2
Preventive Maintenance Classification per Area/Department

Area / Department	PMs Assigned per Category		PMs Completed on Time
Manufacture	Critical	56	56
	Major	4	4
	Regular	40	25
Laboratory	Critical	27	18
	Major	1	1
	Regular	22	16
Utilities	Critical	72	70
	Major	5	5
	Regular	43	21
Facilities	Critical	24	24
	Major	2	2
	Regular	34	19

Table 3
Preventive Maintenance Overdue Days per Area/Department

Area / Department	Month	Total PM Overdue Days
Manufacture	1	15.0
	2	12.5
	3	10.0
Laboratory	1	9.5
	2	10.1
	3	5.0
Utilities	1	13.1
	2	16.0
	3	16.5
Facilities	1	12.0
	2	16.5
	3	12.3

The information obtained provided a better understanding and guidance from factors impacting the process performance. Therefore, an evaluation of the process was performed with the maintenance crews. By evaluating their procedures and practices, previous factors from the interview were confirmed.

RESULTS

Once the data and information gathered were analyzed and trended, it was observed that none of the evaluated areas reached the target of 100% of completion for the Preventive Maintenance. The results obtained for the average amount of days and percent of completion for the PMs per department are listed in Table 4.

Table 4
Preventive Maintenance Overdue Days and Completion Percentage per Area/Department

Area / Department	Average PM Overdue Days*	Percent of Completion
Manufacture	12.5	85%
Laboratory	8.2	70%
Utilities	15.2	80%
Facilities	13.6	75%

*Average based on the three (3) months period evaluated.

Because the target percentage of completion for the PMs is 100%, no overdue days should be obtained for the process. Utilities was the area with the highest number of PMs assigned and also the highest average of overdue days. A representation of the average overdue days is presented in Figure 1.

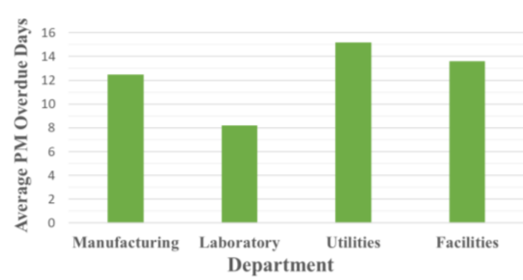

Figure 1
Preventive Maintenance Completion per Area/Department

The higher percent of completion was obtained from the manufacturing and utilities areas as expected based on the manufacturing nature of the company. However, the performance for the areas with a smaller number of PMs assigned, was even lower compared to the areas with a higher number of PMs.

When evaluating the number of PMs that were overdue based on their classification, it was found that the majority are regular PMs as expected due to its priority compared to Critical. Nonetheless, the Laboratory area had the higher number of Critical PMs overdue as shown in Figure 2. None of the major PMs were overdue.

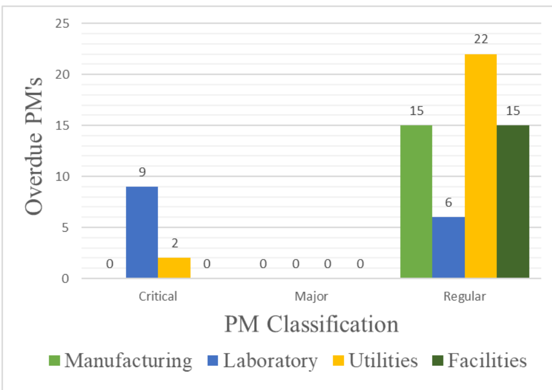

Figure 2
Overdue Preventive Maintenance per Classification

Results provided a visual representation of the performance of the PM process per area. Considering the outcomes from the interviews, it was possible to identify that the are some external factors impacting the process' performance. For example, having only a limited number of dedicated and trained personnel for a specific task (in some cases only one), limits the PM process any time that resource is not available to complete the PM. Regarding planning, sometimes the PMs are triggered at the same dates and the priority is not always clear to the maintenance crew in charge, and sometimes there is not enough personnel to cover the PM demand. Another important contributing factor is the process of documenting the PMs in the maintenance platform. By not doing it on time or making mistakes, the approval process takes longer and the PMs record ended up being late even when the task was completed on the asset or system. These aspects contributed significantly to the delays in the Preventive Maintenance Process were considered in the planning stage of the project.

Improvement Strategy

With a better understanding of the current performance of the preventive maintenance process, it was possible to design some strategies. The first alternative was to provide cross training to personnel from different crews and within the same crew to increase the pool of expertise for tasks that have been performed by a single individual. The second path was to evaluate the planning tool on the maintenance platform to restructure the release date of PMs from a batch mode to a more segregated way, to decrease the load of work per day. The third approach was to update current procedures and train the maintenance crews, so they have a better understanding of prioritization, and also to reinforce the good documentation practices when recording PM records. The fourth measure was to evaluate the increase of the headcounts in areas in which the previous measurements were not enough to improve the process. The fifth and last measure was to implement a weekly monitoring of the process once the implementation of the approved measures was completed, to address any immediate issue that may impact the performance of the process.

All these alternatives were recorded in a formal proposal and a rationale for their implementation was provided to management. As part of the process, the alternatives were evaluated, and the ones selected were the first three and the last one due to the implications and timing. These alternatives were implemented over a short-term period, but the fourth alternative was set apart for a long-term period due to an ongoing restructuring in the company's organization. Following the last alternative, a series of morning workshop meetings were established weekly and after two weeks of the implementation, a decrease in the overdue days and PMs has been observe in the four areas. This last part is a continuous process that will extend out of the scope of this project.

CONCLUSION

For a manufacturing company to operate efficiently, equipment, utilities and related systems need to be at their optimal condition. Preventive Maintenance is one of the alternatives employed to achieve this objective. The performance of the PM process on the four main areas of the pharmaceutical company was found to be beyond the expected target of 100% on time completion. Trends and detonating factors were identified from the evaluated data and alternatives were implemented to improve the PM process performance. As part of the continuous monitoring strategy implemented under this project, a significant improvement in the percentage of on-time PM completion has been observed. Therefore, under the continuous improvement methodology of the company, the monitoring process will continue assessing issues that may impact the performance of the Preventive Maintenance process and searching for alternatives that increase the sustainability of the impacted assets.

REFERENCES

[1] *What is preventive maintenance? types, examples and benefits*. (n.d.). [IBM]. Available: https://www.ibm.com/topics/what-is-preventive-maintenance#:~:text=IBM%20Log%20in,What%20is%20preventive%20maintenance%3F,fixing%20things%20before %20 they%20break.

[2] M.A. Coque, Jr. & G. F. Souza. (2014). "Optimal maintenance time under Imperfect Preventive Maintenance". Vulnerability, Uncertainty, and Risk. https://doi.org/10.1061/9780784413609.254

[3] J. A. Duarte, J. C. Craveiro & T. P. Trigo. (2006). "Optimization of the preventive maintenance plan of a series components system". International Journal of Pressure Vessels and Piping, 83(4), 244–248. https://doi.org/10.1016/j.ijpvp.2006.02.016.

[4] F.I. Mălinescu & I. Virca, (2022). "Research to improve preventive maintenance of technical equipment". Land Forces Academy Review, 27(3), 250–256. https://doi.org/10.2478/raft-2022-0032

[5] N. Udoh & E. Effanga. (2021). "Geometric Imperfect Preventive Maintenance and replacement (GIPMAR) model for aging repairable systems". International Journal of Quality & Reliability Management, 40(2), 566–581. https://doi.org/10.1108/ijqrm-04-2020-0125

[6] E. I. Basri, I. H. Abdul Razak, H. Ab-Samat & S. Kamaruddin. (2017). "Preventive maintenance (PM) planning: A Review". Journal of Quality in Maintenance Engineering, 23(2), 114–143. https://doi.org/10.1108/jqme-04-2016-0014