RELIABILITY PROGRAM AS PART OF A BUSINESS STRATEGY

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ABSTRACT

Plant reliability is an essential factor for the world of investments and companies that are currently in line with Environmental, Social, and Governance (ESG) goals have been supported by investors around the world. This paper states a valuable implementation of a reliability process that creates engagement among stakeholders and decreases the life-cycle cost of a plant while the reliability increases. In addition, it suggests how to create a solid base with the support of different areas and tools that lead to an increase in the reliability of equipment, systems, and plants.

Keywords: Mining, Reliability, Availability, FMEA, ESG, Business Strategy, Maintenance plan, Costs optimization, RCM, CMMS.

INTRODUCTION

In recent times, the mining industry has experienced an increase in expenditure, in a bid to modernize its operations, and has the ability to meet market demand. Costs to maintain these equipment are increasing at a fast pace. However, these increased mechanizations have received special attention to safety-related issues which are part of the ESG goals [3].

Presently, companies that aim for sustainable production are aligned with the environmental, social, and governance (ESG) goals, and these companies are well supported by their investors due to the exhibition of market-based outperformance. According to John Hill (2020), studies show that companies with high ESG ratings exhibit market-based outperformance [5].

To support the ESG goals, the implementation of a reliability program can be a key factor to maintaining better equipment reliability and to be product delivery predictable. A reliability program can assist the ESG goals by providing support on these three pillars:

Environmental: Increasing the operational eco-efficiency, emissions control, energy, and fluid control.

Social: Improving safety in the operations of equipment, minimizing accidents, supporting human development, and increasing community satisfaction with investment in the skills improvement of the employees.

Governance: Preparing risk & crisis management, organizing supply chain management for maintenance in a timely manner, achieving product demand satisfaction due to the reliability of a production plant, reducing cost with maintenance, and analyzing new technologies to be implemented on the production system.

AVAILABILITY AND RELIABILITY

In the industrial environment, the words reliability and availability are used frequently, also they are related to each other. However, they can be misused due to a lack of clarification. This work will utilize definitions from the book Mining equipment, reliability, maintainability, and safety, written by B. Dhillon (2008).

Reliability: The probability that an item/piece of equipment/system will carry out its specified mission satisfactorily for the stated time when used under specified conditions.

Availability: The probability that a piece of equipment/system is functioning satisfactorily at the time (t) when used according to specified conditions, where the total time includes operating time, logistical time, active repair time, and administrative time.
In other words, reliability measures the probability of failure while the equipment is in operation and availability is the amount of time that it is available to operate.
As an example, a mobile equipment with a fire suppression system may have the availability of 85%, meaning that 15% of the time this fire suppression system is down for maintenance checks. On the other hand, the reliability of this fire suppression must be at 100% and is expected to maintain an availability & uptime of at least nine 9s, due to its criticality and the danger that it can cause in the event of a fire incident.
Availability can be measured in the following three different ways: through inherent availability, achieved availability, and operational availability. Still, the focus of this paper is on operational availability, which can be expressed by:

$$AV = [(TH - DT)/TH] \times 100$$

where:
AV is the equipment availability,
TH is the total hours,
DT is the downtime expressed in hours.

OR

$$AV = MTBMA/(MTBMA + MDT)$$

where:
MTBMA= mean time between maintenance actions,
MDT = mean maintenance downtime,
MDT = mean maintenance time + (logistics delay time) + (administrative delay time). [7]

In contrast to availability, reliability takes in the following formula, which takes into consideration the probability of failure in a due time if the equipment is used in regular conditions:

$$R(t) = 1 - F(t)$$

where:
R(t) is reliability in a certain period,
F(t) is the probability of failure in a certain period.

Gathering Data to Achieve the Desired Reliability

Data collection and gathering data is an essential step in building the foundation of any reliability program. However, there is a need not only to ensure proper gathering of information, but also to outline exactly the relevant information necessary to define KPIs as well as gather the information needed to define what maintenance needs to be done, what is the frequency required for a maintenance plan, what are the failure rates of a system or component, what are the materials used, how long it takes to get an item after the request, and how long it takes to fix a piece of equipment in case of failure. Moreover, it is necessary to have information about the impact on production and how much it could cost in case of a failure.
The foundation of a reliability program must be strong, or its implementation can fail due to a lack of essential information. This data can be found with maintenance orders, production logbooks, vendor quotes,

technical drawings, equipment manual, manufacturer information, project specifications, or even laboratory data which brings the information of operation under different circumstances [1][2].
The above-mentioned, are some of the sources where important data can be found and organized in a way that the maintenance and reliability engineering team can easily access. At this stage, a Computerized Maintenance Management System (CMMS) can also play a key role in terms of providing a unique place to store information for future analysis of equipment in a manner that helps to improve its reliability.

Development of The Reliability Process

Within an industrial process, each piece of equipment plays an important role to successfully deliver the final product. As part of the development of a strong reliability strategy, and to prove the effectiveness of the proposed work, the first step is to understand the process, build an equipment hierarchy, make a prioritization of equipment, find the most critical ones to start applying this technique, and then monitor the efficiency of the work done. After this has been done in the most critical ones, it can then be extended to the other pieces of equipment as the company deems necessary.

Maintenance Strategy

The creation of a maintenance strategy can be supported using all the data available, the technical expertise from the company, manufacturer, and suppliers which can be used to create a cost-effective strategy. However, a new installation with unknown data can be reasonably hard for the first time [11], to help build this maintenance strategy, a valuable tool that can be used in this process is the Failure Mode and Effect Analysis (FMEA).

FMEA is an assessment tool for process and equipment which helps to identify the failure modes of each component and the effect of each failure on the whole equipment or process.
FMEA is a qualitative tool that is largely used in reliability engineering [8]. It is important to consider that each component can have more than one failure mode and that each failure mode may have more than one consequence, hence, making the equipment lose performance and compromise the availability and reliability of the process as a whole [8][9]. An example of how an FMEA could be developed is presented in table 1.

Table 1. FMEA for a conveyor belt.

Equipment	Function	Failure Mode	Failure Effect	(S)	(O)	(D)	Risk Priority number (S*O*D)	Recommended Actions
Conveyor Belt	Convey X ton of materials from one place to another	Motor Failure	Conveyor stoppage	8	2	4	64	MCSA
		Gearbox Failure	Speed reduction	5	1	4	20	Oil Analysis
			conveyor stoppage	8	1	6	48	Check oil level
		Pulley Failure	Speed reduction	6	3	8	144	Inspect pulley structure for wear parts
			conveyor stoppage	9	2	8	144	
		Belt Slip-off	Conveyor belt Misalignment	6	2	8	96	Inspect pulleys alignment
			Fire due to high friction	10	1	6	60	Inspect belt motion speed
		Belt breakage	Conveyor stoppage	9	3	4	108	Inspect the belt for damage
		Scraper Failure	Dust migrating to the pulley	4	5	7	140	Inspect scraper adjustment
		Safety System Failure	Accident	10	1	10	100	Inspect pull cords and E-stop buttons
			Conveyor stoppage	8	1	2	16	

The information captured on the FMEA will lead the reliability team to avoid, mitigate or accept the failure and build a plan to minimize the impact in case of failure occurrence. Therefore, it is important to highlight that this assessment needs to be done with people that play different roles within the process. These individuals can be from the maintenance department, production, logistics, equipment manufacture, and other sectors that are related to the equipment and process [10].

The quality of an FMEA is directly related to those involved in its development and the quality of the information recorded.

The outcome of an FMEA for the reliability crew is the information that can be used to define the activities that will be performed on a piece of equipment and the types of maintenance each activity is categorized as. The maintenance types can be preventive maintenance, inspection, and predictive maintenance, or corrective maintenance which only occurs after the equipment fails.

An important decision factor when analyzing the use of preventive or predictive maintenance is also the adoption of data analysis and the use of statistical tools when data is also available. The data available provides key operational parameters such as the Mean Time Between Failure (MTBF), Mean Time to Repair (MTTR), and identifies a pattern of failure. Nevertheless, we can also use this data to perform data analysis using some of the well-known statistical tools such as Monte Carlo simulation, Weibull, and Poisson.

The most common statistical tool currently is the two-parameter Weibull distribution that can be used for the prediction of the reliability of a single component in a certain period. It is important to highlight that for every component in an equipment the reliability can change due to the purpose of the item [1]. As an example, we can use a vibratory feeder that receives ore and has the same liner in the base and the walls of the feeder. Even though it has the same material, the friction suffered in the baseliner is bigger than the friction suffered in the liners installed on the wall, which causes different reliability between both liners.

Even though the two-parameter Weibull distribution is one of the most common failure rate prediction tools used today, due to its efficiency and accuracy, the shape and scale parameters are directly affected by changes in the operational data used. Hence, using an unsuitable failure distribution will generate the wrong results and compromise the overall reliability of the equipment [1].

It is important to remember that all the actions taken based on data analysis need to be done in alignment with the expectations of the customer. The actions related to the assets need to meet the expectations of safety, reliability, and cost of the overall process. Certainly, if a high rate of reliability is applied on an equipment that is not critical to the process neither to the safety of the employees and customers, it can cause high expenditure that is unnecessary for the business. A general rule of thumb is that equipment with higher criticality are prioritized in the process of developing a maintenance strategy, as their failure can adversely impact safety, finance, and reputation of the operating company, and can lead to license revocation. A recommended article that may help to analyze the cost (x) benefit of an inspection interval can be found in the reference article [4].

Maintenance Plan

For the development of maintenance plans, it is necessary to carefully analyze the outcomes from the maintenance strategy, create a procedure that comprises the steps to execution, skills required, spare parts, and technologies involved to do the job in an appropriate way.

At this level, the tasks need to be categorized into the maintenance plan to fulfill its purpose. Those categories are operational check, lubrication, inspection based on condition, and restoration [10]. Hence, all those categories need to provide feedback to optimize equipment performance and increase the reliability of the operational plant [6].

Procedures must be written clearly and shall contain all the information required to perform a job as expected. As an example, a lubrication task must provide at least the amount and type of oil/grease, the lubrication points, and the equipment condition at the time of execution. An inspection based on a condition task should provide parameters to check the condition that signalizes if the item is good or bad, and a restoration task must provide details with a standard to meet the expectations with the best way to replace or restore an item of the equipment. Hence, those procedures still need to provide information about spare parts and tools required to perform the job [9].

During the development of the maintenance plan, requirements to accomplish the task and improve the life-cycle cost of the asset are raised. Therefore, at the end of this stage, it is important to create a knowledge matrix and an assessment plan to accomplish those activities with the expected quality. These tools will give a direction for the skills required for the job and a direction for the skills development plan inside of the existing team [6].

Integration of the Reliability Department Inside and Outside of a Business

As observed throughout this article, the relationship of a reliability team inside and outside of the business is very important for the sole purpose of achieving the high efficiency of the reliability program.

Inputs from manufacturers, operation, and maintenance specialists will help in the development plan to indicate the best activities to be performed in a piece of equipment. The procurement department is going to play an important role in the availability of spare parts. Designers can provide drawings to develop a procedure and can work into the updates required after modifications. Moreover, the IT department will provide assistance to increase the use of a computerized maintenance management system and support integration with new technologies to improve performance in maintenance tasks [9].

CONCLUSION

In conclusion, the approach taken in a reliability program needs to be strategic and integrative as its success does not rely only on a team comprised of engineers and trades personnel, it's also supported by a large chain involving stakeholders inside and outside of the business environment.

Metrics to manage data, tools to develop the analysis, and a process flow similar to figure 1 must be implemented and followed by the reliability team.

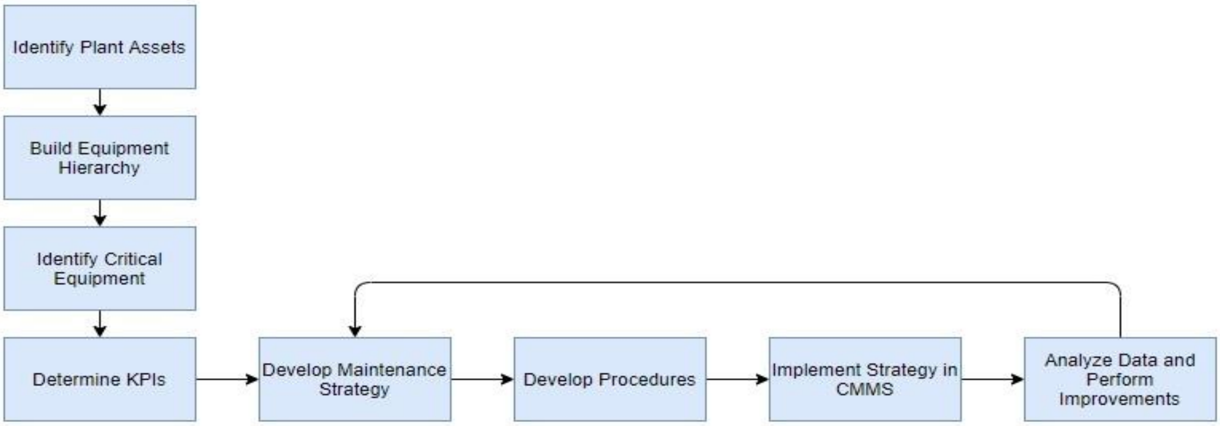

Figure 1: Flow diagram of a reliability process.

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