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Study of the Maintenance of Industrial Assets of the Beverage Industry in Angola

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The reliability of industrial assets aims to minimize unexpected failures that can result in production stoppages, high repair costs, and risks to worker safety. Thus, effective maintenance strategies play a key role in proactive asset lifecycle management, with a view to maximizing reliability and minimizing costs. In this context, the present work describes the importance of reliability and maintenance studies of industrial assets to ensure the operational efficiency, safety and sustainability of industrial facilities from the perspective of analyzing the current state of equipment maintenance practices of a beverage filling line in Luanda-Angola. In this way, the state of the equipment that makes up the industrial process flow was identified, in terms of meeting the requirements established in the EN 16646: 2014 and ISO 55 000 standards, and observing the gaps or possible problems and proposing solutions described through a maintenance master plan. In addition, adjustments to practical procedures were proposed in order to improve the management of industrial processes, based on the standards referenced herein. Therefore, the implementation of this project made it possible to improve the operational performance of the industrial unit.

1. Introduction

The beverage industry sector has experienced considerable growth in Angola, mainly since 1994 and has been associated with the construction of new factories and the rehabilitation of other industrial units, many of them paralyzed, due to the degradation of equipment and limited access to raw materials. This last fact is due to the absence of maintenance and physical asset management strategies, which cover the equipment contained in industrial processing lines, as it involves high costs (Kaminda, 2019).

Therefore, industrial assets, especially equipment, machinery, and facilities, play a crucial role in industrial operations, requiring scheduled maintenance procedures to ensure operational continuity, minimize unplanned downtime, and extend the life of equipment. In the beverage industry, which demands high efficiency and quality, effective maintenance minimizes production losses and ensures product compliance and quality. Thus, reliability and maintenance studies should be characterized as tools that aim to increase the level of knowledge to improve the performance of industrial processes and assets (Annamraju, 2017).

Thus, maintenance aims to ensure the availability of the physical assets involved in industrial production processes, to ensure safety, preservation of the environment and reduction of process costs (Kaminda, 2019).

The implementation of asset management enables the holistic analysis of industrial processes that results in the evaluation and definition of priorities, described in specific management plans. In this way, the use of the EN 16646:2014 standard and the set of ISO 55000 standards, enables the implementation of the asset management structure in companies, based on the principles of asset management and provides a platform for continuous improvement of the company's internal processes. The EN 16646 standard describes the importance of maintenance during the implementation of physical asset management and highlights the relationship of these processes with maintenance. In this way, maintenance results in the preservation of the reliability of industrial assets. All equipment must first be categorized in order to choose the proper maintenance method for each situation (Salaw et al. 2023), with emphasis on Predictive and Preventive Maintenance. Predictive maintenance, based on continuous monitoring and data analysis, allows the early identification of potential failures, enabling scheduled interventions. Preventive maintenance, in turn, involves the regular execution of activities in this area, to minimize failures resulting from natural wear and tear. The effective combination of the referenced approach minimizes unplanned downtime and optimizes associated costs (Marquez, 2020; IAM, 2014; Salaw et al., 2023).

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On the other hand, asset reliability involves the ability of a system or component to perform its function, under specific conditions, for a certain period of time. Evaluating and improving reliability encompasses identifying potential failures, analyzing possible causes, and implementing preventive measures. Thus, the methods commonly used to assess asset reliability include Failure Mode and Effect Analysis (FMEA) and Mean Time Between Failures (MTBF) (Salaw et al., 2023; Marquez, 2020).

Thus, the advancement of technology driven by significant industrial asset maintenance innovations involves the use of Internet of Things (IoT Sensors) that enable real-time monitoring, Big Data analysis, enables more accurate predictions, and the implementation of Artificial Intelligence enables pattern identification and automated decision-making. Therefore, the adoption of such technologies boosts maintenance efficiency and contributes to the reliability of industrial assets (Soori, 2023).

In this context, this work seeks to analyze the current state of maintenance practices of beverage filling line equipment in Luanda (Angola), from the perspective of identifying the state of operationalization of the equipment, based on the EN 16646: 2014 and ISO 55 000 standards, and to identify any gaps or problems and propose a solution based on a maintenance master plan and recommend practices that can improve asset management.

2. Methodology

For the development of this work, data were collected based on interviews with employees of the organization, who were selected according to the requirements of the Self-Assessment Methodology (SAM).

Thus, between 50 and 70 employees from three specific areas of the company were selected, whose data made it possible to determine the arithmetic average of the parameters evaluated in each area. For the reliability of the data, the interview focused on employees with a higher level of knowledge of the principles of operationalization of the asset management system. After the participants confirmed, the survey notebooks were shared. The data collection involved:

- Employees of the Technical Department, responsible for the maintenance of the company's assets, which includes the inspection, assembly and repair of equipment;
- Employees of the Production Department, who ensure production, which involves from the reception of raw materials to the final product;
- Employees of the Quality and Control Department, responsible for the inspection and control of the production process, which involves from the raw material to the final product.

The use of the SAM methodology aims at the self-assessment of the organization's capabilities, based on the principles established in PAS 55:2008 and Standard (ISO) 55 001. The use of this tool results in the performance of the assessment, based on appropriate requirements, with emphasis on the degree of maturity of the organizations, mainly in the field of asset management and in the perspective of evolution of the degree of maturity for certification. In this model, the user can select between the two requirements, the one with the greatest emphasis, before the start of the process. When assessing an organization, according to the PAS 55:2008 specification, the maturity scales and requirements that must be met are similar to those of the assessment contained in the PAM model. However, when assessing a given organization according to the criteria of (ISO) 55 001, the questions raised should indicate the competencies of the organization in relation to the criteria of the standard, but with limited required information.

In this way, the capability assessment according to ISO 55 001 allows us to know the third maturity level out of the four existing levels and the maturity levels established beyond ISO 55 001. Figure 1 addresses the referenced maturity levels and the respective descriptions that encompass the progressive growth of this parameter, from level zero that characterizes innocence, level one to consciousness, level two to progression to the development of maturity and level three characterized as level of competence. Therefore, the two levels established in addition to the standard (ISO) 55 001, levels associated with optimization and excellence, cover the length exceeding the requirements established in the standard referenced in this work.

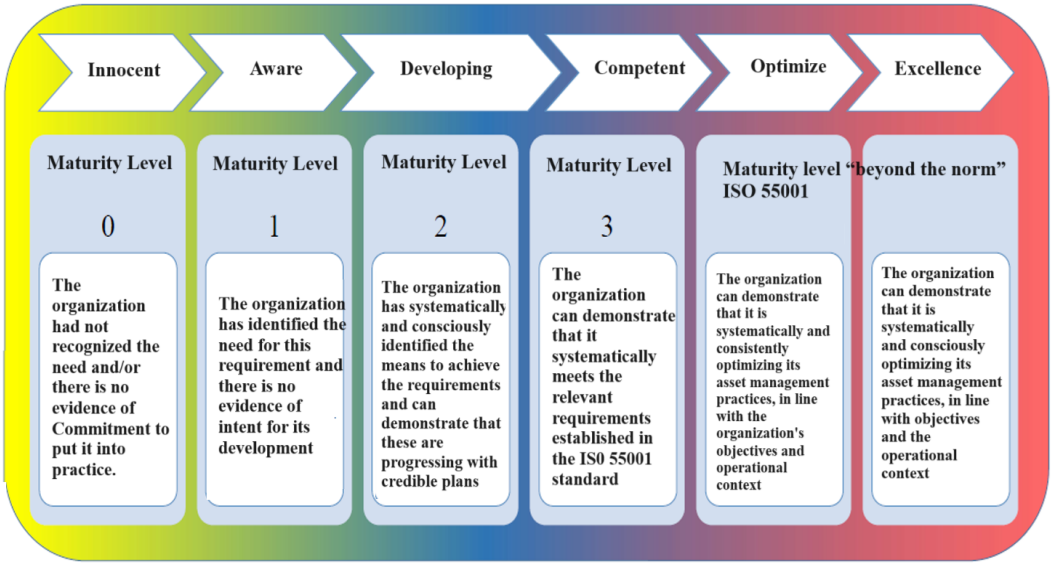

Figure 1: ISO 55001 Standard: Maturity Levels Scale, Source: Adaptation of (IAM, 2014).

According to IAM (2014), the questions were designed to cover the requirements of the (ISO) 55 001 standard, with the establishment of the interdependencies and links, whose cataloguing describes the cross-references to 27 clauses and sub-clauses of the (ISO) 55 001 standard (Table 1).

Table 1: Questions adjusted in light of the standards (Iso) 55001, Source: Adapted from (IAM, 2014)

Section	Requirement	Título of Requirement	Nº of Questions (Requirement)	Nº of Questions
4	4.1	Understand the organization and its context	2	8
	4.2	Understand stakeholder needs and expectations	3	
	4.3	Determine the scope of the asset management system	1	
	4.4	Asset Management System	2	
5	5.1	Leadership and commitment	1	3
	5.2	Politics	1	
	5.3	Organizational rules, responsibilities and authority	1	
6	6.1	Actions to avoid risks and opportunities for the asset management system	1	4
	6.2.1	Objectives of asset management	1	
	6.2.2	Planning to achieve asset management objectives	2	
7	7.1	Resources	2	9
	7.2	Competence	1	
	7.3	Awareness	1	
	7.4	Communication	1	
	7.5	Document general information	1	
	7.6.1	Information requirements	1	
	7.6.2	Create and update information documents	1	
	7.6.3	Control of information documents	1	
8	8.1	Operational control and planning	2	5
	8.2	Change management	2	
	8.3	Subcontracting	1	
9	9.1	Monitoring, measurement, analysis and evaluation	2	5
	9.2	Internal audits	1	
	9.3	Management review	2	
10	10.1	Non-conformities and corrective actions	3	5
	10.2	Preventive actions	1	
	10.3	Continuous improvement	1	
Total			39	39

Based on the requirements of the asset management system, according to the standard (ISO) 55 001 and the maturity indexes, the 5×7 matrix was elaborated, which covers the maturity indices (rows) and the maturity levels (columns), to characterize a given organization (Table 2).

Table 2: Main characteristics of maturity levels

Main Characteristics of each Maturity Level	
Level 1: Undefined or Unpredictable	Basic activities are usually performed, but there is a lack of rigor in planning and execution, confusing, unpredictable and inconsistent performance.
Level 2: Organized or Disciplined	Organized (Disciplined): Products according to specified standards and requirements, execution of the main processes, is planned, managed and progressively moves towards well-structured processes.
Level 3: Well-structured, standardized, and consistent	Well structured (Standardized and consistent): The basic activities are performed according to a well-defined process, following standards adopted by the entire organization.
Level 4: Managed (Predictable and Controlled)	The organization is focused on process management, detailed performance measurements are collected and analyzed; knowledge of process capacity; a good margin of accuracy in performance forecasts;
Level 5 Optimized (Continuously improved)	Performance targets based on business objectives are quantitatively established, systematic measurements to provide feedback on process performance and guide improvement and innovation actions.

Figure 2 describes the block diagram of the beverage production process, which covers the various stages involved, with the involvement of rinsing, filling, corking, washing and labeling, batch marking, packaging and palletizing operations.

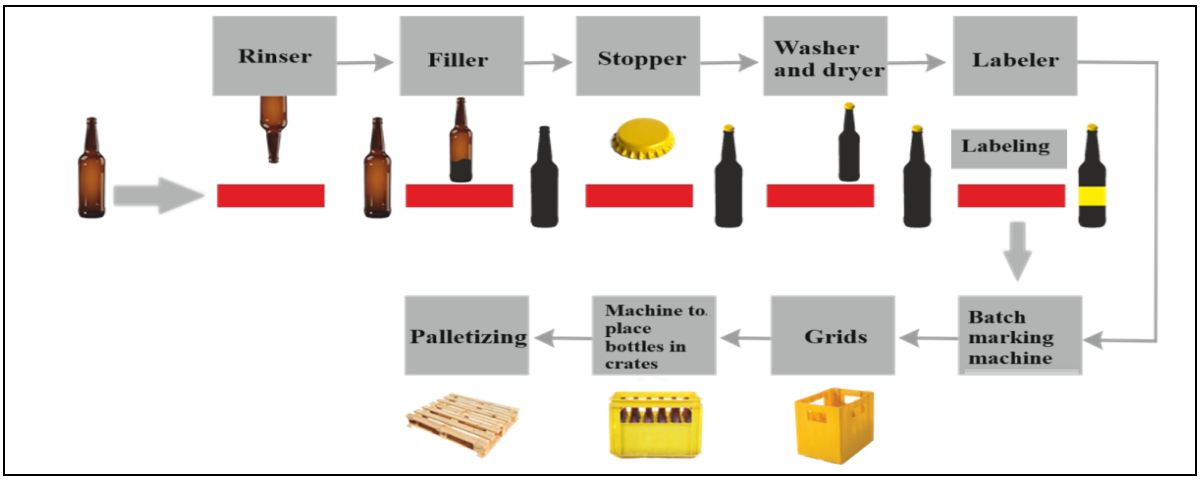

Figure 2: Block diagram of the beer bottling process. Source: Author

3. Results and Discussion

After data collection, the answers were transferred to an EXCEL spreadsheet, which made it possible to perform the graphical analysis and tabulation of the results (Table 2), with the support of statistical evaluation, which made it possible to understand the levels of statistical deviations, through the calculation of means and standard deviation. As mentioned in this study, the first interview involved employees of the Technical Department, responsible for the maintenance of the company's assets, which includes the inspection, assembly and repair of equipment, the results of which are presented in Table 2.

Table 2: Results of the interview of the employees of the Technical Department

Requisitos ISO 55001	Total of Questions	Minimum Credit	Maximum Credit	Total Credits	Average	Percentage (%)
Organizational context	7	0	63	41	5,86	65%
Leadership	3	0	27	23	7,67	85%
Planning	4	0	36	32	8,00	89%
Support	9	0	81	65	7,22	80%
Operationalization	5	0	45	37	7,40	82%
Performance evaluation	5	0	45	33	6,60	73%
Improvement	5	0	45	37	7,40	82%

The analysis of the results contained in Table 1 shows the global maturity indexes of the Technical department, with an average performance of approximately 80%, which corresponds to level four of the company's maturity.

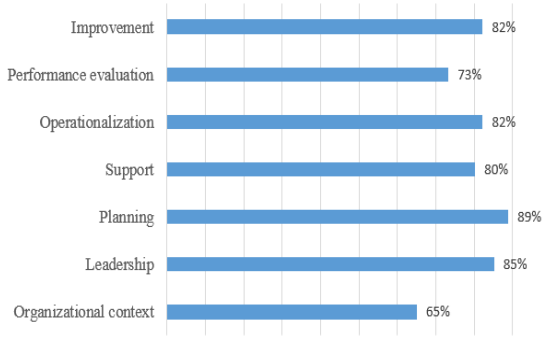

Figure 3: Bar Diagram related to the Maturity State of the employees of the technical Department.

Therefore, according to the description in Table 1, this level shows that the organization is focused on process management, with detailed performance measurements, collected and analyzed.

This level also shows the knowledge of the process capacity of the employees. Thus, it can be said that the department referenced here is at a stage of maturity that guarantees the proper performance of the bottling process.

The analysis of the data in Figures 3 and 4 reinforces the overall maturity index of 80% for the employees of the technical department, guaranteeing them a high level of competence and efficiency, which guarantees the quality of the processes carried out.

Figure 4: Radar diagram related to the Maturity State of the employees of the technical Department.

Therefore, the department referenced here aims to support the organization's operations effectively and contribute to long-term competitiveness and sustainability.

In the context of the Angolan beverage industry, this maturity can be crucial to address specific challenges and continuously improve operations.

Table 3: Results of the interview of the employees of the Production Department

Requirements ISO 55001	Total of questions	Minimum Credit	Maximum Credit	Total Credits	Average	Percentage (%)
Organizational context	7	0	63	43	6,14	68%
Leadership	3	0	27	19	6,33	70%
Planning	4	0	36	28	7,00	78%
Support	9	0	81	59	6,56	73%
Operationalization	5	0	45	37	7,40	82%
Performance evaluation	5	0	45	37	7,40	82%
Improvement	5	0	45	33	6,60	73%

Table 3 describes the maturity indices of the performance evaluation and operationalization of the employees of the Production Department, above 80%. The other parameters evaluated have approximate rates of 70%, therefore with an overall evaluation of 75% and maturity level four, characterized as an organization focused on process management, performance measurements, knowledge of the process capacity and a good margin of accuracy in performance forecasts.

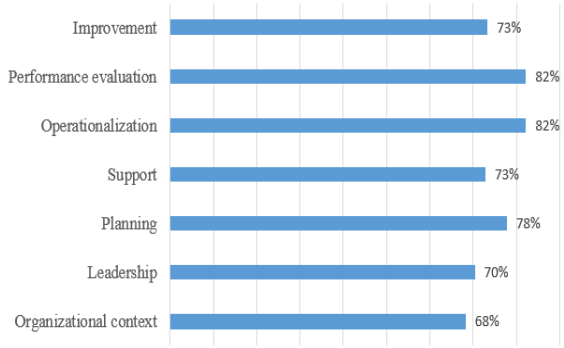

Figure 5: Bar Diagram related to the Maturity State of the employees of the Production Department.

In this context, the overall maturity index of 75% of the Production Department of an Angolan beverage plant indicates an advanced stage of development and with a solid performance. However, there are areas of opportunity for further improvement that can propel the Department to levels of excellence. In the field of technologies, training, process optimization, quality management and sustainability, the manufacturing unit must continue to improve operations to increase competitiveness in the domestic market (Figures 5 e 6).

Figure 6: Radar Diagram related to the Maturity State of the employees of the Production Department.

The analysis of the results of the evaluation of the employees of the Quality and Control Department, responsible for the inspection and control of the production process, which involves from the raw material to the final product, is presented in Table 4.

Table 4: Results of the interview of the employees of the Quality and Control Department

Requirements ISO 55001	Total of questions	Mínimm Credit	Maximum Credit	Total Credits	Average	Percentage (%)
Organizational context	7	0	63	39	5,57	62%
Leadership	3	0	27	13	4,33	48%
Planning	4	0	36	28	7,00	78%
Support	9	0	81	51	5,67	63%
Operationalization	5	0	45	29	5,80	64%
Performance evaluation	5	0	45	35	7,00	78%
Improvement	5	0	45	31	6,20	69%

Therefore, the data present in Table 4 and Figures 7 and 8 show the maturity indexes, "Leadership", at a stage below 50%, the "Organizational Context", "Support", "Improvement" and "Operationalization" at the levels of 60%, and the "Performance Evaluation" and "Planning" index with 78%. In this context, the Global Assessment of the Quality and Control Department presents an overall performance of 66%, characterized as a managed maturity level.

This level of performance is characterized as well-structured, whose basic activities are performed according to a well-defined process, following standards adopted by the entire organization.

Thus, the overall maturity index of 66% for the Quality and Control Department indicates a moderate level of development, with an established functional base, but with areas that require significant improvements. To achieve higher levels of maturity, the beverage plant must focus on standardizing processes, adopting advanced technologies, continuously enhancing, improving risk management, and promoting a culture of continuous improvement.

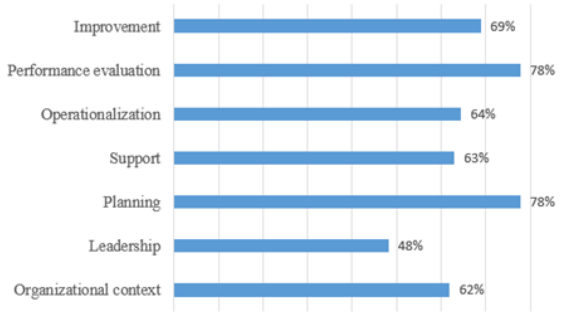

Figure 7: Bar Diagram related to the Maturity Status of the employees of the Quality and Control Department.

Figure 8: Radar Diagram related to the Maturity Status of the employees of the Quality and Control Department.

With such efforts, the manufacturing unit can increase significant improvements in the quality of processes and products, increase operational efficiency and strengthen its competitive position in the market.

4. Conclusion

With the results obtained from this work, it can be concluded that:

i. The company's maturity level, according to the international standards ISO 55001 and EN 166462014, allows the identification of strengths and strengths, as well as defining the measures to be taken to improve the weaknesses and maintain the strengths, that is, through a Gap Analysis it was possible to verify "what is done" and "what is to be done" to comply with the requirements of the standards analyzed here.

ii. The overall maturity indices of 80% for the Technical Department, 75% for the Production Department and 66% for the Quality Control Department indicate that the beverage plant has a strong technical and production base, but demands a focus significantly on improving quality control. By investing in advanced technologies, continuous training, process optimization, and greater integration between departments, the manufacturing unit can increase global performance, improve product quality, and strengthen its competitive position in the market.

iii. Compliance with the requirements of the specification allows the organization to ensure that the basic concepts of asset management are being met, eliminating impediments present in the continuous improvement action of the organization's processes.

iv. Effective reliability and maintenance of industrial assets is essential to ensure the continued operation, safety, and sustainability of industries. Proactive strategies, such as implementing predictive maintenance practices and incorporating emerging technologies, are crucial for maximizing asset reliability and minimizing operating costs. Investing in continuous studies in this area is essential to face the dynamic challenges of the industrial environment and promote operational excellence.

References

Annamraju, Syamsudar. (2023). Reliability Based Maintenance of Industrial Assets. https://www.researchgate.net/publication/316167537_Reliability_Based_Maintenance_of_Industrial_Assets. DOI:10.4018/978-1-5225-0651-5.ch018.

BS EN 16646. (2014). Maintenance. Maintenance within physical asset management (en-standard.eu) (10/10/2013)

Coelho, R. W. (2015). Aplicação do conceito de Gestão de Ativos Físicos numa Estação Elevatória de Águas. (Dissertação de Mestrado). Lisboa: ISEL.

D'Alesio, C. (2012). Maturity assessment of physical asset management practices in manufacturing plants and infrastructures. (Trabalho Final de Mestrado). Milano: Scuola di Ingegneria dei Sistemi - Politecnico di Milano.

Dantas, J Kertsnetzky, V Prochnik. (2002). Economia industrial: fundamentos teóricos e práticas.

Marquez, A., Fernandez, P, Fernandez, Juan, Lopez, A. (2020). Maintenance Management through Intelligent Asset Management Platforms (IAMP). Emerging Factors, Key Impact Areas and Data Models. Energies 13(15):3762. DOI:10.3390/en13153762.

Marques, A. (2011). Norma NP EN ISO 22000: - Sistema de Gestão da Segurança Alimenta (Dissertação de Mestrado). Universidade Tecnica de Lisboa.

Management Platforms (IAMP). (2020). Emerging Factors, Key Impact Areas and Data Models, Energies 13, 3762; doi:10.3390/en13153762.

Salaw, Enesi Yekini et al. (2023). Impact of Maintenance on Machine Reliability: A Review. E3S Web of Conferences. https://doi.org/10.1051/e3sconf/202343001226

IAM – The Institute of Asset Management. (2014). "The self-Assessment Methodology – Guidance", Version 1, disponível em: https://theiam.org/Self-Assessment-Methodology-Guidance-20 Jun14, site consultado em 10/08/2019.

ISO 55000, Asset management — Overview, principles and terminology.

ISO 55001, Asset management — Management systems — Requirements.

ISO 55002, Asset management — Management systems — Guidelines for the application of ISO 55001.

Soori, Mohsen, Arezoo, Behrooz, Dastres, Roza. (2023). Internet of things for smart factories in industry 4.0, a review. Internet of Things and Cyber-Physical Systems. Volume 3, 2023, Pages 192-204. Volume 3. https://doi.org/10.1016/j.iotcps.2023.04.006.

Kaminda, P. M. (2019). Estudo da manutenção de activos industriais e sua aplicação na perspectiva da indústria de bebidas angolana. Dissertação de Mestrado em Engenharia de Sistemas Industrias (MESI), Universidade Agostinho, Faculdade de Engenharia, Luanda, Angola.