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Occupational Safety Model in Maintenance Operations: A Case Study of a Service Company

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Abstract

This article aims to implement a security model in a maintenance company to reduce accidents. The main problem is the high number of accidents recorded in the maintenance area, specifically 28 accidents in a 6-month period. Root causes are determined through a problem tree, and subsequently, tools such as the risk matrix, continuous IPERC, and safety procedures are assigned. The model was implemented in medium and low voltage electrical work, where a higher level of risk was identified through the risk matrix, specifically in the maintenance activities of medium and low voltage electrical panels, as well as in illuminated signs. Regarding the continuous IPERC matrix, it was developed for the identification and description of hazards and their sources in activities classified as more hazardous found in the risk matrix evaluation. Next, safety procedures were developed, with one for each more hazardous electrical job, detailing objectives, scopes, normative references, definitions, responsibilities, preventive measures, main procedure, PPE, and tools. By creating procedures for each hazardous activity, they were unified to form the main safety model. When implementing the model in the study company, results over two weeks showed a reduction in the number of accidents, thus achieving the main objective. The number of weekly accidents in the most hazardous electrical maintenance area decreased from 2 to 0. The uniqueness of this model lies in its specific focus on occupational safety in electrical work, particularly in medium and low voltage.

Keywords
Security, Maintenance, Electricity, Accidents, Risks

1. Introduction

In the 1980s, Facility Management services were primarily focused on cleaning management, activities with a relatively low level of risk. It was in the 1990s that the industry's integration saw an expansion into higher-risk activities, particularly in mechanical and electrical work (HODGGE, et al. 2014).

It transitioned from being a simple outsourced contracting service to what is now considered a "global phenomenon" (Godino, et al. 2022). The attractiveness of companies engaged in FM business lies in the evolution this sector has undergone. This transformation is explained by significant internal changes within companies. They transitioned from being associated with cleaning, security, and maintenance sectors to becoming one of the broadest and most promising businesses across various industries and sectors (Ferri, et al, 2009). The breadth within the industry allows this market to be considered one with companies of all sizes dedicated to various activities or services (Mohamat Nor et al., 2014). Therefore, (Mondor Intelligence, 2023) regards it as a highly competitive market with no dominant companies or organizations.

According to (Zalejska-Jonsson, 2020), the use of Facilities Management involves outsourcing processes to generate cost reduction, and (Lam, 2011) increased efficiency compared to internal execution. This transfer of authority and management in activities brings a benefit to client organizations, as it eliminates the need to focus on processes that are undertaken and executed by FM services (Shohet, et al, 2004). Thus, FM is understood, as per (Kamaruzaman, et al, 2010), as a balance between technical, managerial, and business aspects, which can also be related to strategic and operational decision-making.

Internationally, this growth is on the rise. According to (MarketsAndMarkets, 2023), the global FM market is projected to grow, considering sales of $45.6 trillion in 2022, $49.6 trillion in 2023, and an anticipated growth to $94.8 trillion by 2028 (Figure 1).

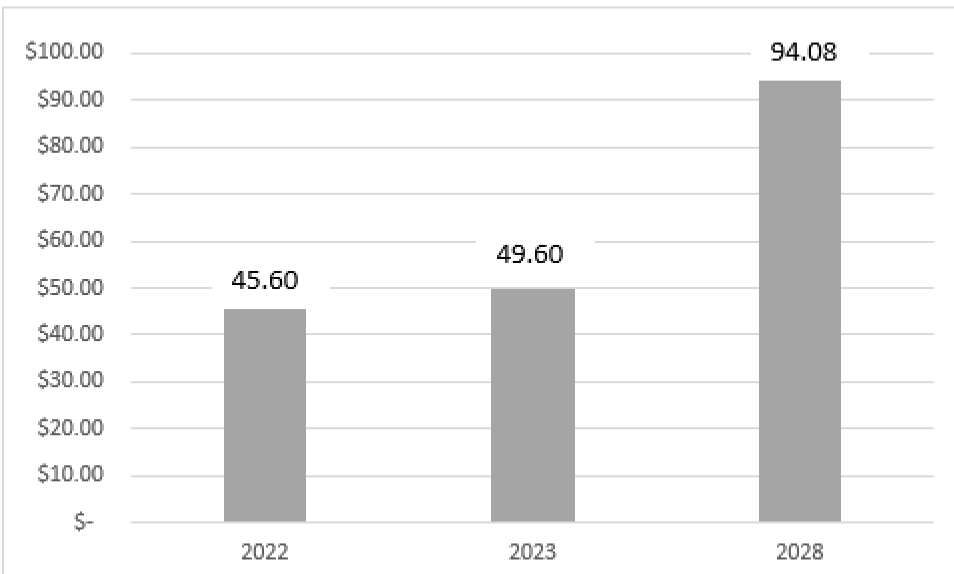

Figure 1. Global Facility Management Market Projected for the year 2028 (trillions of USD)

Note. Adapted from "Facility Management market by Offering (Solutions (IWMS, BIM, Facility Operations & Security Management) and Services, Vertical (BFSI, Retail, Construction & Real Estate, Healthcare & Life Sciences) and Region -Global Forecast to 2028" by Markets and Markets, 2023. (https://www.marketsandmarkets.com/Market-Reports/facilities-management-market-1030.html)

Regarding companies participating in the Peruvian market, Eulen is a clear example of the potential within the industry. In its "Sustainability Report 2022," it details the sales generated by its FM service, reaching 199,249.32 thousand euros in 2022, compared to 172,216.53 thousand euros in 2021, representing a sales increase of 15.70% (EULEN, 2023). Similarly, the company under study for this article had sales of 26.88 million soles in 2021, a 26.67% increase compared to sales in 2020, which were 21.22 million soles.

Like any industry or service, risks are inherent. According to (Ikediashi, et al, 2012), the risks associated with FM contracts include the level of service, inexperienced clientele, and low operational security. The first is linked to the company's experience or years of service, the second to clients' knowledge, and the third to occupational health and safety. Due to these issues, (Zalejska-Jonsson, 2020) suggests that the use of FM should be aligned with clients' needs, the company's size, and a comparison between two possible scenarios: internalizing activities or entrusting them to FM services.

For selecting the necessary tools for this research, the main problem was related to the background of other studies. Vilchez-Catillo, et al, 2022, applied the IPERC matrix to identify risks in company activities causing delays. Similarly, (Carrera, et al, 2023) used a risk level matrix to identify the main factors contributing to accidents and employed the IPER matrix to identify the causes of those risk levels. According to (Neciosup, et al, 2021), implementing an STT management system based on national standards, along with using an IPERC matrix, can reduce up to 55% of significant risks in activities.

The gap for improvement is based on comparing the current state of the study company with industry-wide figures in Peru. While Sodexo Peru has 17 accidents and Eulen Peru has 26.43 accidents, the study company has 28 accidents in total, with only 22 accidents in medium and low-voltage electrical work, accounting for 78.57% of the total accidents in the study company. It's worth noting that the sector's average is 21.72, creating a margin of improvement of 22.67% compared to the study company. Similarly, accident occurrence stems from the possibilities that substandard acts or conditions may cause harm and, consequently, medical leave.

1.1. Objectives

The main objective is the implementation of an occupational safety model in the mentioned company to reduce accidents in the maintenance area. The two primary activities where the methodology will be applied are maintenance work on medium and low-voltage electrical panels and illuminated signs. In conjunction with the main objective, the aim is to identify the most relevant causes and issues in the company related to the number of accidents, and to develop a safety model that enables the reduction of accidents in medium and low-voltage electrical work. This involves considering the application of national and international Occupational Health and Safety standards, utilizing the risk matrix tool to identify the risk level of maintenance work, and employing the IPERC matrix to prevent accidents in the maintenance area.

2. Literature Review

In the industrial sector, one of the primary objectives is to design safe workspaces (Arciniega-Rocha et al., 2023). Therefore, it is crucial to locate and identify risk factors in activities. According to Medina et al. (2016), these risk factors must be assessed and eliminated for effective risk prevention, leading to a reduction in accidents. Florian et al. (2023) emphasize that Occupational Health and Safety (OHS) is also essential for enhancing the physical and mental well-being of workers. Consequently, there is a growing demand for the implementation of both public and internal policies in companies to promote the prevention of occupational accidents (Riaño et al., 2016).

The significance of identifying risk factors and their levels is fundamental for associating them with appropriate solutions. Ikediashi et al. (2012) highlight that poor service quality is the primary criterion for a risk factor to be more critical. Similarly, they identify safety and inexperience as the next most significant criterion.

Vilchez-Castillo et al. (2022) utilized the IPERC Matrix to analyze the reasons behind delays in occupational safety-related activities within a company. With this tool, they successfully reduced work deadlines by 125%, achieving a complete compliance rate of 100% with the established timelines. In other words, they eliminated a 25% delay compared to the originally planned deadlines.

In Carrera et al.'s (2023) study, risk matrix and IPERC were employed to identify and mitigate risk levels associated with the causes of accidents. It was emphasized that static and dynamic loads were the primary factors, related to excessive weight loads and ergonomic postures. Through the application of these tools, they managed to reduce the risk levels of static loads from 10 to 5 and dynamic loads from 10 to 6.

Neciosup et al. (2021) implemented an Occupational Health and Safety Management System (OHSMS) based on ISO 45001:2018. Using the IPERC matrix, they reduced the most significant risks from 55% to 18%. Another notable research by Medina et al. (2016) conducted risk assessment and analysis of accident causes through the IPERC matrix, establishing control measures such as the use of Personal Protective Equipment (PPE) and worker training. In Martinez and Mendoza's (2021) investigation, the IPERC matrix was employed, resulting in a remarkable 78.46% decrease in accident rate. Moreover, they implemented follow-up controls at an impressive 82.57% to ensure the ongoing effectiveness of safety measures.

Lee and Lee (2023) developed object recognition using visual technology for workplace management in a construction company. The process involved capturing images of construction sites, restructuring them in a virtual environment, and implementing procedures based on the studied situations to provide a comprehensive safety management system.

Unver and Ergenc (2021) utilized the Analytic Hierarchy Process (AHP) to develop a framework for accident risk reduction in forestry-related tree-cutting jobs. Their results highlighted various criteria such as psychological, physical, technical, biological, etc. The key contribution of this research is the identification of problems using a tool that, through data collection and numerical processes, yields valuable results.

3. Methods

The present work has an explanatory scope, as its purpose is to establish the causes of the events to be studied, in this case, accidents in the maintenance area. Additionally, an exploratory scope is required to explain this phenomenon. Furthermore, the research employs a pre-experimental methodological design with a quantitative approach.

The company under study belongs to the facilities sector, providing the required information through interviews with internal personnel from the safety department and supplying documentation, including accident records and prior procedures.

To initiate the process of problem identification and assessing the risk level of activities, it is crucial to define the research scope and specify the activities it will focus on. The activity groups developed include Maintenance for Illuminated Signs and Maintenance for Electrical Panels, as these represent the medium and low-voltage electrical work with the highest number of accidents, according to the provided information.

The risk level matrix will be applied to determine the risk level of each activity within the previously mentioned groups. To establish the final value, the frequency and severity values of the activity in the event of a potential accident or incident must be defined. Tables 1 and 2 will define the values and attributes of each level for each variable.

Table 1. Values and Meaning of Probability or Frequency of Occurrence

Probability/Frequency		
1	Very unlikely	1 accident x 5 years
2	Unlikely	1 accident x year
3	Likely	1 accident x 6 months
4	Frequent	1 accident x month
5	Very frequent	1 accident x week

Table 2. Values and Meaning of Severity or Impact

Severity/Impact		
1	Insignificant	Does not cause major injury
2	Significant	Causes a minor injury
3	Important	Generates a serius injury
4	Critical	Can cause irreversible injuries
5	Catastrophic	Fatal

Once defined, we will proceed to the development of a 5 x 5 matrix that will detail the ranges of risk levels, which can be categorized as: Low (1 to 5), Medium (6 to 11), and High (12 to 25) (Table 3). The matrix detailing the is presented in Figure 1 below.

Table 3. Risk Level Matrix

	Severity/Impact				
Probability/Frequency	*1*	*2*	*3*	*4*	*5*
5	5	10	15	20	25
4	4	8	12	16	20
3	3	6	9	12	15
2	2	4	6	8	10
1	1	2	3	4	5

Ultimately, the risk level for each activity is determined based on the risk level matrix, taking into consideration both severity and probability. The assigned risk level will be illustrated in Table 4.

Table 4. Risk Level Table for Types of Activities or Jobs in the Studied Company

Types of Jobs	*Probability/Frequency*	*Severity/Impact*	*Risk*	*Risk Level*
Low-voltage panels	3	2	9	9
Medium-voltage panels	3	4	12	12
Initial preventive maintenance	2	2	4	4
Maintenance exclusively of lighting (luminaires)	3	2	6	6
Maintenance of illuminated signs at ground level	3	3	9	9
Maintenance of illuminated signs with scaffolding above ground level	3	4	12	12
Maintenance of illuminated signs with hanging scaffolding	3	4	12	12

Regarding the IPERC matrix, it is crucial for observing modifications and their impact on the risk level of the activity. This tool facilitates the identification and description of hazards and their sources, followed by an assessment using the risk level matrix to determine whether the activity is classified as low, medium, or high risk. Subsequently, control measures to be implemented are established. Later, a risk analysis with the new proposals is presented, demonstrating a significant reduction in risks. The attached Table 5 displays the continuous IPERC matrix of the company's activities.

Table 5. Continuous IPER Matrix

Types of Jobs	*Description of the hazard*	*IPER Assessment*			*Control measures to be implemented*	*Residual risk assessment*		
		A	*M*	*B*		*A*	*M*	*B*
Low-voltage panels	Corrosive gases, hot work, use of inadequate PPE, work with low voltage electricity.		9		Proper procedures, use of height-specific PPE, PPE for electrical work, PPE for hot work.		9	
Medium-voltage panels	Corrosive gases, hot work, use of inadequate PPE, work with high voltage electricity.	12			Proper procedures, use of height-specific PPE, PPE for electrical work, PPE for hot work.	12		
Initial preventive maintenance	Chemicals and corrosive gases.			4				4
Maintenance exclusively of lighting (luminaires)	Work at heights, work with low voltage electricity.		6		PPE for work at heights, PPE for low voltage electrical work, constant maintenance.			4
Maintenance of illuminated signs at ground level	Work at heights, hot work, electrical work, inappropriate use of PPE.		9		PPE for work at heights, PPE for low voltage electrical work, constant maintenance.		6	
Maintenance of illuminated signs with scaffolding above ground level	Work at heights, hot work, direct electrical work, inappropriate use of PPE.	12			PPE for work at heights, PPE for electrical work, PPE for hot work.		6	
Maintenance of illuminated signs with hanging scaffolding	Work at heights, hot work, direct electrical work, inappropriate use of PPE.	12			PPE for work at heights, PPE for electrical work, PPE for hot work.		6	

To conclude the application of the tools, preventive procedures will be developed for each activity with a medium or high-risk level. The procedures will detail the following sections:

- Objectives: Define the main objective of the procedure.
- Procedure Scope: Specify the intended audience for the document and detail the types of activities to which it applies.

- Normative References: Include all references to laws or technical standards used.
- Definitions: Glossary of necessary terms.
- Responsibilities: Roles in the activity and their detailed responsibilities.
- General Preventive Measures: All preventive and safety measures that personnel must consider in any type of work.
- Procedure: Step-by-step details of the necessary tasks.
- Equipment, Tools, Materials, and Personal Protective Equipment.
- Records: If any internal document is used as a reference.
- Change Control: If changes occur, they must be notified in the changes section.

4. Results and Discussion

The chosen validation method was the implementation of the safety model, which underwent review and approval by the Occupational Safety and Environmental Management (SSOMA) department of the study company. The model was presented (KOM) through a Zoom meeting to showcase its features, with an implementation timeframe of 2 weeks. The decision to proceed with this procedure was made due to the similarities it shares with preventive instructions for other activities within the company, such as coding, the format used, and the availability of related instructions that will be attached in the annexes. The implementation schedule will be presented below in Table 6.

Table 6. Gantt Chart for Security Model Implementation

Activities	*Days*																	
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*
Meeting with company personnel	■																	
Send implementation plan	■																	
Define implementation date		■																
Conduct security model training			■															
Implementation follow-up				■	■	■	■	■	■	■	■	■	■	■	■	■	■	
Receive implementation results report																		■

As mentioned earlier, the KOM (Kick-off Meeting) was initiated with the security personnel of the company under study, and on the same day, the implementation plan (schedule and safety model) was sent to them. Subsequently, the date for implementing the model was defined, followed by providing information about the safety model to the maintenance personnel. As mentioned earlier, the implementation timeframe was 14 days, and after this period, the results of the model implementation were received the next day.

Specifically, regarding the model's application, the real scenario records 28 accidents, of which 22 are linked to the two main activities of the company under study: maintenance of electrical panels and luminaires, the focus of this document. The monthly average of tasks performed for each of these activities is detailed in the Table 7 below.

Table 7. Monthly Average Work for Each Activity

Lighted Signs (Monthly tasks)	Electrical Panels (Monthly tasks)
43 tasks	12 tasks

Subsequently, a weekly average of 1 accident per week was obtained from a six-month record of 22 accidents in maintenance activities involving electricity. This calculation establishes an initial scenario of 2 accidents on average every 2 weeks.

Following the 2-week period during which the SSOMA department of the company implemented the safety model, they reported the absence of accidents, thus validating the functionality of the model. The results were analyzed and assessed in comparison with the pre-established expectations. To be considered in the implementation results, all evaluated activities had to meet the minimum required number and adhere to the established procedures. The results are presented in the following Table 8.

Table 8. Implementation Results

Before	Expected	Result
2 accidents for 2 weeks	0-1 accident for 2 weeks	0 accidents for two weeks

4.1 Discussion

In the literary realm, authors who previously undertook similar projects achieved comparable results in terms of effectiveness. However, it is noteworthy that they extended the implementation over a longer period compared to the execution of the present project. An example is the study by Arciniega et al. (2023), which applied its manual over a significantly more extended timeframe. In contrast, our risk analysis highlighted differences, identifying that electrical tasks and work at heights presented the highest risks.

Vilchez-Castillo et al. (2022) incorporated the IPERC Matrix to identify the causes of delays in activities related to the occupational safety of the company. This tool reduced work deadlines from 125% to complete compliance with the established 100% timelines, eliminating a 25% delay in the scheduled deadlines. In our project, we aim to achieve 100% compliance with deadlines by reducing accidents, eliminating penalties for lost time.

Carrera et al. (2023) used the risk matrix and IPERC to identify and eliminate risk levels in the causes of accidents. They pointed out that static and dynamic loads were the main factors, related to excess weight loads and ergonomic postures. Applying these tools, they reduced the risk levels of static and dynamic loads from 10 to 5 and from 10 to 6, respectively. In our research, we also reduced risk levels in specific activities, such as illuminated signs and electrical panels.

We identified six activities, three of high risk and three of moderate risk. Florian et al. (2023) identified 29 high and moderate-risk occupational hazards, while Medina et al. (2016), Neciosup et al. (2021), and Martínez et al. (2021) recorded 12, 262, and 60 occupational hazards, respectively. These risks, evaluated through risk matrices and IPERC, are significant and can lead to delays or accidents.

Despite the obtained results, the study has limitations. The implementation period is relatively short, requiring long-term monitoring. Worker resistance to change and limitations in accessing some confidential data can affect the accuracy of the results.

The findings of this research have important theoretical and practical implications. Theoretically, they confirm the effectiveness of the implemented safety model in the company. Practically, they indicate that these measures can significantly improve occupational safety and health, reduce costs associated with accidents, and enhance productivity. The implementation of the safety model to reduce accidents in electrical maintenance work has proven its effectiveness. However, a continuous approach with training and a safety culture is required to maintain and improve achievements in the long term.

5. Conclusions and Future Research

Using the risk matrix, it is concluded that the most hazardous activities in the maintenance area are those related to electrical work. This includes maintenance of low-voltage electrical panels, maintenance of medium-voltage electrical panels, maintenance work on illuminated signs at ground level, and/or using fixed or multidirectional scaffolding and hanging scaffolds. It is evident that challenges and risks associated with tasks such as electrical maintenance, or the installation of illuminated signs can be mitigated through specific measures. These actions help reduce the residual risk level to a point lower than the initial risk of the activity. The use of an IPERC matrix provides a clear representation of how these risks are anticipated and controlled, directly influencing the risk level associated with each task. It can be asserted that this anticipation is achieved by assigning preventive actions based on the established safety model.

The critical need to implement a specific safety model for medium and low-voltage energy tasks is important for a facilities management company. It was indicated that prior to the implementation of the safety model, there were a total of 22 accidents caused by energy-related tasks. Subsequently, it was calculated that accidents occurred at a rate of 2 per every 2 weeks. After implementing the specific safety model for medium and low-voltage tasks, the figure reduced to 0. Therefore, it can be conclusively stated that the functionality and the unique contribution of the research have been demonstrated.

The procedures carried out are supported by national and international Occupational Health and Safety standards. From a legal perspective, the application of most of these standards is necessary. However, whether mandatory or not, the recommendations provided by some of these standards remain relevant. Even in cases where they may not be obligatory, they often serve as the foundation for performing a procedure. Therefore, it is concluded that the use of these standards is essential for guiding preventive or corrective procedures during the activities of any company in the industry.

It is necessary that, for future projects, safety models be implemented over an average period of 3 to 6 months to achieve greater accuracy with the results. Likewise, continuous monitoring should be carried out to make the necessary corrections over the course of time.

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Biographies

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Mateo Bresani Doig graduated from the University of Lima with a bachelor’s degree in industrial engineering in 2023. He has developed professionally in the service and maintenance industry (Facility Management). His areas of interest include the development of occupational safety in service industries. He is currently working at National Facilities.