FACULTY OF ENGINEERING

ACADEMIC MASTER'S IN HEALTH, SAFETY AND ENVIRONMENT ENGINEERING

MASTER'S THESIS

RESEARCH TOPIC:

DEVELOPMENT OF AN ENVIRONMENTAL MANAGEMENT SYSTEM FOR THE ELECTRICAL MAINTENANCE SECTOR OF MAPUTO INTERNATIONAL AIRPORT

Research author:

Edson Orlando Mucavele

Maputo, August 24, 2022

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This dissertation is submitted in partial fulfillment of the requirements for obtaining a Master's degree in Health, Safety and Environment of Eduardo Mondlane University.

Research author:
Edson Orlando Mucavele

Supervisor:
Prof. Doutor Clemêncio Nhantumbo, Engº

Maputo, August 24, 2022

RECOMMENDATION OF THE BOARD OF EXAMINERS

The undersigned certify that they have read and recommend to the Faculty of Engineering a thesis entitled **"DEVELOPMENT OF AN ENVIRONMENTAL MANAGEMENT SYSTEM FOR THE ELECTRICAL MAINTENANCE SECTOR OF MAPUTO INTERNATIONAL AIRPORT** "submitted by **EDSON ORLANDO MUCAVELE,** in partial fulfillment of the requirements for the degree of Master Program in **HEALTH, SAFETY AND ENVIRONMENT ENGINEERING.**

_____

Prof. Doutor Clemêncio Nhantumbo, Engº

Supervisor

_____

Doutor Marcelino Januário Rodrigues, Arq.to

Course Coordinator

DECLARATION

I hereby certify that this material, which I now submit in part fulfilment of the requirements for the award of Master's in Health, Safety and Environment Engineering is entirely my own work and has not been taken from the work of others save to the extent suck work has been cited and acknowledged within the text of my work.

Maputo, August 24, 2022

The author

(Edson Orlando Mucavele)

DEDICATION

To my parents for their unconditional love. I dedicate

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To God for the gift of life, for the blessing and opportunity to once again continue with my studies.

The present work had the collaboration of several relevant individuals from different social levels so that it was possible to achieve the objectives of the work.

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Abstract

Civil aviation organizations with special emphasis on airports play a critical role in the air transport value chain. However, in airport management there are sectors whose activities and operations can negatively affect the quality of the local environment. Hence, there is a need to introduce, at the strategic and operational level of these sectors, a structure that protects the environment in balance with the socio-economic interests of the organization. The research aims to develop an Environmental Management System (EMS) that provides a methodology and framework to systematically identify and manage the significant environmental aspects of activities in the Electrical Maintenance sector at Maputo International Airport. For the development of the present work, a qualitative approach was used and a functional analysis of the sector and the associated environmental risks was carried out through a combination of a set of methods such as Structured Analysis and Design Technique (SADT), Environmental Analysis of Failure Modes and Effects (E-FMEA); SWOT analysis; matrix method with significance filters, in addition to interviews with sector employees. For the establishment of the EMS structure, the PDCA management model was adopted and adapted to the requirements of the ISO 14001 Standard. The results of the study showed that the probability of failures occurring in the electric generator set and other electrical equipment and systems in the sector that can cause damage to the environment is low. However, it was found that employees have poor knowledge about the environmental risks to which they are exposed. On the other hand, there is interest shown by the sector in protecting the environment where some efforts were observed to control environmental aspects such as the existence and implementation of environmental procedures and practices for waste management. The structure of the system proposed in the present work shows a framework at the strategic and operational level and seeks to integrate the internal and external elements of the sector. During the interviews, the employees of the sector consider the present proposal of an appropriate system. Thus, the implementation of the EMS based on the proposed structure is considered feasible and adequate.

Keywords: Environmental Management System, Electrical Maintenance, Maputo International Airport, Environmental risk analysis, PDCA model.

Resumo

As organizações de aviação civil com especial destaque para os aeroportos desempenham um papel crítico na cadeia de valor do transporte aéreo. No entanto, na gestão dos aeroportos existem sectores cuja actividades e operações podem afectar negativamente a qualidade do meio ambiente local. Daí que surge necessidade de introduzir ao nível estratégico e operacional destes sectores uma estrutura que protege o meio ambiente em equilíbrio com os interesses socioeconómicos da organização. A presente pesquisa procurou desenvolver um Sistema de Gestão Ambiental (SGA) que fornece uma metodologia e estrutura para identificar de forma sistemática e gerir os aspectos ambientais significativos das actividades do sector de Manutenção Eléctrica do Aeroporto Internacional de Maputo. Para o desenvolvimento do presente trabalho recorreu-se abordagem qualitativa e foi realizada uma análise funcional do sector e os riscos ambientais associados através de combinação de um conjunto de métodos como Análise Estruturada e Técnica de Projecto (SADT), Análise Ambiental de Modos de Falha e Efeitos (E-FMEA); análise SWOT; método matricial com filtros de significância, além da entrevista aos colaboradores do sector. Para o estabelecimento da estrutura do SGA foi adoptado o modelo de gestão PDCA e com adaptação aos requisitos da Norma ISO 14001. Os resultados do estudo mostraram que a probabilidade de ocorrência de falhas no grupo de geradores eléctricos e outros equipamentos e sistemas eléctricos do sector que podem causar danos ao meio ambiente é baixa. Entretanto, constatou-se que os colaboradores possuem fraco conhecimento sobre os riscos ambientais a que estão expostos. Por outro lado, existe interesse demostrado pelo sector em proteger o meio ambiente onde observou-se alguns esforços para controlar os aspectos ambientais como a existência e implementação de procedimentos e práticas ambientais para gestão de resíduos. A estrutura do sistema proposta no presente trabalho mostra um enquadramento ao nível estratégico e operacional e busca integrar os elementos internos e externos do sector. Durante as entrevistas os colaboradores do sector consideram a presente proposta de sistema apropriado. Assim, admite-se viável e adequada a implementação do EMS com base na estrutura proposta.

Palavras-chave: Sistema de Gestão Ambiental, Manutenção Eléctrica, Aeroporto Internacional de Maputo, Análise de riscos ambientais, modelo PDCA.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

LIST OF ANNEXS

LIST OF ABBREVIATIONS AND ACRONYMS

ACI	Airports Council *International*
LCA	Life Cycle Assessment
ADM, E. P	Mozambican Airports, Public Company
EIA	Environmental Impact Assessment
MIA	Maputo International Airport
AR	Risk Assessment
ARA	Environmental Risk Assessment
EDM	Electricity of Mozambique
E-FMEA	Environmental Failure Mode and Effects Analysis
IATA	International Air Transport *Association*
ICAO	International Civil Aviation Organization
ISO	*International* Organization for Standardization
WHO	World Health Organization
PDCA	Plan, Do, Check and Act
PGR	Risk Management Program
SADT	Structured Analysis and Design Technique
EMS	Environmental Management System
SME	Electrical Maintenance Sector
RPN	Risk Priority Number

1 INTRODUCTION

1.1 Background of the research

Currently, organizations are more aware that their activities and behaviors influence and change environmental conditions. These organizations also understand that they need to adopt new eco-friendly habits and attitudes. These organizations include airports whose activities interact with the environment and may adversely affect it. The main environmental issues associated with the operation of airports are greenhouse gas emissions, noise pollution, land use and hazardous waste generation. Thus, airports are called upon to find a solution to mitigate their environmental impacts.

According to the work on "Environmental Management System (EMS) Practices in the Aviation Sector" developed by the ICAO (International Civil Aviation Organization), an EMS provides a methodology and framework to systematically identify and cost-effectively manage aspects significant environmental impact of aviation organizations operations and has proven to be effective in a wide range of organizations, including airports [1]. In addition, airports with EMSs in place have reduced the frequency and severity of environmental incidents and improved compliance with regulatory requirements [2].

Airports play a crucial role in the air transport value chain and are extremely energy intensive to conduct their operations. One of the airport sectors that concerns organizations and individuals linked to the environment is the electricity sector, responsible for supplying electrical energy for all electrical equipment and systems at the airport. One of the sources of electricity consumed at airports comes from non-renewable resources.

Greenhouse gases are a by-product of energy generation and use. Consequently, airports are increasingly trying to sustainably manage their energy requirements as part of their environmental policies and strategies.

All airports have a sector responsible for managing the maintenance of electrical equipment and light signaling systems as well as supplying electrical energy to the airport's electrical systems, or has an equivalent sector. According to the references [3]relating to the Aerodrome

[1] *ICAO Doc. 9968: "Report on Environmental Management System (EMS) Practices in the Aviation Sector" page 1-2.).*

[2] *Delaney, Elizabeth and Barbara Thomson, 2013, Environmental Management System Development Process: A Synthesis of Airport Practice. ACRP Synthesis 44, Transportation Research Board. US National Academy of Sciences, Washington DC. (ACRP 2013, p. 24)*

[3] *ICAO Annex 14 - Aerodromes (International Standards & Recommended Practices)*

• ICAO Aerodrome Design Manual Part 4 - Visual Aids

Lighting System, there are documents that guide activities involving the electricity component at aerodromes and airports. According to ICAO (1986) to ensure the regularity and safety of aviation, it is necessary that the aerodrome lighting and radionavigation aids have high integrity and reliability. The probability of failure of well-designed and maintained lighting and radio aids at a critical time is considered to be extremely low. According to the same source, electrical systems for aerodrome visual aids and navigation systems require good quality installations and consideration for resources that are not normally involved in other electrical installations.

Maputo International Airport (MIA) has a sector called Electrical Maintenance (SME) which is responsible for managing the maintenance of electrical equipment and light signaling systems and supplying electricity to the facilities of this airport. This sector was chosen for the development of the present study because its activities have extreme interaction with the local environment, mainly due to the following environmental aspects: emissions of gases expelled by electric generators, noise generation, diesel oil spillage and waste generation as fluorescent lamps, sodium vapor, LED, batteries containing acids and lead, diesel engine oils, among other environmental aspects.

The present research work intends to develop an Environmental Management System suitable and applicable to the specificity of the sector to contribute to the reduction of environmental impacts, improve environmental performance and comply with regulatory requirements.

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1.2 Research problem

Airports are now aware of the importance of being environmentally friendly (Durmaz, 2011). The main forces driving environmental programs at airports can be divided into three categories – community, government and domestic interest. And while they are all very different, none can really be seen without taking into account the context of the others, and different pressures tend to act on different environmental issues (Oh, 2008, *apud.* Durmaz, 2011). Governments can require airports to demonstrate compliance with local pollution limits, impose penalties for non-compliance, and require the implementation of mitigation programs (Oh, 2008, *apud.* Durmaz, 2011).

• *ICAO Aerodrome Design Manual Part 5 - Electrical Systems*
• *ICAO Airport Services Manual Part 9 - Airport Maintenance Practices*
• *ICAO Manual of Surface Movement Guidance and Control Systems*

Airports play a critical role in the air transport value chain. By facilitating the provision of air transport services to passengers and/or air cargo carriers, key stakeholders in the air transport value chain – e.g. airlines, ground handling agents, air traffic control, transport organizations aircraft maintenance and flight catering companies - require reliable, safe and economical electrical power. In other words, each stakeholder in the air transport value chain requires energy to carry out its activities. Airports use extremely energy for their operation. Therefore, electrical equipment and systems in airports require attention at all stages of their life cycle, aiming at maintaining safety, complying with legal requirements and the efficiency of civil aviation. Special attention must be given to electrical systems dedicated to navigation aids, which must meet, among others, some civil aviation safety requirements. However, activities related to the management of maintenance of electrical equipment and systems generate impacts on the local environment, considering also that one of the by-products of energy consumption is the production of $CO_{2\ gases}$ and others with harmful potential on the environment. environment and the local community. With the growing demand for improving civil aviation safety and its environmental responsibility, the sectors responsible for managing the maintenance of electrical equipment and systems and for supplying electrical energy to aerodromes and airports are called upon to intensify their efforts in the continuous improvement of their activities in favor of the environment and safety throughout the value chain.

The activities conducted by the sectors responsible for electricity and management of electrical systems and equipment at airports create elements with the potential to cause damage to the environment. At a global level, airports incorporate sustainability efforts into their actions as a response to society's greater demand to live in healthier and more sustainable environments (Monsalud, Ho, & Rakas, 2014). Thus, the airport industry, like many other industries, is facing the effects of increasing environmental pressure (Graham, 2014). Consequently, airports are working to become more environmentally friendly (Vanker, Enneveer, & Mäsak, 2013). Particular case of the Electrical Maintenance sector at Maputo International Airport, of which there are several activities whose by-products are the generation of hazardous waste and emissions of polluting gases with the potential to cause damage to the environment and the local community. Some actions taken to improve the environmental performance of operations are not effective as several necessary environmental and organizational management elements are not integrated. Another reason for the poor environmental performance of these sectors is related to the lack of an organizational and systematic structure that allows for the maintenance,

updating and continuous monitoring of processes aimed at the continuous improvement of environmental performance. This problem leads us to the following question: ***What is needed to address the potential environmental impacts associated with the Electrical Maintenance sector in a systematic and structured way*** ?

1.3 Justification

The sector seeks more practical and systematic solutions for its activities with the potential to cause damage to the environment. There is little information in the sector about the environmental impacts that can be caused by its activities and little knowledge about its repercussions on the environment and the local community. The present work intends to contribute by trying to respond to the concerns of the sector in particular through the development of an environmental management system, which can later be integrated into the quality management system implemented by the Airport. This system will present an organizational structure and compatible with the sector since the study seeks to functionally analyze the interaction between the elements, components and subsystems of the sector that can generate environmental impacts. The sector's environmental management system will contribute to the process of identifying significant environmental aspects, facilitating the identification of the needs and expectations of interested parties, such as equipment suppliers, electrical systems, among other goods and services, customers, among others. It will also contribute to the following aspects:

- Clear understanding of environmental aspects and impacts
- Proven industry commitment to environmental protection
- Improvement of internal and external management processes
- Clear view of roles and responsibilities
- Improved environmental and other regulatory compliance

1.4 Research objectives

The main objective of this work is to develop an Environmental Management System suitable and applicable to the Electrical Maintenance Sector of Maputo International Airport. In this perspective, the specific objectives are:

- To describe the functioning of the sector's components, elements and subsystems;
- To identify the environmental risks associated with the functioning of the sector;

- To analyze the internal and external factors associated with the implementation of the EMS;
- To identify environmental aspects and assess associated impacts;
- To propose an environmental protection framework in balance with socio-economic needs.

2 LITERATURE REVIEW

2.1 Airport Management

An airport is one or more aircraft runways together with associated buildings or terminals where aircraft passengers or cargo are processed Radhakrishnan (2020) & D oganis (1992). According to Dempsey (2000), airports are a vital component of the global air transport network, where airlines and passengers come together. For historical, legal and commercial reasons, the actual activities performed at an airport for which the airport manager or owner is responsible vary significantly between countries and often between airports operating in the same country. Thus, airport activity may, in some cases, encompass almost all activities carried out at an airport, while in others it may encompass only a relatively small part of the total airport activity (Doganis, 1992). The airport's basic infrastructure and facilities are composed of runways, taxiways, apron (ramp), passenger terminals, air cargo terminals and ground transportation interchange facilities (Ashford *et al.,* 2011 & Seyanont, 2012).)

2.2 Airport Energy Management

A fundamental component in the management of airports, which currently constitutes a major challenge in this civil aviation sector, is the management of electrical energy, which directly or indirectly impacts the environment. According to Radhakrishnan (2020) and Ortega & Manana (2017) airports are energy intensive areas due to huge buildings (both passenger terminals and non-passenger areas) equipped with heating and air conditioning facilities, as well as the high energy demand for electrical and lighting equipment and the electricity needs of the many facilities located in the airport area. (Kazda *et al* , 2015) in addition to providing the electricity needed to support commercial aviation operations – for example, lighting systems and meteorological systems in the field of weather forecasting – electricity is also needed for airport structures, aircraft hangars and other airport facilities. Thus, energy management and optimization, including for heating, cooling, air conditioning and lighting, proves to be highly essential for airports (Graham, 2014).

The management of airport facilities ensures that a wide range of energy and environmental issues are addressed. Administrators should reduce energy use, thus increasing airport efficiency, according to Radhakrishnan (2020). Large volumes are found at commercial airports. Fuel is also considered to be one of the airport's biggest operating expenses as the airport staff ramps up to a higher level of energy usage due to the combined fuel and diesel generator costs.

2.3 Sustainable Airport Management

The sustainable development of the airport is an exercise in balancing the demands of the different aspects of sustainability – that is, economic, social, environmental and ecological (Durmaz, 2011). It falls under the general concept of sustainable transport, which can be defined as "meeting current transport and mobility needs without compromising the ability of future generations to meet those needs". It is a concept that applies broadly to all areas of effective airport management – including finance, operations, human resources, community and investor relations, environment, etc.

According to Amaeshi & Crane (2006) to achieve its objectives, sustainability applied to transport must meet the following basic conditions:

- Renewable resource usage rates not exceeding their generation rates;
- Rates of use of non-renewable resources that do not exceed the rate of development of sustainable renewable substitutes and
- Pollution emission rates that do not exceed the assimilative capacity of the environment.

In environmental sustainability, it is important to address the term of airport sustainability practice. This term is broad encompassing a wide variety of practices applicable to airport management. Such as:(ACRP, 2008)

- Protection of the environment, including conservation of natural resources.
- Social progress that recognizes the needs of all stakeholders
- Maintenance of high and stable levels of economic growth and employment.

The growth of air travel and the consequent need to expand many airports, together with the increase in the press and public awareness of environmental issues, mean that the aviation sector is under greater scrutiny; Day-to-day activities, as well as more ambitious projects, often become high-profile (Durmaz, 2011). However, the industry has responded proactively through individual activities as well as through the development of the Sustainable Aviation Initiative, which is a comprehensive industry-endorsed program to reduce the negative impacts of aviation (AOA, 2006).

As regulators, governments often target airports for environmental effects that are not apparent to the public. Air, water and soil pollution are often at the forefront of concerns and are subject to regulations and laws regarding local air quality and water and soil contamination.

2.4 Environmental management system

The term Environmental Management System is used throughout this research work. Environmental Management System (EMS) is a set of management principles designed to identify, assess, monitor and reduce the negative environmental impacts of an organization's activities [4]. The system benefits an organization by offering a systematic approach to evaluating and controlling ongoing activities, increasing environmental awareness and complying with relevant regulatory documents. According to the same document, an EMS provides many different and useful tools to detect, understand and manage the elements involved in your activities, products and services that have the potential to impact the environment.

Another definition is found in the ISO 14001:2015 Standard which states that an Environmental Management System is part of the overall management system that includes the organizational structure, activity planning, responsibilities, practices, procedures, processes and resources for develop, manage to implement, review and maintain the environmental policy. The United States Environmental Protection Agency (EPA) defines EMS as a set of processes and practices that allow an organization to reduce its environmental impacts and increase its operational efficiency [5]. Just as the Standards Council of Canada explains that an EMS must be able to verify an organization's impacts on the environment and help it set environmental objectives and targets and assess how well they are being achieved [6].

According to Sheldon & Yoxon (2002) the interaction between the organization and its environment becomes the focus of environmental work beyond the fluid interface between them.

According to Sammalisto (2007) standardized EMSs are designed not only to increase the efficiency of the operation or focus on customer requirements, but also to facilitate communication between the organization and the stakeholders directly or indirectly involved in the organization's activities.

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[4] *ICAO - An Environmental Management System for Airports: ECO AIRPORT TOOLKIT see at .https://www.icao.int/environmentalprotection/Documents/SGA_at_Airports.pdf*

[5] *United States Environmental Protection Agency (EPA) - See www.epa.gov*

[6] *The Standards Council of Canada (SCC) website: https://www.scc.ca/en/accreditation/management-systems/environmental*

2.4.1 PDCA Management Model for the development of an Environmental Management System

According to Alves (2015) the PDCA cycle is a management tool for the purposes of continuous improvement and control of processes and products. Also called the Shewhart cycle or Deming cycle, in the 1930s Walter Shewhart introduced the cycle involved in quality management, and in the 1950s William Edwards Deming and the PDCA cycle gained worldwide recognition through their lectures in Japan.

The Deming cycle is based on a cycle, with planned and recurring activities, to improve results and/or achieve established goals, and therefore does not have a predetermined end. The principle is to make the processes involved in the implementation of management clearer and more flexible, identifying the causes of problems and the solutions for them. The letters that form the name of the PDCA model or method, mean in the source language: PLAN, DO, CHECK, ACT, that is, PLANNER, EXECUTE, VERIFY and ACT (See Figure 2-1).

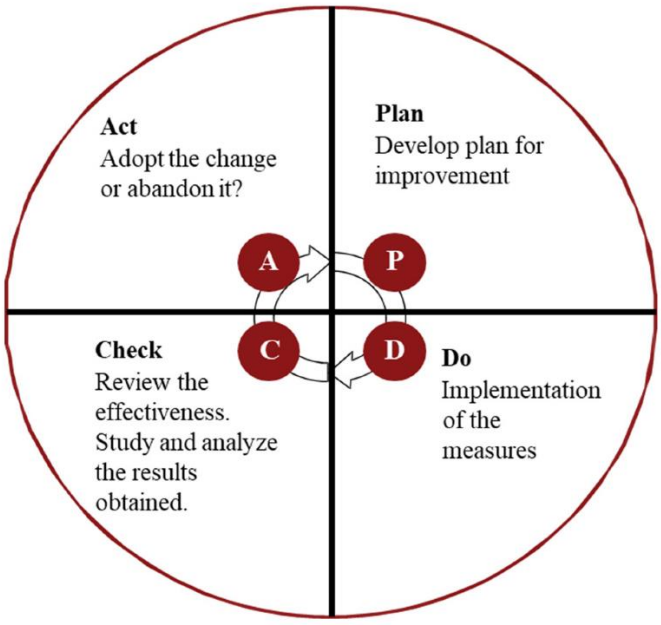

Figure 2-1. PDCA Cycle Model

(Source: Nguyen et al., 2020)

The first stage of the Deming cycle - **"Plan" (P)** is associated with the recognition of the possibility of changes, namely, its improvement and its programming. It establishes the improvement objectives and designs an action plan that will make this objective viable. It is necessary to identify the problem, analyze the causes that affect it, generate solutions and

develop an implementation plan. During this step, each action can be supported by tools and methods such as Ishikawa diagram, Pareto-Lorenz diagram, process mapping or brainstorming according to Jagusiak-Kocik (2017). While Alves (2015) considers the cycle begins with the definition of a plan, based on company policies or guidelines. At this stage, a process or problem to be solved is chosen, which can be an activity, an assembly line, a method, etc. This phase, according to Campos (2004) (apud Alves, 2015), is divided into five stages:

1. Problem identification: it is performed whenever the company finds an undesirable result (effect) resulting from a process (set of causes).
2. Goal setting: The problem will always be the unachieved goal, the difference between the actual outcome and a desired value called a goal. Every goal to be set must always consist of three parts – management goal, deadline and value.
3. Phenomenal Analysis: Detailed analysis of the discovered problem and its characteristics, through collected facts and data.
4. Analysis of the process (causes): look for the most important causes that cause the problem, through the analysis of the important characteristics.
5. Action plan: it is a product of the entire process that refers to the PLAN stage, which contains in detail all the actions that need to be taken to achieve the originally proposed objective.

In the next step - **"Do" (D)**, the same author considers it to be the stage of implementation of the plan, which consists of training those involved in the method to be used, in the execution itself and in the collection of data for further analysis. This stage, according to Campos (2004) (apud Alves, 2015), is divided into two:

1. Training: when the plan is disclosed to all involved before execution;
2. Action execution: when the plan is executed. During this execution, periodic checks must be carried out to maintain control and eliminate possible doubts that may arise during the execution.

Jagusiak -Kocik (2017) considers this step that the plan developed to make changes to the process is implemented in a company (to increase its productivity or quality and eliminate the causes of problems). It occurs with the support and understanding of management. At this stage, tools such as action scheme, benchmarking, flow diagram or checklist can be used.

All good or bad actions and results must be recorded to enter the next phase of the PDCA cycle (Alves, 2015).

The third step **"Check" (C)** is equivalent to verifying, testing, if the solutions presented to a company have brought adequate results. Measurements are taken and compared with the values shown in the plan. Control sheets, control charts, process capability indices can be used to help (Jagusiak-Kocik, 2017). This can be combined with implementing the plan, verifying that the work is being done correctly, or with statistical analysis of the data and verification of control items. Errors or failures can be identified in this step (Alves, 2015).

The last step of the PDCA **"Act" cycle (A)** is linked to the application of the implemented solutions. When these solutions are proven, they are considered the norm and lead to the standardization and monitoring of activities (Jagusiak-Kocik, 2017).

The PDCA cycle is contained in a circle and never ends. The knowledge acquired in the last step becomes the basis for the next cycle; improvement is not seen as the end and does not bring satisfaction with the current situation, and therefore, continuous improvement is sought.

2.4.2 Benefits of Environmental Management Systems

According to ICAO, an EMS provides an organized and systematic means of managing environmental processes at an airport, which can result in multiple co-benefits. In other words, an airport that has a well-designed EMS improves the management of operations with the potential to cause an environmental impact. It also improves monitoring and reporting of compliance with legal requirements. Furthermore, the ICAO considers that the EMS process can simplify complex environmental issues, providing a structured approach that makes environmental management more efficient, reduces costs and allows continuous improvements in environmental performance, improves the airport's internal management processes and increases the understanding of employees on environmental issues and responsibilities.

According to Delaney (2013), airports that have established and implemented the EMS have improved compliance with legal requirements and have also shown the severity and reduced frequency of environmental incidents.

The literature shows that there are other benefits of implementing an EMS such as ease of communication and demonstrating airport due diligence in managing environmental issues. Also, according to ICAO, another major benefit of an EMS is helping an airport to identify if there are gaps in its environmental management program and assessment practices.

2.5 Environmental Risk Analysis

As risk exists in all areas of human activity, both private and professional, risk assessment is an attempt to analyze the precipitating causes of risk in order to more efficiently reduce its probability and effects (Sluser *et al* ., 2007). In this vein, in the literature there are numerous methodological guidelines in the field of environmental science to provide guidance for a risk assessment program. Risk assessments and their detailed key principles can also be used to assist in the development of the decision-making process. The common notion of risk is associated with actions or decisions that can have undesired results. This implies that risk-based approaches focus on negative impacts and their prevention (Hokstad & Steiro., 2006). Risk assessment emphasizes the potential negative environmental impacts of an organization's activities and allows the identification of indicators that directly reflect its efforts, efficiency and effectiveness in reducing or even preventing them. Risk assessment is one of the steps in the general risk management procedure. According to works such as de (Lalley, 1982; Kolluru et al., 1996; Aven and Kristensen, 2005 *apud* Sluser *et al* ., 2007) Risk management is a technique used to identify, characterize, quantify, evaluate and reduce losses from actions or decisions that may have undesired results. **The first step** of the generic procedure involves risk identification, which is the systematic identification of all potential actions or decisions with unintended consequences that may result from the operation of an organization. The **next step** involves risk assessment, while other steps address issues such as risk assessment to determine the organization's ability or willingness to tolerate its consequences in view of the associated benefits and the selection and implementation of the most preferable approach to risk reduction. unacceptable risks (Kolluru et al., 1996; Karrer, 1998 *apud* Sluser *et al* ., 2007).

2.5.1 Tools for environmental risk assessment

According to Sluser *et al* ., (2007) to assess the quality of environmental components (air, water, soil and human health), environmental management applies tools such as risk assessment (AR), environmental impact assessment (EIA), life cycle assessment (LCA). EIA tends to focus on identifying impacts associated with planned activities or projects (Demidova, 2002 & Robu, 2005), while environmental risk assessment (ARA) involves a rigorous analysis of these impacts: calculating the probability and magnitude of effects (Robu and Macoveanu, 2005 *apud* Sluser *et al.*, 2007).

However, Carra *et al* , (2012) states that regardless of the elaboration of a Risk Assessment, airports must be operated and maintained within standards considered tolerable for environmental risks, which is why a Risk Management Program (RMP) must be implemented.

The PGR should aim to prevent, mitigate and control the possible and probable risks of accidents that could compromise the health and safety of the population, as well as the environment as a whole.

2.5.2 Risk Assessment Procedures

According to Sluser et al., (2007) environmental risk is the result of interactions between human activities and the environment. Ecological risk management, which refers to the issue of risks generated by past, present and future human activities on flora, fauna and ecosystems, constitutes only a part of environmental risk management. Environmental risk management falls into two categories according to Barrow (1997) apud Sluser et al., (2007):

Environmental risk: this type of risk admits the fact that an organization's activities can generate certain environmental changes. Environmental risk refers to:

- Flora and fauna
- Human health and economic wealth;
- Human social and cultural wealth;
- Water, air and soil resources;
- Energy and climate.

Risk for the organization, from the point of view of environmental issues: this category includes the risk of non-compliance with current or future legislation and criteria. This category also includes claims in the organization's business recorded as a result of inadequate management, deterioration of the company's credit, costs of lawsuits and difficulties in guaranteeing or at least maintaining the possibility of continuing operations and development activities. Problems related to safety and health at work, as well as risk management in an emergency situation, can be significant from an environmental risk point of view.

Environmental risk management provides a formal set of processes that forms the basis for environmental decision-making and supports the decision-making factor in the steps to minimize the level of uncertainty.

2.5.3 Qualitative risk assessment

i. Preliminary Hazard Analysis (APP).

APP focuses on regions where hazardous materials are concentrated, as well as at main units, monitoring locations where uncontrolled leakage of hazardous substances or energy losses is possible.

The main points considered are:

- substances used in the process and potential hazard;
- system units;
- interfaces between system components;
- environment;
- system operations;
- Safety equipment.

ii. "What if" method

This method is based on the iteration of a series of questions that lead to the identification of unexpected events with possible unfavorable consequences and is applied in specific fields of activity (Gavrilescu, 2003).

iii. Failure Mode and Effects Analysis

This analysis can be done at both qualitative and quantitative levels and focuses on plant/system components. It is mainly based on the elaboration of a table, which contains:

- position, name and description of the equipment;
- faulty paths;
- consequences;
- assignment of critical coefficients on a previously established conventional scale.

The method algorithm involves the following steps:

- system definition;
- identification of the faulty route;
- analysis of failure causes;
- analysis of failure effects;
- analysis of compensation possibilities;
- assessment of the risk associated with each faulty route;
- proposals for remedial and preventive measures.

The E-FMEA method is a tool used in product and process ecodesign. Ecodesign is a new approach to design that depends on identifying the environmental aspects linked to a product and considering the design process at an early stage of product development. The E-FMEA takes into account the environmental impacts of the product (or process) and enables its improvement. The E-FMEA method allows a systematic summary of potential environmental problems associated with a product or process, before their consequences occur. The purpose of the E-FMEA is to identify and assess potential environmental impacts at all stages of a product's life cycle in a strictly defined manner (Kania et al., 2014) . According to the same authors, the objectives of the E-FMEA in environmental management are:

- preventive risk assessment of environmental impacts and preparation of counterattack operations;
- identification of critical components and potential weak areas,
- early diagnosis and location of possible errors and environmental impacts,
- prevention of an important problem for the environment,
- improvement of systems, products and processes in the environmental aspect.

The notions in the E-FMEA of the FMEA of quality are replaced by the environmental notions: defect – environmental influence, cause of the defect – cause of the impact, sequence of the defect – environmental load, importance of the defects – importance of the impact, probability of appearance of the defect – probability of cause, probability of detection – impact factor Lunarski, 2006 (apud Kania et al., 2014). 'Environmental impact' is not valued and 'environmental burden' means negative consequence of impacts. This is the criterion that estimates the importance of environmental impacts (S).

The potential technical causes make it possible to estimate the probability of occurrence of the impact risk (O). One can estimate the possibility of influence of causes. If the impact is small, the problem and related risk can be reduced quickly. The criteria: assessment of the importance of the environmental impact (S), probability of occurrence of the cause (O) and causes of influence (D) in the range of 1 (small risk) to 10 (high risk) are assigned. Finally, the product of these three RPN values (Risk Priority Number) is obtained. These three factors are estimated by experts according to a scale based on commonly agreed assessment criteria.

Below is the procedure for calculating the RPN Lunarski, 2006 (apud Kania et al., 2014) :

1. Preparation and approval of a schedule;

2. Assessment of environmental load by impact. Elaboration of proposals of points of importance (S) and attribution of adequate values for an analyzed load;
3. Assessment of impact causes. Elaboration of points proposals (O) and attribution of adequate values for an analyzed cause;
4. Assessment of environmental protection actions. Elaboration of proposals for points (D) and attribution of adequate values for an analyzed action;
5. Calculation of RPN as a product of SOD;
6. Determination (by a work team) of acceptable RPN values below which the result obtained is considered satisfactory and completion of the E-FMEA analysis. Although the calculated RPN is greater than the acceptable RPN value, it is necessary to propose additional actions to reduce the environmental burden;
7. Determining acceptable RPN. This is a specific difficulty and is linked to a subjective approach to the problem by the work team, taking into account external conditions and the current state of the company.

iv. HAZOP method

According to Sluser et al., (2007) the HAZOP was designed as an applied technique for the systematic identification of potential hazards and operational problems in new plants. Through HAZOP, a critical examination of plants or processes is carried out by an experienced team to identify all possible deviations from a given project, along with the undesired effects on safety, operation and the environment that would arise. Possible deviations are found through rigorous questionnaires, containing keywords, applied to the analyzed project.

The success or failure of the study depends on: the accuracy of the design or other data used for the study; technical skills or staff experience; the team's ability to use the method as a support for predicting the possible deviation, cause and consequences. HAZOP will be beneficial during the design or assembly of new plants/processes or during major modifications to the existing one; when environmental/quality risks or cost issues associated with the operation arise; after a major incident involving burning, explosions, leakage of toxic substances; when it should be explained why an industry code or practice cannot be followed (AICE, 1992; Gavrilescu, 2003).

The objectives of the HAZOP (hazard operability) methods are (Crawley, 2000): • Identification of risk locations, • Determination of the particularities of the project that lead to the identification of the probabilities of the occurrence of some unwanted events, •

Establishment of the necessary information for the project in the perspective of ensuring plant reliability, • Initiation and development of quantitative studies related to hazards and risks.

2.5.4 Quantitative risk assessment

Some methods such as HAZOP are able to identify the hazard, but do not provide quantitative information about the values referring to the probabilities of occurrence of events that lead to undesired consequences. Many events are required to come together to result in the occurrence of an incident such as damage to process units and equipment or control systems, improper operation, etc. Thus, chained event sequences that would result in the appearance of dangerous incidents in the form of a logical tree can be defined, such as Event Tree Analysis (AAE) and Fault Tree Analysis (AAF), respectively.

i. Event Tree Analysis

ETA is an inductive logic model that identifies the possible outcomes of a given initiating event. An initiating event will usually result in an accident or incident. ETA considers the responses of operators and security systems to an initiating event. This technique is the most suitable for analyzing complex processes that involve few safety systems or emergency procedures. The first step in designing an event tree is defining an initiating event that can lead to system damage: equipment or utilities failure, human error, natural disasters. The next step is the identification of intermediate actions to remove or reduce the effects of initiating events.

The event tree contains two branches for each intermediate event, one for a successful exploit and one for a failed system exploit. The upper part represents success, while the lower part represents failure. Within a simplified model, the initiating events become the damage of P2. There are a few response stages in the initiating event that include the warning alarm for low flow, operator response and P1 damage. Assessment using event tree analysis contains the following steps (example): 1. the equipment is damaged and becomes the initiator of events. The probability of this event has been set to 1. 2. The vessel low flow warning alarm may work or fail. If it works, the top branch is covered. If it doesn't work, the lower branch is covered. The warning has a success probability of 0.998. 3. Operator does or does not respond to warning alarm. The probability of response is 0.952. 4. The last answer is for the operator to put the equipment into operation. The probability of this event is 0.995. Event tree analysis is the best analysis for the initiating event that can lead to the final effect of the event. Each branch of the tree constitutes a separate sequence of relationships between the safety functions of the

initial event. Considering the same system and the same hypothesis about the probabilities, identical results can be obtained by both methods.

ii. Fault Tree Analysis

The fault tree is larger than the event tree due to the fact that it is based on a single damage-related effect. Many people are tempted to think logically about security systems using the upcoming event tree. The risk assessment along the tree event can be summarized as follows (Gavrilescu, 2003):

- identification of initiating events that can materialize in accidents;
- identification of security functions to reduce initiating events;
- elaboration of the event tree;
- description of the results of an accident and its probability.

3 RESEARCH METHODOLOGY

3.1 Research Design

According to King, Keohane, & Verba (1994) "a research design is a plan that shows, through a discussion of our model and our data, how we intend to use our evidence to make inferences". According to QuestionPro [7], research design is understood as methods and techniques chosen by a researcher, which, by combining them in a reasonably logical way, have the purpose of efficiently treating the research problem. On the other hand, Gorard (2013) makes a different observation when considering that "Research design is not fundamentally about techniques or procedures. It's more about care and attention to detail, driven by a passion for the assurance of our conclusions obtained through research. In its simplest form, research design is about convincing an audience of skeptical people that the important decisions behind research findings are the safest possible. (...) It is the task of social scientists to make these decisions as infallible as possible". Thus, for the present work, care was taken to identify in advance the path that best deals with and seeks reality of the object of study in order to infer and propose solutions to overcome the identified problem.

3.2 Research Type

Considering the objectives of the present work and the identified problem, a qualitative and applied research was carried out. As for the technical procedures, a case study was used, which consists of a more in-depth investigation approach of an individual, a family, a group or an organization Fortin (2009), as this allows to obtain real results from the observations. of the phenomena that occurred from the experience obtained by the researcher at the place of study. The research is empirical, an investigation in which observations are made to better understand the phenomenon to be studied (Hill & Hill, 2002). Bibliographic research was also carried out on various topics such as environmental risk analysis, environmental management systems, good environmental practices, and others relevant to the aviation sector, especially International Airports. This work included desk research of all relevant documentation related to the sector, including other relevant documentation from Maputo International Airport, in order to gather all information related to environmental issues. Interviews with relevant sector officials were used to obtain specific information on routine practices related to their work, environmental aspects, environmental challenges, etc. The research also included field visits,

[7] *view-source: https://www.questionpro.com/blog/pt-br/desenho-de-pesquisa/*

aiming to observe the study area and compare it with the information collected through interviews and document analysis.

3.3 Research Methods

3.3.1 Approach Method

As for the approach, the Hypothetical Deductive method was used, since the observations lead us to formulate ideas or theories that lead us to verify whether or not they agree with the hypotheses raised.

3.3.2 Procedure method and data collection techniques

Considering the type of research, the defined objectives and the hypotheses raised, a qualitative approach was used, namely document analysis, questionnaire and semi-structured interviews based on the interview guide (see Appendix 1 and 2) and direct observation. According to Ketele & Roegiers (1999), interviews, observation and document collection are three of the main methods used to collect data.

3.3.2.1 Structured Analysis and Project Technique

This technique translates into a graphical language for describing systems along with a methodology for producing such descriptions. This model is an understanding, a simple representation of some reality that is suitable for a certain purpose (Li, 2016). This technique was developed by Ross (1977) as a result of ongoing problem-solving work in the 1950s at Softech. It has been used extensively to describe complex systems in communicative design, military planning, and computer-aided manufacturing (Dickover, McGowan, and Ross, 1977 *apud* Ahmed, 2014). SADT has been successfully applied in problem analysis and functional specifications.

SADT notations consist of box-arrow diagrams (blocks), with four arrows on each side defined as: input, output, control and mechanism and an activity in the middle (see figure 3-1). Its settings consist of the following:

- **Activity:** It is any function or process that serves to transform inputs into outputs;
- **Input:** The data/information required by an activity to start the transformation process;
- **Output:** The data/information produced by the activity as a result of this transformation;
- **Control:** Any restriction that affects the behavior of the activity in some way;
- **Mechanism:** People, resources or any means necessary to carry out the activity;

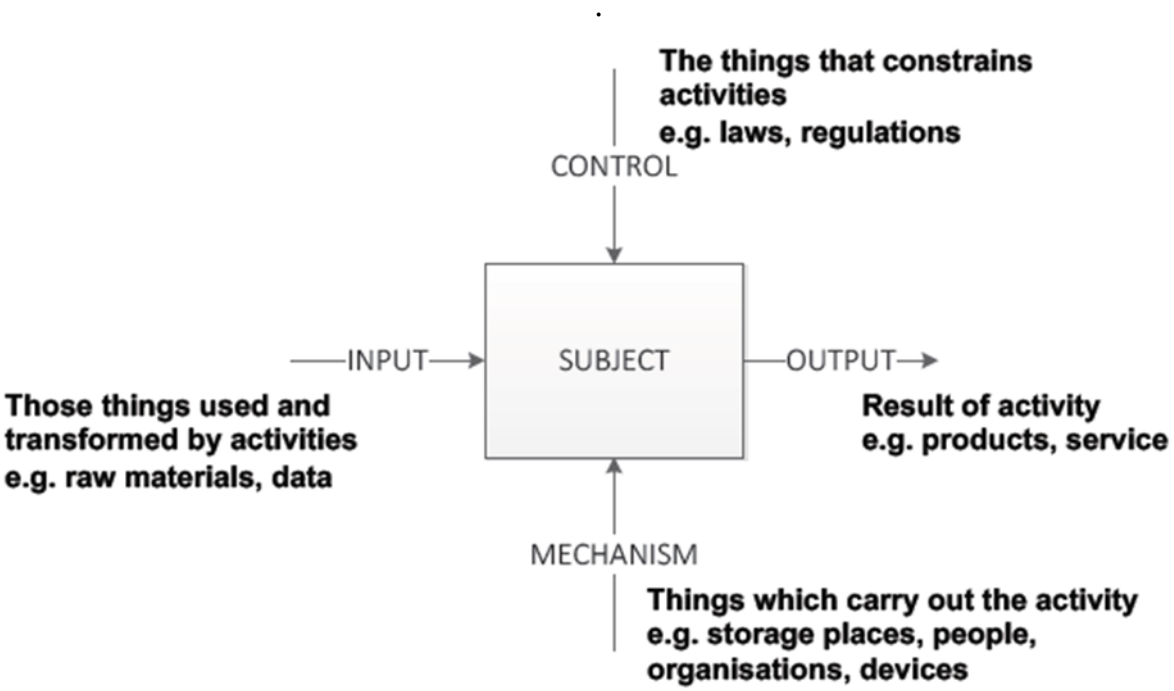

Figure 3-1. General SADT notation

(Source: Li, 2016)

3.3.2.2 Failure Modes and Effects Analysis (E-FMEA)

Failure Modes and Effects Analysis has applications in numerous areas such as product development, manufacturing processes, services and maintenance actions (Pedrosa, 2014 *apud* Sardinha *et al* ., 2009).

The Failure Modes and Environmental Effects Analysis used in the present work for environmental risk assessment is proposed by Roszak *et al* ., (2015). The authors assume that the essence of environmental management in an enterprise must be kept within the scope of environmental management of the organization's processes or activities, including the management of technology and infrastructure, allowing to reduce the level of risk of environmental impact of the activities. Considering the above assumption, methodologies for risk analysis of the environmental impact of the SME were developed. The values of the probability of occurrence indices were defined, as well as the significance and detection for the environmental risk in the analysis of the E-FMEA.

The E-FMEA analysis developed uses the evaluation of the three most important criteria to be met in carrying out activities for better service delivery:

- Compliance with legal requirements in the area of environmental impact;

- Meet the requirements for the impact of service provision on the environment;
- Compliance with the requirements for the purposes of the infrastructure used in the process of using and maintaining machines and equipment.

The result of the E-FMEA analysis is the risk assessment of the impacts of activities/operations on the environment. See Tables 3-1 to 3-4 which contain criteria used in the E-FMEA analysis

Table 3-1. General criteria used in the specific parts of the E-FMEA analysis

occurrence, the	**significance, S**	**detection, D**
Environmental standards and ranges	Environmental standards and ranges	The use of supervisory systems and measures in relation to machinery and equipment
Stability and failure of machines and equipment	Stability and failure of machines and equipment	The use of supervisory systems and measures with regard to the standards and scope of the environmental process

(Roszak, 2014)

Table 3-2. Criteria used for occurrence

Possible risks for the risks of impacting the process on the environment, including exceeding standards and scopes, the law established for the process and failures of machinery and technological equipment used in the process - which affect the environment			
O	Occurrence		Features
1	Unlikely	Does not occur.	Violation of established standards and environmental ranges in a process is excluded. Stable, without the emergency operation of machinery and technological equipment
2	almost unlikely	Providing an incompatible (lack of) product is almost impossible. High process quality and machine capacity.	Almost impossible violation of environmental standards and ranges established for the implemented process. Very high guarantee that no failure of machinery and technological equipment will occur
3	Rarely	There are flaws, but rarely. The high quality of the	There are short-lived violations of established environmental standards and

Possible risks for the risks of impacting the process on the environment, including exceeding standards and scopes, the law established for the process and failures of machinery and technological equipment used in the process - which affect the environment			
O	Occurrence		Features
		process and the capacity of the machine	scopes for implemented processes. High guarantee of the absence of machine and technological equipment failures.
4 5 6	Moderate	Appearance is very likely. The process has good qualitative capability but is unstable.	The implementation of processes with established environmental standards and ranges, but with temporary infractions. A failure of machinery and technological equipment is likely or very likely
7 8	Often	Frequent gaps are expected. The process is characterized by low quality and is unstable.	The process is characterized by frequent violations of environmental standards and bands. Frequent failures of machines and technological equipment with an impact on the environment
9 10	very frequent	Error is almost inevitable. The process is characterized by very low capacity and the quality is unstable	The process is often carried out at a level that violates established standards and environmental limits. Very frequent breakdowns of machinery and technological equipment with an impact on the environment

(Roszak, 2014)

Table 3-3. Criteria used for Severity

The importance of the impact of machinery and equipment failure on the environment, the continuity of the process, exceeded the environmental standards and scope of the process			
s	Severity		Features
1	extremely low	Product defect will not affect the conditions of use. The downside of the process will in no way affect the	Machine and equipment failures in the process have no impact on the environment. There is no violation of environmental standards.

The importance of the impact of machinery and equipment failure on the environment, the continuity of the process, exceeded the environmental standards and scope of the process			
s	Severity		Features
		quality of the product/service.	
2 3	Low	The importance of defects is small and leads only to a slight deterioration of the product. Process downside slightly affects product/service quality	Machine and equipment failures are rare and have little impact on the environment, requiring the adoption of standardized methods to stabilize the process. The shutdown process is short and does not significantly affect the continuity of production. Violations of environmental regulations do not occur often.
4 5 6	moderate	The defect of the product leads to a clear dissatisfaction. Process downside significantly affects product quality	The increasing number of machinery and equipment breakdowns has a clear impact on the environment and requires the adoption of standardized methods to improve stabilization. The shutdown process is short, slightly affecting the continuity of production. Violations of environmental regulations are rare, and their impact on the environment is local (in the area of machinery, equipment).
7 8	High	It is impossible to use the product as intended. The downside of the process results in a product incompatibility	Breakdowns that occur in machinery and equipment have a significant impact on the environment and require the use of more than just stabilization process methods and standards. The interrupted process seriously affects the continuity of production. Exceeding environmental

The importance of the impact of machinery and equipment failure on the environment, the continuity of the process, exceeded the environmental standards and scope of the process			
s	Severity		Features
			standards affects the environment around the production hall – workplace
9 10	Very High - Critical	Product defect jeopardizes user safety or violates the law. The downside of the process can lead to the need for product repair	Machine and equipment breakdowns have a major impact on the environment and people, and require the use of specialized methods to stabilize the process, including the intervention of specialized services unavailable to the company. The interruption process has a strategic level impact on production continuity. Exceeding environmental standards affects the environment with a larger area than just the production shed/worksite.

(Roszak, 2014)

Table 3-4. Criterion used for Detection

Detection of machine and equipment failures that impact the environment, in addition to exceeding environmental standards and ranges in the process			
D	Detection		Features
1 2	Very High	The control measures used and the supervision provided give us almost certainty that the product defect or the process disruption that the defect may cause will be detected.	The surveillance system and measures used provide almost complete assurance and: • Predict the failure of machines and equipment and their protection against the occurrence of environmental risk; • Process stability remains within the limits of accepted standards and environmental ranges.

Detection of machine and equipment failures that impact the environment, in addition to exceeding environmental standards and ranges in the process			
D	Detection		Features
3 4	High	The control and supervision measures used offer a good opportunity to detect product defects or process interference.	The surveillance system and measures used offer a good opportunity to: • Predict the failure of machines and equipment and their protection against the occurrence of environmental risk; • Detect the absence of process stability within accepted standards and environmental ranges.
5 6	Moderate	The control and supervision measures used offer a good opportunity to detect a failure or interference in the process, but have limited capacity to control it to 100%.	The surveillance system and measures used provide an opportunity to predict the failure of machinery and equipment and protect them against the occurrence of environmental risk.
7 8	Low	It is very likely that the control and supervision measures will not detect a failure or interference in the process.	The surveillance system and measures used are not capable of predicting machine and equipment failures and protecting them against the occurrence of environmental risk.
9	Very low	It can be assumed with great certainty that the control measures adopted do not detect defects in the product or interference in the process.	The system and surveillance measures used make it possible to predict the failure of machines and equipment and protect them against the occurrence of environmental risk to a very small degree.
10	Impossible	There are no known means of control and supervision to	There is no surveillance system and measures available to predict the failures of machinery and equipment and their

Detection of machine and equipment failures that impact the environment, in addition to exceeding environmental standards and ranges in the process			
D	Detection		Features
		detect product defect or process interference.	protection against the occurrence of environmental risk

(Roszak, 2014)

Risk Criticality

Finally, there is the classification of the degree of risk presented in Table 3-5, whose objective is to categorize the RPN in order to determine the failure modes that require greater attention and the subsequent implementation of improvement actions in order to reduce the risk. associated with each of the faults. The equation for calculating RPN is shown below:

$$RPN = O * S * D \qquad \text{[Equation 1]}$$

O – occurrence; S- severity; D – Detection

Table 3-5. Classification of the degree of risk considered for the present study

Level	**Risk Degree (RPN)**		**Degree of urgency of measures**
1 -	RPN < 70	**Normal** Level where all three RPN factors (especially severity and probability of occurrence) have values less than 5	It does not require corrective and preventive actions (however, according to the person responsible for the sector, the corrective/preventive action could be presented
2 -	Typically 70 < RPN < 140	**Critical** Level where at least one factor of three RPN factors (especially severity and probability of occurrence) has a value greater than 5, but the RPN is relatively low.	Corrective/preventive action is essential
3 -	RPN > 140	**Critical** Level where at least two of the three RPN factors have high	Requires immediate corrective/preventive action

Level	Risk Degree (RPN)		Degree of urgency of measures
		values or the RPN number is too high	

3.3.2.3 SWOT Matrix

The SWOT Matrix analysis is a tool used to perform scenario analysis (or environmental analysis), being used as a basis for the management and strategic planning of an organization (Daychouw, 2007 *apud).* Silva *et al.*, 2019; Gurel & Tat, 2017) .

According to Chiavenato (2000) *apud* Silva *et al.*, 2019, the acronym SWOT means S-Strengths, W-Weakness, O-Opportunities and T-Threats. It is known as SWOT analysis and it seeks to assess the Strengths and **Weaknesses** in **the** internal environment of the organization and **the Opportunities** and Threats in the external environment. The organization has strong control over the Strengths and Weaknesses that constitute internal aspects under its management. However, the organization does not have full control of the external factors of the environment in which it operates. In other words, according to Chiavenato (2000) the internal analysis of the organization can be controlled and involves all goods, whether human or non-human. In addition to the assets used in the analysis, those that the organization retains, but which for some reason are not being used, are also considered, as well as those assets that the organization does not yet have, but could obtain. Furthermore, the evaluation of the activities developed is fundamental. In the context of external analysis, the same author theorizes that the external environment can only be monitored. To analyze it is to have an overview, that is, to transcend the walls of the organization in which it operates and involve politics, culture, legislation and market changes (see the SWOT Matrix model in table 3-6).

Table 3-6. SWOT Matrix Model

Internal environme	**Strengths**	**Weaknesses**
external environme	**Opportunities**	**Threats**

Source: (Gurel & Tat, 2017)

For the present research work, the SWOT matrix is used to analyze the internal and external context of the sector within the scope of management and strategic planning for the implementation and implementation of the EMS in the sector under study.

3.3.2.4 Environmental Impact Assessment

Assessment of Environmental Impacts was based on the combination of Leopold matrix and interaction matrix methods, plus the parameters required by law to characterize the impacts.

Criteria used to analyze environmental aspects and impacts

a) Nature or Qualification (N)

Attribute used to characterize the impact in terms of effects.

- ***Positive (PO):*** beneficial impact.
- ***Negative (NE):*** adverse impact.

b) Form of Incidence: (E)

This attribute indicates whether the impact involves one or more aspects (natural resources or aspects of the socio-economic environment.

- ***Direct (DI):*** impact generated when an action on a certain component (eg soil, water) of the environment affects only that environment in a certain location and covers the areas of direct influence, previously defined for each aspect and summarized below.
- ***Indirect (IND):*** impact generated when an action in a certain component of the environment promotes changes reaching other compartments of that environment in a larger area, in view of the interdependence between the various factors and covers the areas of indirect influence, previously defined for appearance and continue summarized.

c) Occurrence or Temporal Scale (O)

This attribute relates to the time of manifestation and permanence of the impact.

- ***Short Term Occurrence (ST):*** they occur simultaneously with the action that generates them.

- ***Medium Term Occurrence (MT):*** they occur with a delay in relation to the action that generates them on the scale of months.
- ***Long Term Occurrence (LT)***: they occur with a delay in relation to the action that generates them on the scale of years.

d) Reversibility (R)

Attribute used to identify the ability of the affected environment to return to its previous state if (1) the external request ceases or (2) corrective action is implemented (Sánchez, 2006).

- ***Reversible (RE):*** Effects that can be reversed.
- ***Partially reversible (PRE):*** when the effects can be minimized.
- ***Irreversible (IRE):*** permanent effects.

e) Severity (S)

The severity attribute concerns the degree of alteration of the impacted elements or aspects.

- ***Negligible:*** Negligible impact between workers and third parties within the airport facilities and none in the community;
- ***Smaller:*** Does not cause activities and vessels to stop or cause insignificant delays; It does not cause any significant environmental impact; Does not cause damage or cause minor damage to equipment, materials and installations; It does not cause injuries or damage to health.
- ***Moderate:*** May cause significant repercussion among workers within airport facilities and minor repercussion in the community; it causes a light and reversible impact on the environment, inside the airport; causes minor damage to equipment, materials and facilities; causes minor injuries or minor health disturbances to workers or third parties when inside the facility;
- **Substantial:** Causes serious injury and health damage to workers or third parties within the airport, and mild injury or health damage to community members. Occasional death or disabling injury may occur within the airport; causes severe damage to the indoor environment and light severity damage outside the airport; causes major damage to airport equipment, materials and facilities, and reasonable damage to the community. Requires immediate corrective actions; it can cause major repercussions among workers and third parties within the airport and significant repercussion in the community;

- **Catastrophic:** It can cause death, serious injury, irreversible damage to the health of workers or third parties inside the airport, members of the community. It can cause major damage to equipment, materials and facilities at the airport and in the community. Requires immediate corrective actions; it can cause major and lasting repercussions among workers and third parties within the airport and large repercussions with reasonable duration in the community;

Table 3-7. Criteria for severity of environmental impact

Severity	Criterion	Punctuation
Negligible	Impact of negligible magnitude	1
Smaller	Impact of reduced magnitude	2
moderate	Impact of considerable magnitude	3
Substantial	Impact of great magnitude	4
catastrophic	Large-scale impact	5

f) Probability (P)

To assess the probability that any event or environmental aspect will have any effect on the environment.

- **Very Low "Extremely Unlikely":** Theoretically possible, but unlikely to occur over the lifetime of the facility;
- **Low "Remote":** Unexpected occurrence over the lifetime of the installation;
- **Average "Occasional":** Likely to occur at one time or another over the lifetime of the facility;
- **High "Frequent":** Expected occurrence, once or twice each year;
- **Very High "Continuous":** Expected occurrence once or twice each month;

Table 3-8. Criteria for probability of environmental impact

Probability	Criterion	Punctuation
Very low	extremely unlikely	1
Low	Remote	2
Average	occasional	3
High	Frequent	4
Very High	Continuous	5

g) Importance of Impacts (I)

Importance is determined through the product of probability and severity from the following equation: I = P x S

Table 3-9. Importance of Impacts

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

h) Classification Key for Importance of Impact

Table 3-10. Classification Key for Importance of Impact

Rating for Importance of Impact		
Low	**[1-4]**	
Medium	**[5-12]**	
High	**[15-25]**	

i) Significance Level Classification Key

This attribute is a combination of the previous ones and focuses on ranking the identified impacts.

- ***High:*** when the impact considered negative or positive is classified, in terms of the other four criteria defined, in at least three of the following characteristics: form of indirect incidence, area of indirect influence, permanent, irreversible duration and large magnitude.
- ***Low:*** when the impact considered negative or positive is classified, in terms of the four other defined criteria, in at least three of the following characteristics: form of direct incidence, area of direct influence, temporary duration, reversible in the short and medium term and low magnitude.
- ***Medium:*** in the intermediate situations between the two extremes.

To determine the level of significance of the Airport's environmental aspects within the scope of the EMS, information such as the Importance of Impact Environmental (I), applicable legislation and interested parties.

Table 3-11. Significance Level Classification Key

Classification for Significance of Aspects		
Not Significant (NS)	**[1-9]**	
Little significant (PS)	**[10-19]**	
Significant (S)	**[20-35]**	

4 CASE STUDY

The specific operations at an airport for which the airport administrator or owner is responsible vary significantly between countries and also between airports located in the same region for geographic, legal and commercial reasons (Radhakrishnan, 2020). According to the same author, in some cases, the airport authority can cover practically all operations carried out at an airport. Elsewhere, it can only cover a reasonably limited part of the airport's general activity. For the present work, the sector chosen as a case study is the Electrical Maintenance sector, which is described below, and is managed by Maputo International Airport.

4.1 Overview of the Electrical Maintenance Sector

Electrical Maintenance is the sector responsible for managing the maintenance of electrical equipment and light signaling systems and supplying energy to all infrastructures, including all types of electrical equipment and machines in the airport grounds. The main activities in this sector are Preventive and Corrective Maintenance of Electrical Equipment and Systems at Maputo International Airport.

In case of need, it also provides technical assistance and maintenance of equipment and related systems from ADM, EP, installed at Maputo Airport, Bilene, Inhaca, Ponta de Ouro, Inhambane, Vilankulos and Xai-Xai.

What most concerns the sector in terms of environment are: noise, smoke, fuel vapor, high concentration of dust and exposure to battery acids.

Possible emergency situations: Explosions, Fuel Spills, Fires and snake and/or scorpion/spider bites.

There are two companies contracted in this sector, one provides cleaning services and the other provides Technical Assistance to Generator Sets. The latter generates excessive waste, due to the nature of the services performed.

4.2 Characterization of the Electrical Maintenance Sector

The Electrical Maintenance Sector is characterized by:

- **Its environment:** Main institutions/companies/organs that collaborate with the sector (suppliers, partners, trainers, etc:) Company that provides technical assistance to generator sets - Transportes Pinho; SOCOAL – Electrical and lighting equipment; Partners (EDM, EP/LAM);
- **Its purpose:** supply of energy and light signaling to all technical and commercial areas of MIA and technical assistance to electrical equipment and systems;

- **Its activity:** Preventive and Corrective Maintenance of Electrical Equipment and Systems at Maputo International Airport
- **Its structure:** Hierarchical dependency (See figures 4-1 and 4-2)

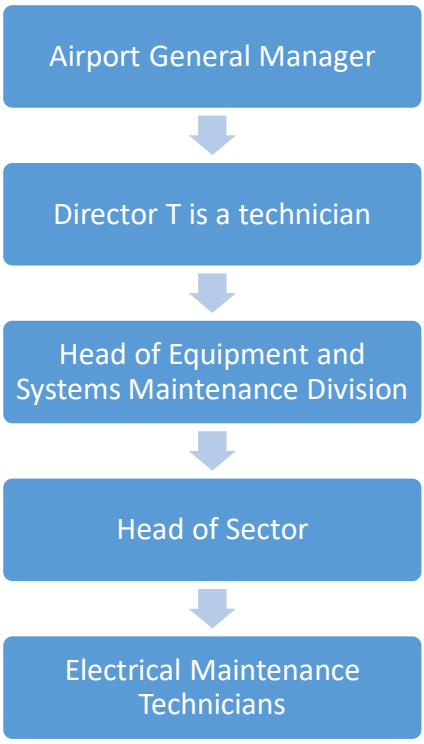

Figure 4-2. Administrative dependency

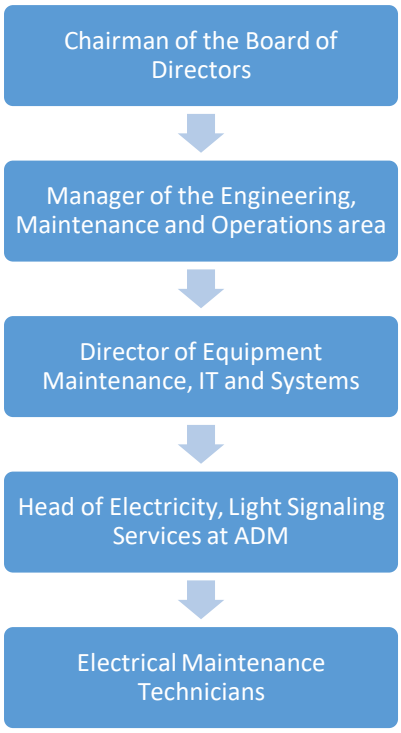

Figure 4-1. Technical dependency

Number of employees: 7 employees with secondary and elementary academic level. No specific training in Environment

Functions and Responsibilities of the Sector: Maintenance and management of electrical systems and equipment at Maputo Airport, in order to ensure the supply of energy and light signaling

Capacity, Size or Degree of Importance: Equipped with minimum capacity to meet requests: Strategic sector in the airport's operation, where vital air navigation equipment cannot lack energy.

Services Provided by the Sector: Preventive and corrective maintenance of electrical systems and equipment (Daily, Monthly, Semi-annual and Annual Inspection).

Level of coverage of sectoral services at the airport: All technical and commercial areas.

Main Challenges or Problems (environmental) in the environmental management component identified by the sector: Not knowing how to deal with the solid and liquid waste produced

Identification of all types of waste generated in the sector or by the service provided: Fluorescent Lamps, Sodium Vapor, LED, Lead Acid Batteries, SAE W 40 Diesel Engine Oils, Gases Emitted by Diesel Generators;

Destination given to waste

- The lamps are collected by the contracted cleaning company and taken to the garbage containers;
- The oils are delivered to the fire department, which uses them for emergency simulation situations;
- The sulfated batteries, which are replaced, are reused by employees for home solar systems.

Description of tools, machines, equipment (active and obsolete) used in or by the sector:

- Miscellaneous electrician's tool, consisting of screwdrivers, star keys, spanner, hammer, french wrench, universal pliers, pressure, hex keys, razor, socket wrenches;
- Equipment consisting of diesel generator sets, UPS, dry and oil transformer stations, constant current regulators.
- Main institutions/companies/organs that collaborate with the sector (suppliers, partners, trainers, etc.) Company that provides technical assistance to generator sets - Transportes Pinho; SOCOAL – Electrical and lighting equipment;

Partners (EDM, EP/LAM);

4.3 Description of activities developed by the Sector

The proper functioning of the systems depends on the preventive maintenance program used and the quality of the inspections carried out. The frequency and details of inspection, cleaning and routine maintenance will vary depending on the type of equipment, its use and position. In this sector, periodic and non-periodic maintenance are carried out. Periodic maintenance is

carried out through daily, weekly, monthly, quarterly, half-yearly, annual and five-yearly inspections.

4.3.1 Routine maintenance management

In this case, the maintenance management process is understood as all the sectorized tasks to ensure the normal course and implementation of all maintenance actions from their conception to practical execution.

These actions are considered small interventions that include revisions, small improvement actions and repair of small failures as shown in the flowchart below:

The description of the maintenance routine management processes can be found in Annex 1.

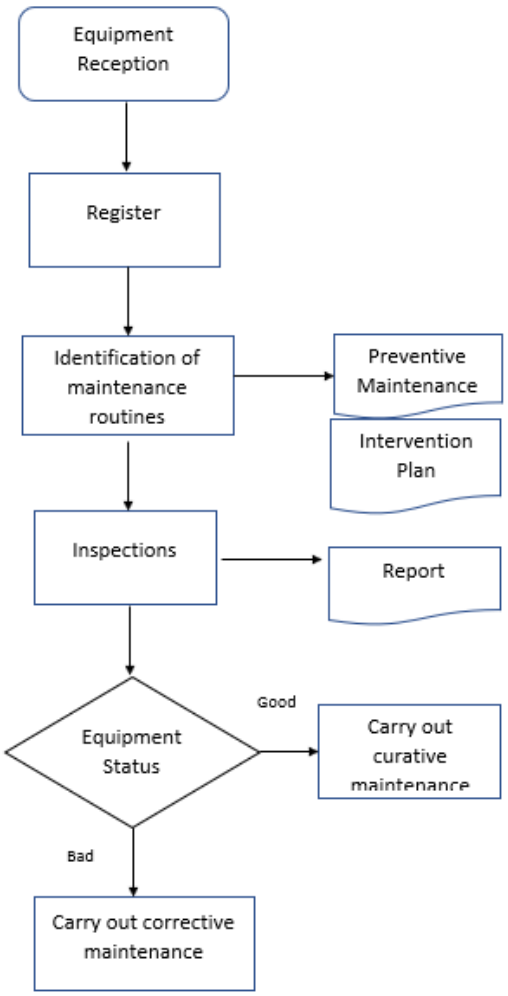

Figure 4-3. Maintenance routine management flowchart

4.3.2 Major maintenance management

At this point, we consider the management of major maintenance as a set of sectoral actions to restore the functionality of equipment in cases where malfunctions occur that, by their nature, are considered serious.

The description of the major maintenance management processes can be found in Annex 1.

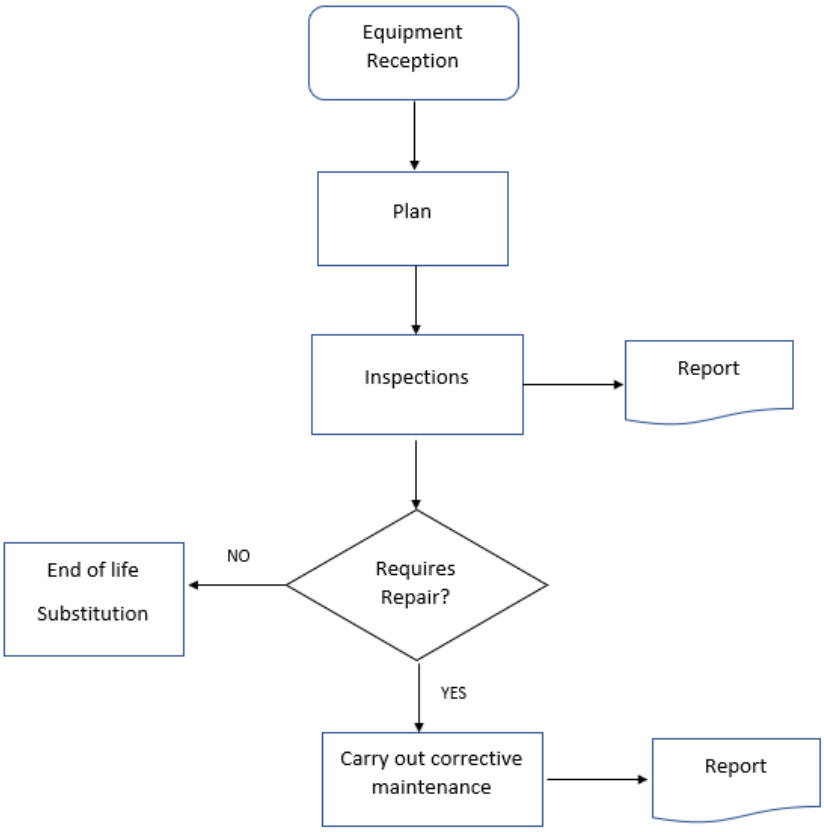

Figure 4-4. Flowchart of the major maintenance management process

4.4 Waste Management Practices adopted in the Electrical Maintenance Sector

With regard to environmental issues, the sector focuses on waste management. Waste management in the sector consists of:

- Avoid mixing toxic or hazardous waste with common waste;
- Keep the batteries in specific places for later collection by the companies contracted for recycling or reuse of the batteries;
- Conserve the oils in specific containers for later transfer to the airport fire department for use in real fire training;
- Deposit gas discharge lamps (fluorescent, mercury vapor, metal halide vapor, mixed lamps) in specific containers and subsequently buried;
- Hire the services of specialized companies to deactivate and transport radioactive lightning rods.

5 RESULTS AND DISCUSSION

This chapter presents in the first part the results obtained from the qualitative research. The second part presents the structure of the Environmental Management System developed that seeks to reflect the reality of the sector and its technical capacity for implementation.

5.1 Analysis of the Electrical Maintenance sector

The main objective of analyzing this sector is to understand the service provided and the activities carried out through the interaction between its different components, elements and the relevant information and associated environmental aspects of the system.

5.1.1 Application of Structured and Technical Analysis of Sector Project

The result of the technical and functional analysis of the Sector obtained through the application of Structured and Technical Analysis of Project - SADT is illustrated in figure 5-1. According to this analysis, the **system** to be studied in this section is the preventive and corrective maintenance service of electrical systems and equipment and electrical energy supply.

The system components: Various electrician's tool made up of screwdrivers, star spanner, spanner, hammer, french wrench, universal and pressure pliers, hex keys, razor, socket wrenches, among others;

Subsystems: Planned Maintenance, Electricity Supply Source and Unplanned Maintenance. The results of the structured analysis of these subsystems can be seen in Appendix 3.

Elementary systems: Equipment consisting of diesel generator sets, UPS, dry and oil-fired transformer stations and constant electric current regulators.

The main system under study at the top of Figure 5-1 obtained from the Structured and Technical Analysis of the Project, using the System Activity Model design, has the following aspects identified:

Inputs: equipment maintenance requirements; detailed information on the breakdown of electrical equipment or systems; automatic signal of lack of electrical current in the electrical system;

Outputs: Preventive and corrective maintenance carried out and the supply of electrical current

Control Inputs: Equipment manufacturer's maintenance instructions, instructions from superiors;

Mechanisms: Accessories and substitutes; Miscellaneous maintenance tools; maintenance log book, etc.;

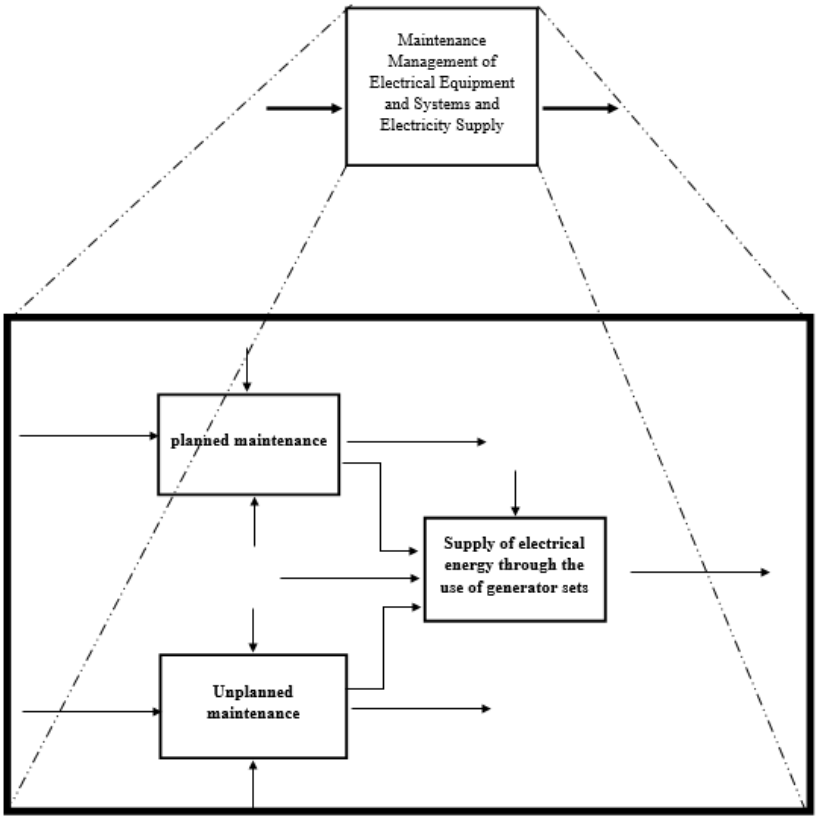

Figure 5-1. SADT for Main Sector Activity

From this main system, 3 subsystems can be observed that work in a mixed way, that is, in series-parallel as shown in the lower box of figure 5-1. These 3 subsystems work in a combined way to result in the final service of the sector, which is to ensure preventive and corrective maintenance of electrical systems and equipment and supply of electrical energy throughout the airport. There is a dependency between the maintenance subsystems and the supply of electrical energy through the use of generator sets. In other words, with a view to guaranteeing that the supply of energy through the generators in situations of absence of electrical current from the public network, it is necessary that both planned and unplanned maintenance be carried out in this subsystem.

Figure A3-1 in Appendix 3 shows SADT analysis results for planned maintenance. This activity is based on the maintenance of maintenance routines identified during the maintenance management process as described in Annex 1. Planned maintenance is also based on ICAO

recommendations. The environmental aspects to consider in this subsystem is the generation of electronic waste, which despite the frequency of generation and disposal being considered low, these wastes deserve special attention due to their dangerous chemical nature that can negatively affect the environment. Another environmental aspect identified is the generation of paper and liquid waste such as acid from batteries. The results of the SADT analysis presented in Figure A 3-2 in Appendix 3, for electricity generation and supply, show that the environmental aspects of this subsystem are fuel and lubricating oil spills, gaseous emissions, noise generation and hazardous waste from the use of batteries. Therefore, environmental actions for improvement or mitigation must be focused on these aspects. The main operating elements of the subsystem are diesel generator sets, UPS, dry and oil transformer stations and constant current regulators. Finally, the unplanned maintenance subsystem shown in figure A3-3 in Appendix 3 clearly shows similar environmental aspects to the planned maintenance subsystem. However, as it is not a planned maintenance, there are conditions to consider in the management of changes to the environmental management system to be implemented, such as replacement of the equipment model, elaboration of new procedures, etc.

5.1.2 Application of the Failure Modes and Effects Analysis Method

The purpose of this section is to present the results of the environmental risk assessment by the Sector Failure Modes and Effects Analysis method: Risks are assessed in different subsystems of the sector, as shown in table 5-1. The criteria adopted and the elements considered for the assessment of environmental risks arising from possible failures in the service provided by the sector are presented in tables 5-1 to 5-5 in the section “Research Methods” in chapter 3. The E-FMEA takes into account the environmental impacts of services and enables their improvement. The E-FMEA method allows for a systematic summary of potential environmental problems associated with services, before their consequences occur. In order to obtain the results presented in the table below , *brainstorming was carried out* with the help of other resources such as manuals for the sector's maintenance management, maintenance plans and failure histories (see Annex 2).

Table 5-1. results of environmental risk assessment by the FMEA method

No	Subsystem	risk description	Causes	Effects	preventive activities	Criteria of importance				risk degree	undesirable event
						O	s	D	CR		
1	planned maintenance	Failure of substitute materials and equipment	Lack of maintenance	Generation of electronic waste	Maintenance	2	4	3	24	Normal	Pollution of soil and water
		Excessive use of paper to record new occurrences	Lack of alternative procedure	Generating more paper waste	None	2	2	2	8	Normal	Ground pollution
		Failure of electrical equipment and systems	Lack of maintenance	Generation of e-waste	Maintenance	4	3	3	36	Normal	Ground pollution
2	Supply of electrical energy through the use of an	Failures during fuel and lubricating oil supply	Technical failures / partial or complete failure to comply with procedures	Fuel and lubricating oil spill	None	3	2	6	36	Normal	Pollution of soil and water
				emission of vapors	None	3	2	4	24	Normal	Pollution of soil and water

No	Subsystem	risk description	Causes	Effects	preventive activities	Criteria of importance				risk degree	undesirable event
						O	s	D	CR		
	electric generator	Failure to start or start the electric generator set	Lack of maintenance	gas emission	Maintenance	2	4	3	24	Normal	Air pollution
				noise generation	Maintenance	1	4	4	16	Normal	Noise pollution, headache, irritability and some hearing damage
		Failures during lubricant removal	Technical failures / partial or complete failure to comply with procedures	Lubricating oil spill	None	2	3	3	18	Normal	Pollution of soil and water
		battery failure	Lack of maintenance	Hazardous liquids such as battery acid	Maintenance	2	4	3	24	Normal	Pollution of soil and water

No	Subsystem	risk description	Causes	Effects	preventive activities	Criteria of importance				risk degree	undesirable event
						O	s	D	CR		
3	Non-periodic maintenance	Failure of substitute materials and equipment	Lack of maintenance	Generation of electronic waste	None	2	4	3	24	Normal	Pollution of soil and water
		Excessive use of paper to record new occurrences	Lack of alternative procedure	Generating more paper waste	None	2	2	2	8	Normal	Ground pollution
		Failure of electrical equipment and systems	Lack of maintenance	Generation of e-waste	Maintenance	6	3	3	54	Normal	Ground pollution

O – Occurrence; S - Severity; D – Detection; CR- Risk Criticality

After completing the E-FMEA analysis of the Electrical Maintenance sector regarding the assessment of potential failures that could negatively affect the environment, it is possible to clearly observe that the situation is normal. However, it is necessary to prepare preventive and corrective actions in case of future changes in materials, equipment, technical procedures, among others.

5.1.3 SWOT matrix application

i. Internal environment

The internal environment is strongly influenced and controlled by the sector, and can be determined, changed by the company's top management.

The identification of internal issues was facilitated by considering issues at a generic level of understanding, associated with values, culture, sector performance, the decision-making process and its strategic orientation. It is also important to consider the services offered, the technologies used and the activities carried out, their capabilities in terms of resources, including people and knowledge.

ii. External Environment

This environment is not fully controlled by the sector. The sector may suffer due to changes in the conditions of the outside environment. In this sense, it is necessary for the sector to develop a strategy to implement the environmental management system and face changes in the external environment. Identifying external issues corresponds to knowing the environment in which the sector is inserted and operates, including its dynamics and trends, to identify how it can influence the effectiveness of the implementation of this system. or by it being affected, in addition to what has already been mentioned in relation to environmental conditions. The external context was considered at local, regional and national levels. Cultural, socio-economic, legal, financial, political, technological and other relevant issues were considered.

The results of the analysis of the applicability of the Environmental Management System in the Electrical Maintenance Sector obtained from the SWOT matrix are presented in table 5-2.

Table 5-2. SWOT matrix of environmental analysis for EMS implementation in the SME

Internal environment	**Strengths** • Existence of consolidated operating procedures; • Existence of Electrical Maintenance Procedures Manual; • Existence of a Quality Management System implemented based on ISO 9001 and an Operational Safety System;	**Weaknesses** • Employees with little knowledge of environmental issues; • Inappropriate environmental procedures and practices; • Weak Environmental Monitoring Plan; • Lack of environmental performance reports; • Budget deficit for implementation of improvement actions; • Competing priorities within the airport can represent a major barrier to implementation;
external environment	**Opportunities** • Greater control of environmental aspects, which implies cost reduction in hiring specialized companies and outsourcing activities; • Greater use of internal resources; • Better relationship with Stakeholders; • Reduction of Stakeholder Complaints	**Threats** • Resistance to the adoption of new environmental procedures;

From the SWOT analysis carried out, it is possible to see that at the internal level there are considerable weaknesses of an environmental nature, but which are easily circumvented. The environmental aspects of the sector are dealt with in the context of the Quality Management System based on ISO 9001 implemented by the airport. Not only that, the airport also has an Environmental Management Plan. However, for the sector under study, it deserves special attention.

5.1.4 Environmental Impact Assessment

5.1.4.1 Identification of Environmental Aspects and Impacts

What most concerns the sector in environmental terms is: smoke, fuel vapor, high concentration of dust and exposure to battery acids.

Typical waste generated in this sector are: Burnt oil, Sulfuric acid, Oil 40 and SAE Diesel, sulphated batteries, fluorescent lamps and LED (Light Emitting Diode, in Portuguese, light emitting diode) and derivatives of generator sets and terminal installations.

Liquid effluents from this sector do not undergo treatment until their final destination. Black water and diesel spills occur most often in diesel tanks. On rainy days, all spilled products are dragged to the airport's drainage system. Currently, there is no procedure being implemented by the sector to control or eliminate these types of spills. The main sources of gaseous emissions are diesel generator sets. There are no measures adopted to control or reduce emissions and these are not monitored. There are emissions of fuel vapors. The sources of noise generation are generator sets, transformers and light aircraft. Due to its location, this sector is exposed to considerable levels of aeronautical noise. The sources that consume water are cleaning services and personal consumption. This water comes from the public network and there is no data in the sector on quantification. The energy consumed is used for lighting, air conditioning, water pumping, moving walks, escalators, elevators and boarding mangroves. Glaciers, stoves, microwaves, among others. The energy consumed is usually from the public network, however, in cases of cuts, the energy supplied by the generators is used.

Activities that generate dust (particulate matter) are: digging trenches for cables and cleaning Transformer Substations. Onshore activities consist of digging trenches for electrical cables and continuous surveillance to identify gaps in black water pipes.

The main equipment used in the sector are: Electric; Lamps, electrical conductors, batteries, circuit breakers, contactors, PLC, reactors, igniters, etc.

Regarding the management of occupational risks, inductions are carried out for people who attend the sector for the first time, but it does not have emergency signs, escape routes, among other signs. They have fire extinguishers but they were all out of date.

An explosion-type emergency situation was recorded in the low voltage electrical panel, which affected two employees, due to a short circuit.

Verified emergency situations: Failure of the 3 main street lighting circuits in series; Control tower blackout due to power failure. Actions taken: On the track, the burned cables were replaced and the work team was reinforced; use of manual override due to automatic failure. This emergency situation jeopardized the operational safety of air navigation.

The summary of Environmental Aspects and Impacts is shown in table 5-3.

Table 5-3. Identification of environmental aspects and impacts

Activities/Operations	Environmental Aspects	Environmental impacts
Use of electric generator, transformer	Fuel consumption (Diesel)	Increasing scarcity of natural resources
	noise generation	Noise pollution
	gaseous emissions	Air pollution
	fuel vapor	Air pollution
	diesel oil spill	Ground pollution
Maintenance of electrical equipment and systems	Generation of solid and liquid waste	Ground pollution
		Water pollution
	dust generation	Air pollution
Opening trenches for cables and cleaning Transformer Substations	dust generation	Air pollution
Use of diesel tanks	diesel spill	Ground pollution
		Air pollution
underground fuel tank	Fuel spillage on the surface of the tank	Ground pollution
		Air pollution
Use of electrical equipment	Energy consumption	Increasing scarcity of natural resources
Cleaning	Water consumption	The growing scarcity of this natural resource
	Solid waste generation	Ground pollution

5.1.4.2 Legal and other relevant requirements

Relevant environmental legal framework applicable to SLMS activities/operations within the scope of the EMS.

Mandatory legal requirements

The EMS will be governed by applicable Mozambican laws, rules, regulations and standards and international conventions or treaties to which Mozambique is a signatory.

The legal requirements that the sector is required to comply with by law under the EMS are presented below:

- **Environment Law –** Law no. 20/97 of 1 October.
- **Regulation for the Management of Solid Urban Waste** approved by Decree No. 94/2014, of 31 December;
- **Hazardous Waste Management Regulation** approved by Decree No. 83/2014, of 31 December
- **Regulation of the Environmental Audit process** approved by Decree no. 25/2011, of 15 June;
- **Environmental Inspection Regulation** approved by Decree no. 11/2006, of 15 June
- **Regulation of Environmental Quality Norms and Effluent Emission** approved by Decree no. 18/2004, of 2 June;
- **Decree No. 67/2010, of 31 December** (amendments to Annex I and inclusion of Annexes 1A and 1B in Decree No. 18/2004, of 2 June)
- **Regulation on the Quality of Water for Human Consumption** approved by Ministerial Diploma No. 180/2004, of 15 September;
- **Land Law –** Law no. 19/97, of 1 October.
- **Water Law -** Law nº 16/91, of 3 August;

Environmental Noise

The Regulation on Environmental Quality and Effluent Emission Standards, approved by Decree no. Land and Environment (MTA) in a specific diploma. However, to date, there are no noise standards or guidelines in Mozambique with regard to monitoring and evaluating noise annoyance.

In the absence of specific legislation, internationally recognized and accepted criteria, such as those of the World Health Organization (WHO), will be adopted.

WHO considers housing, school and hospital areas as sensitive uses/receptors, and the Airport fulfills these conditions.

Other requirements

Requirements that the sector assumes as an integral part of the legal framework under the EMS:

- Contracts entered into with partners, suppliers, subcontractors, among others;
- Agreements with international agencies such as ICAO, IATA, ACI;

Applicable international legislation where the criteria adopted are internationally recognized as WHO. See table 5-4 for the correspondence between the applicable legal framework and the environmental aspects of the sector under study.

Table 5-4. Legal Framework Vs Environmental Aspects of the SME

Environmental Aspects	Applicable environmental legislation
Environmental Noise	International Standards of the World Health Organization
gas emission	Regulation of Environmental Quality and Effluent Emission Standards approved by Decree no. 18/2004, of 2 June;
solid waste	Regulation for the Management of Solid Urban Waste approved by Decree No. 94/2014, of 31 December;
Liquid effluents	Hazardous Waste Management Regulation approved by Decree No. 83/2014, of 31 December

5.1.4.3 Determination of significant environmental impacts

The assessment of Environmental Aspects and Impacts will allow the Airport to prioritize its interventions in order to eliminate or control significant and very significant environmental aspects. This tool allows better management of the adoption and implementation of mitigation measures from a technical and economic point of view. Some measures can bring opportunities for economic and environmental gains in the medium and long term, allowing their self-sustainability. Table 5-5 presents the results of the qualitative assessment of environmental impacts based on the matrix method with filters.

Table 5-5.Assessment and determination of Environmental Aspects and Impacts of the Electrical Maintenance Sector

Worksheet for Identification and Assessment of Environmental Aspects and Impacts														
AEROPORTOS DE MOÇAMBIQUE, E.P. Maputo International Airport			Criteria / Parameters / Attributes						Significance filters					
Doc. At the. 1 1st version	Sector(s): Electrical Maintenance		Probability	Severity	Nature	Incidence	Occurrence	Reversibility	Importance (I = P+S)	Requires compliance with legal requirements	Affects stakeholders Yes = 5; No = 0	summation	Significance level result	Operational Controls
activities	Environmental Aspect	Environmental impact	P	s	N	IN	O	R	I					
Use of Electric Generators and Transformation Points	Fuel consumption (Diesel)	Increasing scarcity of natural resources	2	4	NE	IND	LT	IRE	8	0	0	8	NS	-
	noise generation	Noise pollution	3	4	NE	DI	LT	PRE	12	5	5	22	s	-Use of silencers;
	gaseous emissions	Air pollution	2	4	NE	DI	ST	PRE	8	5	5	23	s	-Program to reduce noise emission levels
	fuel vapor emission	Air pollution	1	3	NE	DI	ST	PRE	3	0	0	3	NS	Program to reduce the levels of gaseous emissions
	diesel oil spill	Ground pollution	3	4	NE	IND	MT	PRE	12	5	0	17	PS	-
Maintenance of Electrical	Generation of solid and liquid waste	Ground pollution	3	5	NE	IND	MT	IRE	15	5	5	20	s	Solid Waste Management Plan,

Worksheet for Identification and Assessment of Environmental Aspects and Impacts														
AEROPORTOS DE MOÇAMBIQUE, E.P. Maputo International Airport			Criteria / Parameters / Attributes						Significance filters					
Doc. At the. 1 1st version	Sector(s): Electrical Maintenance		Probability	Severity	Nature	Incidence	Occurrence	Reversibility	Importance (I = P x S)	Requires compliance with legal requirements	Affects stakeholders Yes = 5; No = 0	summation	Significance level result	Operational Controls
activities	Environmental Aspect	Environmental impact	P	s	N	IN	O	R	I					
Equipment and Systems														including liquids)
	dust generation	Air pollution	1	4	NE	DI	ST	PRE	4	5	5	14	PS	Solid Waste Management Plan, including liquids)
Opening trenches for cables and cleaning Transformer Substations	dust generation	Air pollution	1	4	NE	IND	MT	IRE	4	5	5	14	PS	Dust reduction program
Fuel supply to generator sets	diesel spill	Ground pollution	3	4	NE	IND	MT	PRE	12	5	0	17	PS	Spill control program
Unloading fuel into underground fuel tank	Fuel spillage on the surface of the tank	Ground pollution	3	4	NE	IND	MT	PRE	12	5	0	17	PS	Spill control program

Worksheet for Identification and Assessment of Environmental Aspects and Impacts															
AEROPORTOS DE MOÇAMBIQUE, E.P. Maputo International Airport			Criteria / Parameters / Attributes						Significance filters						
Doc. At the. 1 1st version	Sector(s): Electrical Maintenance		Probability	Severity	Nature	Incidence	Occurrence	Reversibility	Importance (I = P x S)	Requires compliance with legal requirements	Affects stakeholders Yes = 5; No = 0	summation	Significance level result	Operational Controls	
activities	Environmental Aspect	Environmental impact	P	s	N	IN	O	R	I						
Use of electrical equipment	Energy consumption	Increasing scarcity of natural resources	2	4	NE	IND	LT	IRE	8	0	0	8	NS	-	
Cleaning	Water consumption	The growing scarcity of this natural resource	2	4	HUH	IND	LT	IRE	8	0	0	8	NS	-	
	Solid waste generation	Ground pollution	3	4	HUH	IND	MT	PRE	12	5	0	17	PS	Solid Waste Management Plan, including liquids)	

5.2 EMS Framework for SME

The Environmental Management System structure proposed to the Electrical Maintenance sector that is applicable and appropriate follows the PDCA management model and adapted to the requirements of the ISO 14001 Standard. Figure 5-2 shows the concept of the PDCA management model, the EMS for the Electrical Maintenance Sector.

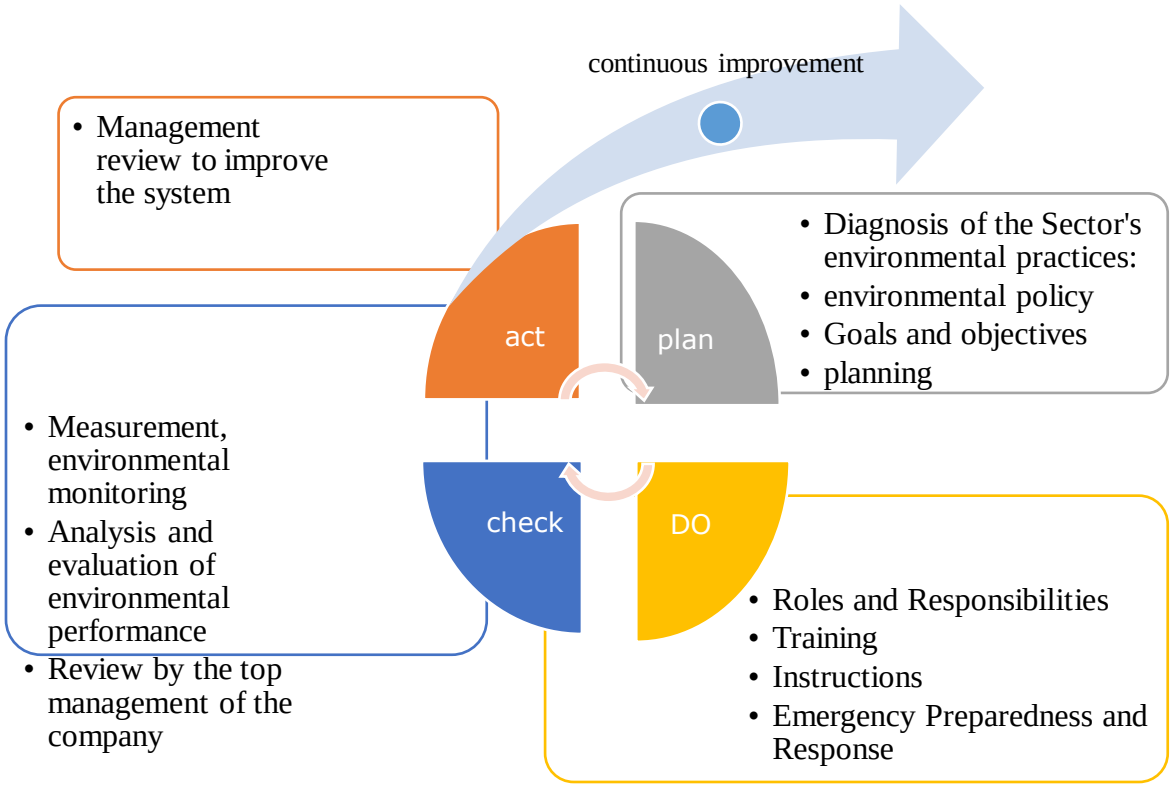

Figure 5-2. EMS structure for the sector based on the PDCA management model

5.2.1 Planning Structure - PLAN

In accordance with the requirements of the ISO 14001 Standard, one of the aspects to be considered in the planning phase is the understanding of the company in its global context, the environmental actions and the establishment of an Environmental Policy, the definition of environmental objectives and targets, as well as the definition of of actions to achieve these goals.

5.2.1.1 Environmental Policy Statement

The Environmental Policy Statement was prepared in this study after the exercise of recognition of the current situation, analysis and assessment of the sector in the strategic and environmental

context of the company. Another aspect that was considered in the elaboration of the policy was to try to make it compatible with the context of the sector in the preservation of the environment. This Policy represents a declaration of commitment to environmental protection insofar as environmental issues will be taken into account in the definition of sector strategies, in meetings with interested parties, in the definition of procedures and management plans for the maintenance of equipment and electrical systems, among other scenarios. The sector's Environmental Policy Statement can be consulted in Appendix 4.

5.2.1.2 Environmental objectives, targets and planning to achieve them

The environmental objectives defined are linked to the significant environmental aspects identified in the present study. These objectives can be measured through performance indicators.

The defined environmental objectives are:

- Reduce the noise emission levels generated;
- Reduce the levels of gaseous emissions from the sector;
- Reduce the generation of solid waste and proceed with its pre-treatment;

These objectives are in line with the Environmental Policy proposed in this work. Find in table 5-6 the planning to achieve the environmental objectives determined for the Electrical Maintenance Sector.

Table 5-6. Planning to achieve environmental objectives

Item	environmental objectives	activities	Resources	measuring instruments	goals
1	Reduce noise emission levels	-Implement engineering measures and perform periodic maintenance to reduce equipment noise;	Acquisition of sound insulation accessories	-Number of noise complaints from employees in a given period of time.	Reduce by 10% by 2024
			In future acquisitions, opt for silent equipment or that generate noise at low levels		
			Replacement of obsolete equipment and accessories that cause noise;		
		- Develop operational procedures to reduce noise emission levels;	Not Applicable	-Number of noise complaints from employees in a given period of time.	Reduce by 10% by 2024
2	Reducing the levels of gaseous emissions	Implement engineering measures to reduce the levels of gaseous emissions from equipment;	In future acquisitions, choose electrical equipment or equipment that emits less gases	-Number of complaints related to smell; - Annual amount of renewable energy acquired or generated, in total and in proportion to the total energy used; -Number or percentage of employees who share cars or other alternative single-use vehicles;	Reduce by 15% by 2024
		- Develop operational procedures to reduce the levels of gaseous emissions;	Not Applicable		
3	Reduce generation and improve solid waste management	Identify and hire companies accredited to collect hazardous waste	Request the body that oversees the environment area (MITADER, CMM) for the list of companies accredited	Number of accredited companies hired	Reduce by 15% by 2024

Item	environmental objectives	activities	Resources	measuring instruments	goals
			for the collection of hazardous waste		
		Pre-treatment of hazardous waste such as fluorescent lamps that will be crushed and deposited in a specific and appropriate deposit	-Acquisition of a drum for crushing and deposition of fluorescent lamps; - Specific deposits for oil residues and contaminated by oil;	- Direct observation during periodic and occasional visits;	
		Distribution of waste segregation deposits in airport ecopoints	-Purchase of bins in sufficient quantity and sizes	- Direct observation during periodic and occasional visits;	
		Guide employees, suppliers and contractors on the reduction of solid waste generation and segregation	- Dissemination of environmental policy and best practices for solid waste reduction and management	-Total amount of waste generated; - Percentage of waste recycled (including and excluding construction and demolition materials).	

5.2.2 Operational Structure - DO

5.2.2.1 Roles, Responsibilities and Authorities.

a) Responsibilities and Authorities - Operational Controls

1. The Sector Chief is responsible for controlling the operations, processes, activities, personnel and equipment of his sector.

b) Shift leaders are responsible for the following:

2.1. Assist in the identification of operational controls, preparation of work instructions and development of inspection procedures when necessary;

2.2. Provide support to the sector leader to ensure that all applicable operational controls are identified and documented.

2.3. Prepare and maintain the list of operational controls for the sector in the EMS data management system;

c) The sector technicians are responsible for the following:

3.1. Identify operational controls necessary to control the process or activities where the lack of control could lead to pollution or deviation from environmental policy;

3.2. Maintain operational controls in accordance with manufacturer's instructions or developed procedures.

3.3. Establish work instructions to control significant environmental factors, impacts and/or other activities that require standardized procedures.

3.4. Establish and implement appropriate inspection actions.

3.5. Coordinate with other sectors responsible for maintaining operational controls at their facilities.

3.6. Maintain a list of facilities for operational controls.

3.8. Ensure that appropriate and competent facility personnel are trained in operational controls.

5.2.2.2 Training, awareness and skills

a) Training and awareness

This requirement requires Sector employees to be aware of the significant aspects and impacts present in and associated with their work. It also requires them to be aware of their contribution to the effectiveness of the EMS, which includes the benefits of improving health and safety performance and the implications of not meeting the EMS requirements, including also those that derive from not complying with the procedures and sector practices.

The sector needs to identify the most appropriate ways to ensure that employees are aware. Some means that the sector can use are: awareness-raising meetings, training, communication, individual or team meetings, group presentations, debate sessions, assessment interviews, among others. Initiating awareness at the stage of integration of new hires into the sector is a good practice.

People's awareness of the above points can go through:

- Promote the discussion of environmental aspects to improve their understanding, their importance and their benefits for the sector;
- Involve employees in the determination and analysis of environmental impacts, informing and training them in the criteria used to determine the significance and the results obtained;
- Align the activities of employees with the company's objectives;
- Explain individual responsibilities in the effective functioning of EMS processes and in improving their performance;

b) Competence

It is essential that employees in the sector have skills consistent with the roles, responsibilities and authorities assigned to them in order to be successful, contribute to an effective EMS and continuous improvement. The Sector must identify training needs associated with environmental impacts and the EMS in order to guarantee skills at this level.

Employees with assigned EMS roles and responsibilities must be competent to:

a) Identify aspects and assess environmental impacts;

b) Contribute to the achievement of health and safety at work objectives,

c) Respond to emergency situations,

d) Conduct compliance assessments.

5.2.2.3 Communication

It is important to establish one or more communication mechanisms in the sector to ensure the implementation and achievement of the intended results of the EMS.

The sector must establish:

a) Information to be communicated about the EMS, environmental aspects and impacts, compliance obligations, its activities, results obtained, including environmental performance and improvements;
b) What are the relevant information to be obtained from the outside world to ensure the maintenance of the EMS, including change management, such as updating standards, knowledge of new technologies, communication from relevant Stakeholders;
c) When to communicate: periodically, in reaction to external requests, according to the times defined by the rules, etc.;
d) With whom to communicate: to its employees, collaborators, students, teachers, suppliers, its customers, partners, legal entities and other EMS Stakeholders;
e) How to communicate: in person, by letter or work letter, in a meeting, on the website or social networks, advertising, product catalogs, brochures, flyers, Media, public reports, etc.

5.2.2.4 Structure of the EMS documentation

The sector may use the structure of its EMS documentation created in this work which consists of the following levels of documented information:

- **Policies:** Policies are documents that demonstrate the overall commitment to improving quality performance and are authorized by the management team.
- **System** Procedures: High-level procedures that define the activities to be carried out to ensure that the EMS meets the standards.
- Module workflows, operating procedures, and work instructions. Control and operational procedures:
    - Meet customers' requirements.

- Provide supplemental guidance and instructions to support the intent of the EMS.
- Ensuring that EMS requirements are adequately addressed within the sector.

- Forms and records are evidence to prove that the EMS is operational.

The sector may, when it deems it necessary, create another structure that will adapt to the new reality in accordance with the management of change. The structure of the EMS documentation will follow the diagram shown in Figure 5-3:

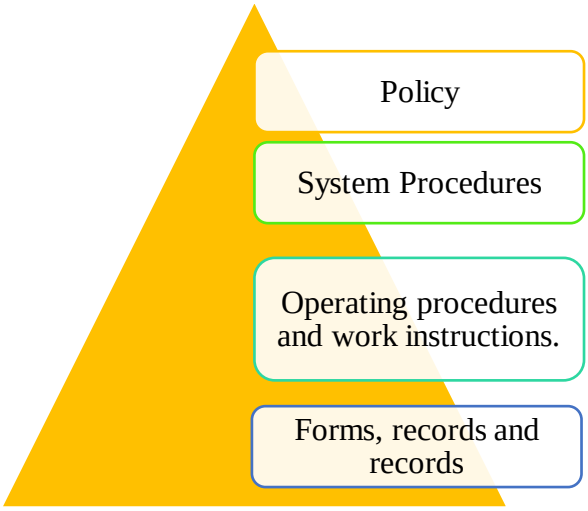

Figure 5-3. The EMS Documentation Structure for the SME

5.2.2.5 Management of operational controls

This section deals with operations and activities that can have a significant impact on the environment and applies to industry employees involved in industry-related work activities. This section addresses aspects of the description of the process for determining, documenting and implementing operational controls in the EMS.

Operational controls are the means by which the sector controls and manages activities and services associated with significant environmental aspects identified at the planning stage. For this EMS, the following will be considered:

- Administrative controls consisting of practices or procedures designed to reduce or eliminate pollution at source and;

- Engineering controls consisting of physical devices designed to reduce or eliminate pollution.

Operational controls may be linked to legal requirements determined by the airport.

Each sector in the EMS will determine and document the current operational controls in operation in the sector and the operational controls necessary to control significant environmental impacts.

Documentation of engineering controls must include:

1. A description of the control and how it affects the process/equipment;
2. Assignment of responsibility for the maintenance and inspection of the control
3. A reference to the maintenance and inspection schedule
4. A reference to the maintenance and inspection procedure
5. a reference to training and/or competency requirements for the responsible person;

Documentation of administrative controls must include:

1. Designation of the control as a procedure or work instruction;
2. Origin control document identifier;
3. assignment of responsibility for conducting administrative control training;
4. A reference to the competence requirements of sector officials or contractors performing administrative tasks under the control.

The work instructions will be reviewed with responsible personnel and will be posted in an appropriate location close to the operation.

Operational controls must be maintained and periodically evaluated.

Maintenance, inspection and training records must be kept on file for at least three (3) years or as required by the regulatory or document retention schedule.

1. the frequency specified in the maintenance procedures.
2. Designated inspectors will receive appropriate training.
3. Any problems observed during the inspection will be brought to the attention of a supervisor and corrective actions will be taken and documented on the inspection form .

Operational planning and controls

Operational controls in accordance with significant environmental aspects determined in the system

- Program for the reduction of gaseous emissions and noise levels
- Solid and liquid waste management procedures
- Liquid effluent management procedures

5.2.2.6 Emergency preparedness and response

Once emergency situations have been identified, the sector should develop:

- Aircraft accident response procedures inside and outside the sector perimeter;
- emergency fuel spill procedure;
- Fire Explosion and Emergency Procedure;
- Emergency procedures to be carried out when snake and/or centipede/spider bites and attacks by other animals occur;

For other emergencies, the sector has an emergency plan

For employees, visitors and other interested parties who wish to visit the facilities/sectors, they will undergo an induction to be carried out by a technician appointed by the sector responsible for security.

5.2.3 Verification Structure - CHECK

5.2.3.1 Measurement, Monitoring, Analysis and Evaluation

The sector will determine:

a) The aspects of the EMS that will be monitored and measured.
b) The responsibilities, frequency and methods for monitoring, measurement, analysis and evaluation required.
c) The criteria against which your EMS performance will be evaluated.
d) When monitoring and measuring:
    i. It will be done.
    ii. The results will be analyzed and evaluated.

2. The results of the analysis and evaluation carried out is to evaluate the:

a) Customer satisfaction level.

b) Compliance of products and services.
c) EMS performance and effectiveness, including environment, health and safety and quality.
d) If the planning has been effectively implemented.
e) Effectiveness of actions taken to address risks and opportunities.
f) Performance of external suppliers.
g) Need for improvements in the EMS.

3. Appropriate documented information must be retained as evidence that measurement, monitoring, analysis and evaluation is conducted.

5.2.3.2 Review by the company's top management

1. A formal EMS review must be held every six weeks, all employees are invited and expected to participate in person or through appropriate communication.
2. The agenda will be:
    a) the status of actions from previous management reviews;
    b) changes in external and internal issues relevant to the environmental management system;
    c) information on the performance and effectiveness of the environmental management system, including trends in:
        i. customer satisfaction and feedback from relevant stakeholders;
        ii. the extent to which environmental objectives have been achieved;
        iii. process performance and compliance of products and services;
        iv. nonconformities and corrective actions;
        v. monitoring and measurement results;
        vi. the performance of external suppliers;
    d) the adequacy of resources;
    e) the effectiveness of actions taken to address risks and opportunities;
    f) improvement opportunities.

5. The management review will follow the standard agenda format in the minutes.

6. Shares are attributed and recorded in the management minutes with agreed deadlines.

5.2.4 Action Framework - ACT

The sector should ensure that improvements, non-conformities and corrective actions are reported, recorded, investigated and followed up.

The procedure should also ensure that non-conforming products or services are identified, reported, recorded, investigated and controlled.

1. Employees must report opportunities for improvement, non-compliance, failures and any other EMS issues.

2. Improvements can be initiated by any employee when any of the following issues are identified:

a) Initiate a change in the EMS.
b) Initiate an improvement in the performance and effectiveness of the EMS.
c) When an opportunity for innovation or improvement is identified.
d) When a non-compliance is identified at any time
e) When a discrepancy, non-compliance or improvement is identified during the audit.
f) When a customer complaint or any significant customer feedback is received (including praise).

3. Improvements must be kept up the sleeve, including associated documents and records in relation to the improvement;

4. The improvement workflow will manage the improvement process;

5. Findings will be reported at the management review meeting, including their status;

Considerations

The fundamental basis for defining the EMS structure presented in the work is based on the PDCA Management Model and the requirements of the ISO 14001 Standard. Therefore, in terms of meeting the requirements of the standard, it has similarities with the structure of the Environmental Management System implemented by others. airports [8]. This EMS can help the sector to better control its environmental aspects, however it still does not allow obtaining environmental certification by the certifying entities recognized in the act of the certification audit. Other

[8] *ICAO Doc. 9968: "Report on Environmental Management System (EMS) Practices in the Aviation Sector" page 1-2.).*

requirements of the ISO 14001 Standard were not included in the present work because the development of a system for obtaining certification is not the main objective of this research work. For the sector to be certified in the ISO 14001 Standard, this EMS must include other requirements such as the performance of internal audits, for example. However, the present system meets most of the fundamental requirements of the ISO 14001 Standard whereas other requirements can be met for certification purposes.

6 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

After carrying out this research work, it can be concluded that the fundamental objectives initially proposed were achieved. During the development of the work, it was possible to conclude that the operational procedures are well structured, however, for the environmental component it needs to be revised to reduce environmental aspects such as paper waste generation, fuel and lubricating oil spillage as well as generation of electronic waste. Also, it was found that the probability of occurrence of failures in the procedures, in the electric generators, of the machines and equipment that can cause damages to the environment in the subsystems of the sector is low due to the effectiveness of the maintenance activities carried out. Reducing gaseous emissions, noise generation, and generation of hazardous electronic and liquid waste by 15%, 10% and 15%, respectively, by 2024 can contribute to improving local environmental quality.

The exercise of internal and external analysis from the perspective of the implementation of the EMS in the sector reveals that there are deficiencies that are easily remedied, such as the fact that employees have little knowledge of environmental issues. Thus, the proposed EMS structure reflects the reality and specificity of the Sector, in such a way that training and awareness sections on environmental aspects and the EMS are proposed. The sector's employees consider the present system proposal to be appropriate. Thus, the implementation of the EMS based on the proposed structure is considered feasible and adequate.

6.2 Recommendations

In order to continue the present study and in order to ensure continuous improvement of the proposed Environmental Management System, it is recommended:

- Carry out in-depth quantitative studies to determine the failure rate of electrical system components that could compromise civil aviation safety and the environment.
- Conduct a more in-depth analysis using reliability analysis techniques for electrical equipment and systems, root cause analysis (RCA) of unwanted events such as the Ishikawa analysis method to find other gaps or causes of environmental risk in the sector
- Study the feasibility of implementing operational controls and assessing their suitability and effectiveness from an economic, technical and social point of view, with the aim of continuously improving the sector's environmental performance.

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APPENDICES

Appendix 1. Questionnaire to the Head of Sector

- Roles and responsibilities of the sector;
- Number and characteristics of officials assigned to the sector (age group, last degree acquired, specific training they have;
- Capacity, size or level of importance of the sector in terms of its role at the airport (To what extent is this sector important for Maputo airport);
- Services provided by the sector,
- Description of the activities performed (eg types of maintenance performed, frequency, etc.);
- Main (environmental) challenges or problems in the environmental management component identified by the sector;
- Records and description of emergency situations occurring in the sector (if any);
- Identification of all types of waste generated in the sector or by the service provided (lamps, oils, batteries, etc.) and their respective destination given to these wastes;
- Description of tools, machines, equipment (active and obsolete) used in or by the sector;
- Level of coverage of sector services at the airport;
- Main institutions/companies/organs that collaborate with the sector (suppliers, partners, trainers, etc);

Appendix 2. Interview Guide

AEROPORTOS DE MOÇAMBIQUE, E.P.

INTERVIEW GUIDE

This guide aims to survey the environmental aspects, risks, opportunities and their associated environmental impacts, sources of gaseous emissions, energy generation and consumption and emergency situations, in the Electrical Maintenance sector of Maputo International Airport within the scope of development of an Environmental Management System.

As this is an internal job, all information obtained will be treated as confidential information. For better results, the total guarantee of confidentiality and anonymity of the answers and opinions given will be taken into account. The success of the Environmental Management System strongly depends on everyone's cooperation, so it is essential that you answer the questions asked sincerely.

Sector: _____ Date of receipt: ___/____/20___

Sector specialization activity: _____

_____

Part A - Personal Data **(Mark with an X in the blank square that corresponds to your answer)**								
1. Age:	less than 30		31 to 40		41 to 60		more than 60	
2. Sex			Male		Feminine			
3. Nationality			Mozambican		foreign			
4. Position/Function:								

5. Marital status:	Single		Married		Widower		Others	
6. Education:	Primary		Basic		Medium		Higher	
7. Other professional training					Yea		No	

Part B - Work situation **(Mark with an X the option that corresponds to your answer)**											
1. what kind of job do you do? (tasks/activity)											
2. How many hours do you work per day?											
less than 8 hours		8 am to 9 am		more than 9h		shifts?					
3. Currently, your legal employment relationship is:											
Certain/uncertain contract		Effective / permanent		Provision of services / Subcontractor		No legal employment relationship					
4. How long have you been working in this area/position?											
less than 5 years		from 5 to 9 years		10 years or more							
5. How long have you been working at this company?											
Less than 5 years		from 5 to 9 years		10 years or more							
In general, what is the level of education of the employees assigned to this sector?											
Basic level		Middle level		Higher level							
What is the level of awareness of environmental issues in this sector?											
Very low		Low		Medium		High		Very high			
What has been done in this sector in favor of the environment, so as not to contaminate it? **Reply:**											
What do you think about implementing actions to improve environmental quality?											

Reply:
What are the activities carried out? **Answer** :
Of these activities, which are the main and complementary activities? **Answer** :
Who carries out these activities? Airport Employees or Contracted Company? **Answer** :
Do you have periods when normal activities are not carried out for the purposes of Maintenance, Rehabilitation, Fumigation or other activity (specify activity)? **Answer** :
What do you think concerns the sector the most in terms of the environment? Example: These are high noise levels, high concentrations of dust, fumes, fuel vapor, etc.) **Answers:**
What would be the possible **emergency situations** in your sector? (Example: Fire and explosions, flooding due to heavy rains, snakebites or other animals, or other phenomena) **Answers:**

GARBAGE MANAGEMENT (hazardous and non-hazardous waste)				
Item	**Requirement**	**Reply**	**Probability**	**Severity**
1	What types of waste are generated in the sector? And what are its origins? Example: paper, plastics, metals, cloths, food			
2	How much waste is generated per day and on peak days? (If there is no record of the quantities, you can estimate the quantity in grams (g) or Kilograms (Kg))			
3	What is the composition of these wastes?			

GARBAGE MANAGEMENT (hazardous and non-hazardous waste)				
Item	**Requirement**	**Reply**	**Probability**	**Severity**
4	Where is waste deposited?			
5	What is the destination of uncollected waste? (Example: blown light bulbs, filters, used oils)			
6	Do they receive any treatment before final deposition? Are they separated by type of waste at source?			
7	How often are they collected?			
8	Who collects the waste? (Contracted company or sector personnel)			
9	If it is a contracted company, is it accredited/licensed to collect and treat this type of waste?			
10	Are there any procedures for dealing with waste? (Example: how to handle this waste, with or without the use of equipment)			
11	Are there future plans for the treatment or reuse of waste? If yes, what are they?			
12	What do you think can be done in the sector where you work to improve waste management? Example: what can be done to reduce the generation of waste (describe if you have an idea)			
		Partial Sum:		
Comments and recommendations:				
Risks and Opportunities:				

Part D: EFFLUENT MANAGEMENT (sewage, including spills of fuel and other liquids)				
Item	**Requirement**	**Reply**	**Probability**	**Severity**
1	Are liquid effluents (dirty water) generated in this sector? If yes, what is its provenance?			
2	Where are they discarded? What is the receiving medium? (In which part of the environment the dirty water that leaves the sector is discarded)			
3	Are effluents subjected to any treatment before being discarded? If yes, what is the treatment given?			
4	Are effluent parameters monitored?			
5	What is the volume of effluent generated per day? (Amount of water in liters that the sector discharges into the environment)			
6	Are there measures implemented or proposed to reduce, treat or reuse effluents?			
7	Are there activities that cause spillage of water, fuel or other liquids?			
8	What kind of fuel or other liquid is spilled?			
9	Where does water, fuel or other liquid spills often occur?			
10	What is done after spilling this liquid?			
11	What do you think can be done in the sector where you work to improve effluent management? (describe if you have an idea of how to control spills and what can be done after a spill occurs)			
		Partial Sum:		

Part D: EFFLUENT MANAGEMENT (sewage, including spills of fuel and other liquids)				
Item	**Requirement**	**Reply**	**Probability**	**Severity**
Comments and recommendations:				
Risks and Opportunities				

Part E: MANAGEMENT OF GAS EMISSIONS (Smoke emission including fuel vapours)				
Item	**Requirement**	**Reply**	**Probability**	**Severity**
1	Are there sources of gaseous emissions? Which are they? (indicate the sources or equipment that emit fumes)			
2	Are gaseous emissions monitored and controlled?			
3	Is there any treatment given to gaseous emissions?			
4	Are gaseous emissions measured or quantified?			
5	Are there measures implemented or proposed to reduce or address gaseous emissions?			
6	Are there emission of fuel vapors?			
7	What is done to reduce or extinguish the emission of these vapors?			
8	What do you think can be done in the sector where you work to reduce or extinguish the emission of gases and vapors? (describe if you have an idea)			
		Partial Sum:		
Comments and recommendations:				
Risks and Opportunities				

Part F: NOISE MANAGEMENT				
Item	**Requirement**	**Reply**	**Probability**	**Severity**
1	Is there noise generation in this sector?			
2	What are the sources of noise generation?			
3	Are noise levels measured, monitored and controlled?			
4	Are there measures implemented or proposed to reduce noise levels?			
5	What do you think can be done in the sector where you work to reduce noise levels? (describe if you have an idea)			
		Partial Sum:		
Comments and recommendations:				
Risks and Opportunities				

Part G: WATER CONSUMPTION				
Item	**Requirement**	**Reply**	**Probability**	**Severity**
1	What activities consume water?			
2	What are the purposes of water?			
3	What is the origin or source of the water consumed? (public network or borehole capture)			
4	How much water is consumed in this sector?			
5	What do you think can be done in the sector where you work to reduce water consumption for operational purposes? (describe if you have an idea)			

Part G: WATER CONSUMPTION				
Item	**Requirement**	**Reply**	**Probability**	**Severity**
		Partial Sum:		
Comments and recommendations:				
Risks and Opportunities				

Part H: ENERGY CONSUMPTION				
Item	**Requirement**	**Reply**	**Probability**	**Severity**
1	What are the activities/equipment or materials that use or consume energy?			
2	What is the source of the energy used? (public or internally generated network)			
3	Are there proposals to use energy from other sources? (for example renewable sources)			
4	Is there a record of energy consumption?			
5	What do you think can be done in the sector where you work to reduce energy consumption? (describe if you have an idea)			
		Partial Sum:		
Comments and recommendations:				
Risks and Opportunities				

Part I GENERATION OF PARTICULATE MATERIAL (DUST)				
Item	**Requirement**	**Reply**	**Probability**	**Severity**
1	What are the activities that generate particulate matter (dust)?			
2	What type of particulate matter is emitted)?			
3	Is particulate matter monitored?			
4	What are the measures implemented or proposed to avoid reducing the emission of particulate matter?			
5	Do you think that the dust produced in your sector can harm your health?			
6	What do you think can be done in the sector where you work to reduce dust generation? (describe if you have an idea)			
		Partial Sum:		
Comments and recommendations:				
Risks and Opportunities				

Part J: GROUND MANAGEMENT				
Item	**Requirement**	**Reply**	**Probability**	**Severity**
1	What are the activities carried out on the ground?			
2	What do you think can contaminate the soil in the sector where you work?			
3	What measures are implemented or proposed to prevent soil contamination?			
4	What do you think can be done in the sector where you work to avoid soil contamination? (describe if you have an idea)			
		Partial Sum:		
Comments and recommendations:				

Part J: GROUND MANAGEMENT				
Item	**Requirement**	**Reply**	**Probability**	**Severity**
Risks and Opportunities				

Part K: MANAGEMENT OF EQUIPMENT, MATERIALS AND CHEMICALS				
Item	**Requirement**	**Reply**	**Probability**	**Severity**
1	What kind of equipment and materials are used in this sector?			
2	Is there a maintenance plan?			
3	Who does the maintenance?			
4	What is the current state of conservation of each equipment or material?			
5	What is the power source used for the equipment?			
6	What types of chemicals are used in this sector?			
7	Are chemical products quantified and have identification and expiration labels?			
8	Where are they stored and under what conditions?			
		Partial Sum:		
Comments and recommendations:				
Risks and Opportunities				

Part L: RISK MANAGEMENT				
Item	**Requirement**	**Reply**	**Probability**	**Severity**
1	Are inductions carried out for visitors or people who are visiting the sector for the first time?			
2	In the induction, are the procedures presented for			

Part L: RISK MANAGEMENT				
Item	**Requirement**	**Reply**	**Probability**	**Severity**
	emergency cases or the occurrence of an accident/incident?			
3	Are there procedures and signage for pedestrian and vehicle circulation areas?			
4	Is there a sign indicating the mandatory use of personal protective equipment?			
5	Are there emergency route signs?			
6	Is there an emergency meeting point signage?			
7	Is there a Risk Map attached to the wall?			
8	Is there an Emergency Map (emergency exits)?			
9	Are there nameplates for the sector and its compartments?			
10	Do you have enough fire extinguishers within the expiration dates?			
11	Have you ever been registered or witnessed an accident? If yes, describe under what circumstances			
		Partial Sum:		
Comments and recommendations:				
Risks and Opportunities				

Part M: EMERGENCY SITUATIONS				
Item	**Requirement**	**Reply**	**Probability**	**Severity**
1	Has there ever been an emergency situation in this sector? If yes, answer the following questions. If not, answer questions about potential emergency situations.			
2	What kind of emergency situations have you witnessed			

Part M: EMERGENCY SITUATIONS				
Item	**Requirement**	**Reply**	**Probability**	**Severity**
	or been recorded in that sector?			
3	What actions were taken to stop the situation?			
4	Were these actions effective?			
5	What are the impacts of this emergency situation			
6	Are there emergency procedures in this sector? If yes, are all employees and stakeholders aware?			
7	Are emergency drills performed?			
		Partial Sum:		
Comments and recommendations:				
Risks and Opportunities				

Part N: MANAGEMENT OF COMPANIES CONTRACTED TO PROVIDE SERVICES				
Item	**Requirement**	**Reply**	**Probability**	**Severity**
1	Are there companies contracted to provide services in this sector? If yes, answer the following questions:			
2	How many contractors are there?			
3	What are the services provided by each company?			
4	Are these companies accredited/licensed?			
5	What are the environmental aspects that can be identified from these companies?			
		Partial Sum:		
Comments and recommendations:				
Risks and Opportunities				

Part O: DOCUMENT MANAGEMENT				
Item	**Requirement**	**Reply**	**Probability**	**Severity**
1	What kind of documents does the sector have?			
2	What types of information are recorded in this sector?			
3	After some time and the document is useless, what is done with the document?			
4	What do you think of the idea of moving to register and document in electronic format to reduce the use of paper?			
		Partial Sum:		
Comments and recommendations:				
Risks and Opportunities				

Rating criteria

Severity	**Criterion**	**Punctuation**
Negligible	Impact of negligible magnitude	1
Smaller	Impact of reduced magnitude	two
moderate	Impact of considerable magnitude	3
Substantial	Impact of great magnitude	4
catastrophic	Large-scale impact	5

Probability	**Criterion**	**Punctuation**
Very low	extremely unlikely	1
Low	Remote	2
Average	occasional	3
High	Frequent	4
Very tall	Continuous	5

Appendix 3. Results of the application of Structured Analysis and Project Technique

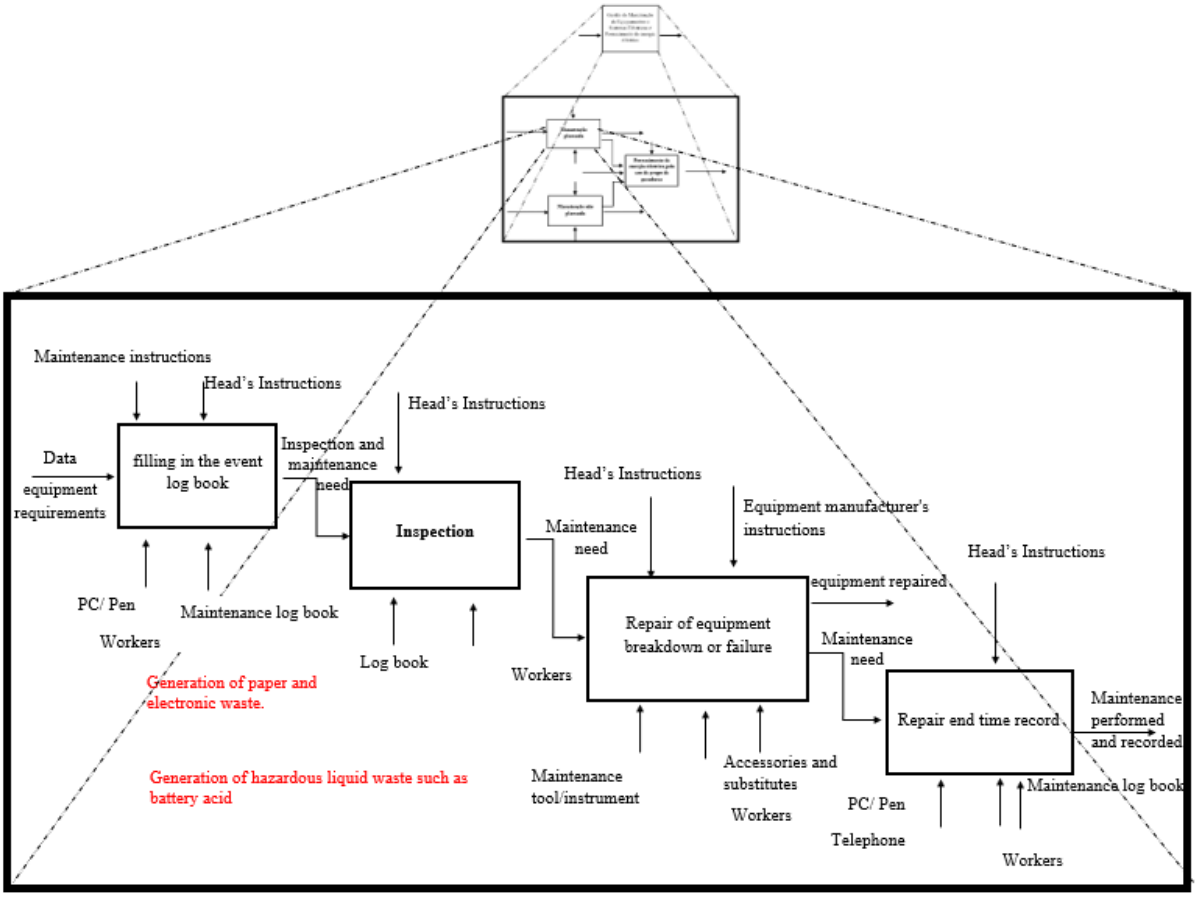

Figure A3-1. SADT for planned maintenance

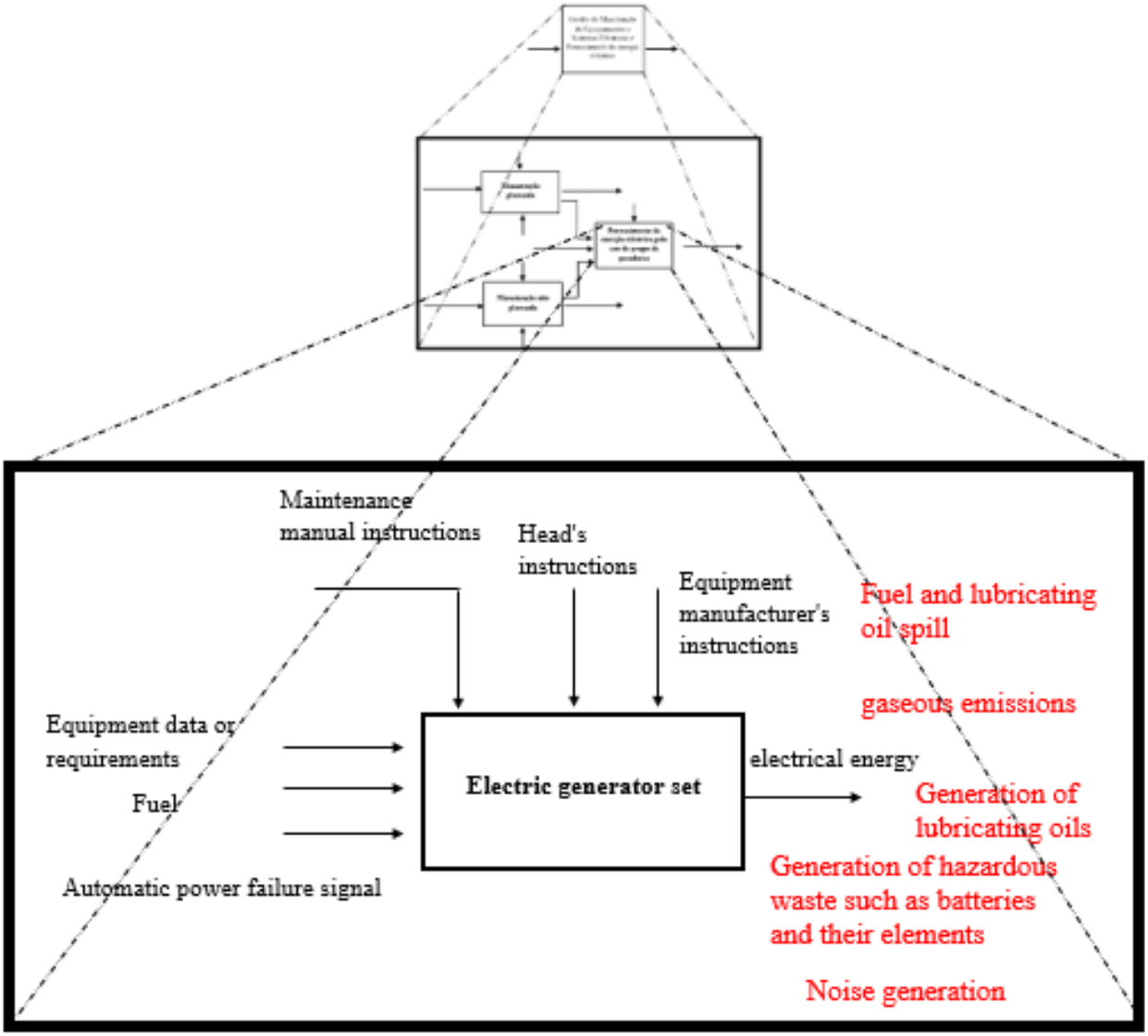

Figure A3-2. SADT for electricity supply

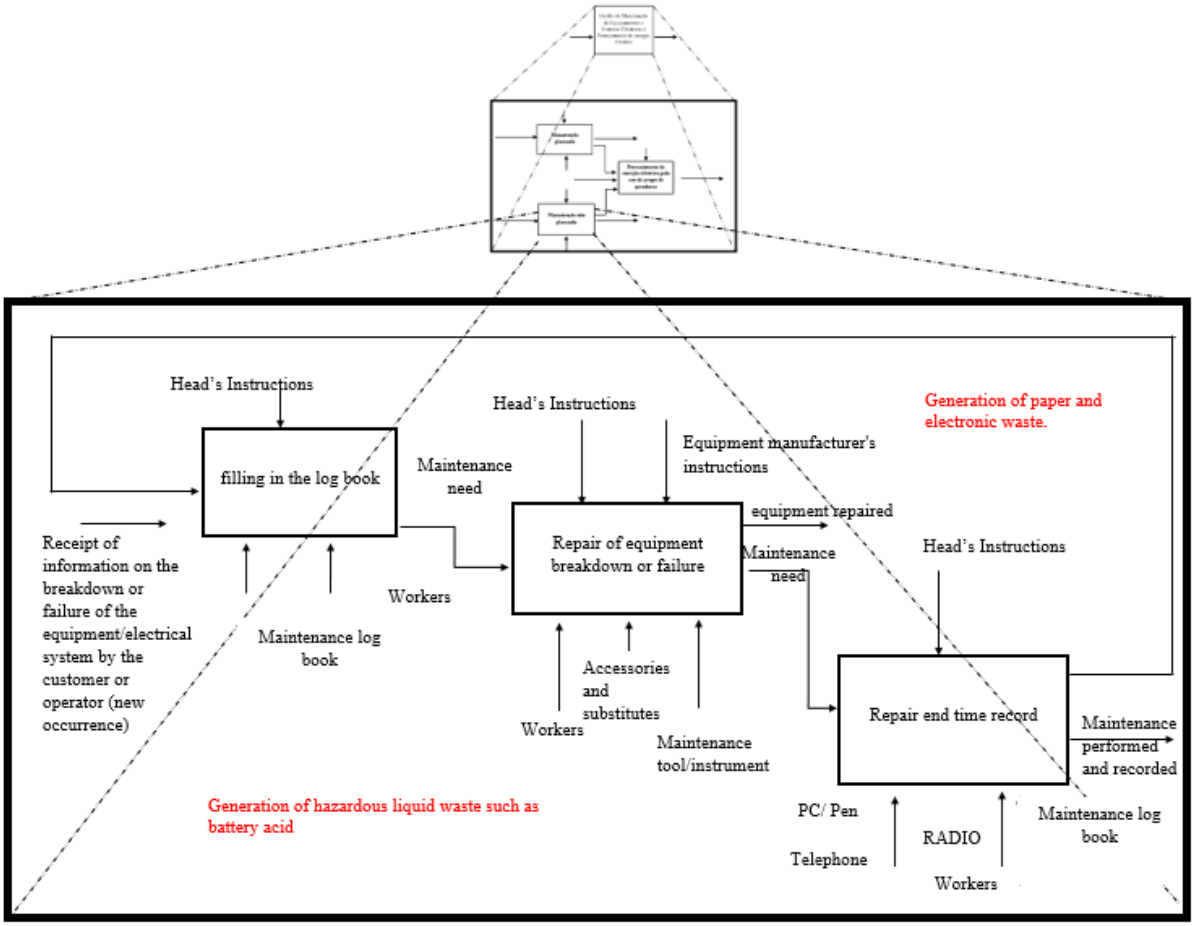

Figure A3-3. SADT for unplanned maintenance

Appendix 4. Proposed Environmental Policy Statement

AEROPORTOS DE MOÇAMBIQUE, E.P.

Environmental Policy

Electrical Maintenance is the sector at Maputo International Airport responsible for Preventive and Corrective Maintenance of Electrical Equipment and Systems in all airport infrastructure.
The Electric Maintenance sector established the Environmental Management System with the objective of integrating actions articulated in its strategic orientation that will allow the control of the environmental impacts associated with the activities of this sector.
The scope and context of this policy covers all activities provided by the Electrical Maintenance sector at Maputo International Airport. The scope and context include our environmental obligations to Employees, Suppliers, Subcontractors, Passengers, Neighbors, Government, National and International Civil Aviation Management Bodies.
The Electrical Maintenance Sector is committed to protecting the Earth's local and global environment. To minimize the environmental impacts related to its activities, the sector is committed to:

- Comply with applicable legal requirements and other requirements to which the sector subscribes related to its environmental aspects;
- Avoid noise, air and soil pollution, reducing noise, gas and vapor emission levels and continuously improving solid waste management;
- Minimize water waste, generation of liquid effluents;
- Raise awareness, educate, train and motivate employees and other relevant stakeholders to carry out tasks in an environmentally sustainable manner;
- Encouraging environmental protection among suppliers, subcontractors and other interested parties;

Top management is committed to ensuring that the protection of the environment is effectively and firmly embedded in the culture of the sector and of all employees, in order to influence all stakeholders to achieve the desired results.
The sector is committed to the continuous improvement of environmental performance.

Maputo, August 24, 2022
Chairman of the Board of Directors, PCA

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ANNEXS

Annex 1. Description of maintenance management process

2.1. routine maintenance

Equipment reception:

Equipment maintenance starts with your receipt after purchase. The reception of the equipment is carried out by a team composed of technicians specialized in the areas to which they refer. During this action, the respective operation and maintenance catalogs containing the respective technical specifications, spare parts and manuals are also delivered.

registration:

Upon receipt of the equipment, the respective record must be prepared by filling in the attached technical data sheet, which contains the technical specifications of the equipment, whose importance lies in the fact that it provides the most relevant characteristics of which time starts the start time of life. useful.

During registration, an asset number will be assigned by the sector responsible for asset management.

Identification of maintenance routines:

Generally, the equipment comes with the maintenance routines included in the respective operation and maintenance manuals. They must be assumed as a fundamental tool for the elaboration of maintenance plans for each equipment.

Preventive maintenance plan:

Maintenance plans are drawn up based on the maintenance routines identified above and also in accordance with ICAO recommendations.

Inspections:

To assess the level of equipment supply, periodic inspection plans are prepared, which should culminate in the presentation of a report to correct programming and/or improve interventions.

The depth of programmed interventions depends on the severity level of the detected anomalies:

a) If the level of failure allows maintenance action with the equipment in operation, curative maintenance will be performed;

b) If the severity level is such that it does not allow maintenance with the equipment in operation and it is necessary to stop it, corrective maintenance will be carried out with the removal of the equipment from operation "out of service".

2.2 Major maintenance

Equipment reception:

Equipment maintenance starts with your receipt after purchase. The reception of the equipment is carried out by a team composed of technicians specialized in the areas to which they refer. During this action, the respective operation and maintenance catalogs containing the respective technical specifications, spare parts and manuals are also delivered.

Planning:

This is a sector of action in the request for routine interventions as a function of time to guarantee the maintenance of the operating conditions of the equipment. Planning takes into account all technical recommendations provided in the equipment catalogue.

Inspections:

To assess the level of equipment supply, periodic inspection plans whose reports are scheduled for improvement interventions that result from a given inspection.

The depth of interventions depends on the level of severity of the detected anomaly.

In this case, a more in-depth assessment is carried out to make the best decision.

a) If the level of failure warrants maintenance action, the option is to perform corrective maintenance by removing the equipment from service.
b) If the level of severity is such that a maintenance action is not feasible, the option is to decree the end of the equipment's useful life and, consequently, its replacement.

Annex 2. Occurrence records

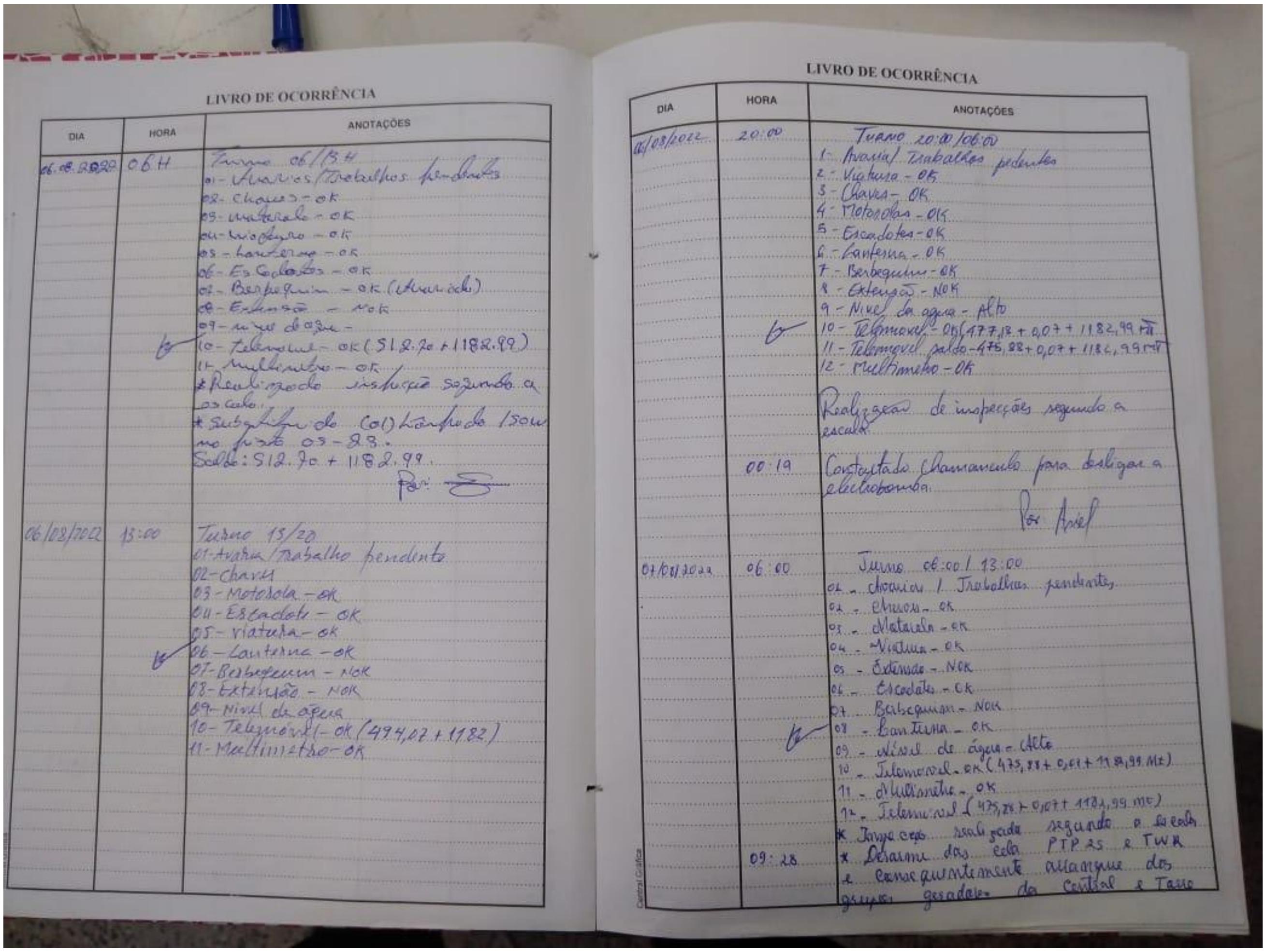

Figure A02-1. Occurrence Book