


# REVIEW SAFETY INSPECTIONS ROUTINES OF PETROLEUM STORAGE FACILITIES AT THE DEPOT

JONATHAN KALASA, (PRE/011/18)

THYOLO, MALAWI

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DECLARATION

I Jonathan kalasa declare that this research project represents my work and that it has never been submitted to this institution or any other institution for any academic purpose. All sources of information have been appropriately acknowledged.

Signature 

Date April 2023

DISSERTATION APPROVED BY:

SUPERVISOR:

Title, Initials, Name: Signature: F.Josiya

ASSESSOR:

Title, Initials, Name: Signature: _____

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## ABSTRACT

This research reviews safety inspections routines of petroleum storage facilities at different petroleum depot in Blantyre. The main plan was to analyze the risk with help of Malawi energy regulatory authority (MERA) guidelines in 2004 and international standard rules associated in different sections which are being carried out in Petroleum depot, during building, handling, storage and distribution/or transportation, and to minimize the hazard in order to make the working environment. As the Depot handles various petroleum products which have got many possible hazards, hence it is necessary to evaluate the Risk from the facilities at the Depot. It is observed that Despite the introduction of the MERA guidelines in 2004, not all petroleum industries in Malawi run through it some follow international standards while only local companies follow the local standards which are MERA standards in their operation at the deport. The types of human casualties collected and recorded between the years (2019-2022) shows that slightly injured are most type of accidents the often occur at the depot and oil storage area, loading and unloading operation area and auxiliary operation area are areas which are most prone to occur accidents. It is also the need for effective inspection by Malawi energy regulatory authority to make sure if the oil marketing company are following the standard guidelines on their everyday routines.

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## DEDICATION

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## LIST OF ACRONYMS

**NOCMA:** National Oil Company of Malawi

**API:** American Petroleum Institute

**MERA:** Malawi Energy Regulatory Authority

**MJV:** Mutual Joint Visit

**ECE:** United Nations Economic Commission for Europe

**OTs:** Oil Terminals

**OTMS:** Oil Terminal Management System

**UT:** Ultrasonic

# CHAPTER 1: GENERAL INTRODUCTION

## 1.1 Background

Major accidents in petrochemical facilities occur during storage process. Many accidents occurred in the past, causing death or injury for workers, huge economic losses, and heavy environmental pollutions. Thus, this paper aimed to review safety inspection routine and adequate hazard analysis in the oil storage facility.

Despite the fact that in Malawi the occurrence of a tank fire accident is a relatively rare phenomenon, its results may lead to unexpected consequences for the installation and also cause potential environmental and healthy damages that is difficult to assess after.

Studies have been undertaken through literature review with the aim to perform statically analysis of accident occurrence in storage tanks. The conclusion of the study is that fire out bursting is the most frequents type of accident in that part of installation, caused primarily by lightning and second place, by maintenance errors.

Most oil marketing companies in Malawi have fuel storage depot used to store and handle their petroleum products, for example, PUMA, PETRODA, NOCMA, TOTAL AND SIMSOIL etc. It is very important to review if the safety check-out procedures practiced method for the storage facilities at the depot up to date are properly in place to maintain zero accident-free status in the country and stay clear from hazardous conditions caused by fire and sudden outburst at petroleum storage depots.

To achieve zero accident-free status in the country and stay clear from hazardous conditions caused by fire and sudden outburst at petroleum storage depots we need to

behave in accordance to high standard safety inspections routine measures, and be in line with good Industry Practices for Oil depots.

## 1.2 Problem statement

Bulk storage facilities have numerous operational and environmental exposures Because of the materials they store – crude oil, natural gas, or refined products containing petrochemicals. Storing and managing the shipment of such materials comes with a host of risks. The fuel-air mixture is the largest proportion in the accident substances; thus, the

vapor cloud explosion should be paid more attention to and the explosion prevention would be the major concerns for safety emergency reaction in oil depots. The analysis of responsibility for accidents shows that the management responsibility dominates among all the causes, so it is essential to prevent accidents in the daily routine operation, and security management should be concentrated throughout the whole period time in oil depots.

The purpose of this research is to look back to the minimum expected standards of control which should be in place at all establishments storing large volumes of petroleum and gas products capable of giving rise to a large flammable vapor cloud in the event of a loss of primary containment in order to correct and resolve problems that can give rise to accident and utilize the past statistics of fire and explosion accidents of oil depots in Malawi to identify the most dangerous areas, vulnerable facilities & equipment, ignition sources, types of accident substances, and major causes to propose enough special lessons learned from those accidents to improve the future security management in oil depots.

### 1.3 Main objective

Reviewing safety check-out procedures practiced methods of petroleum storage facilities at deport.

### 1.4 Specific objectives

- ✓ To review safety procedures of three depots in Blantyre namely Total, VIVO and Nocma.
- ✓ Compare international safety check-out procedures practiced method of petroleum storage facilities at the deport with Local safety check-out procedures practiced method of petroleum storage facilities at the deport

  -Report the shortfalls between the two

  -Recommend the necessarily improvements

## 1.5 Research questions

- ✓ Are the local petroleum industries in Malawi run through uniform safety inspections routine guidelines for petroleum storage facilities at the depot?
- ✓ Are the local petroleum industries in Malawi go after and meet international standard safety inspections routine guidelines?
- ✓ If they are not following, how to improve the future security management in oil depots?
- ✓ They are run through, how to uphold the safety inspection routines for the tanks at the depot properly in place to maintain zero accident-free status?

## 1.6 Significance of the study

Oil depots store huge volume of petroleum products that are extremely flammable substances and so can pose a serious threat to people and the environment, especially in the case of improper design, improper construction, improper management, improper operation or improper maintenance (Nations, 2015). An accident at an oil depot may result in uncontrolled spills, fires and explosions, potentially leading to the loss of human life or to a major environmental disastrous event of great significance. In response to the need to improve the safety of oil terminals, ECE member countries decided to develop safety guidelines and good practices for oil terminals within the framework of the project on hazard and crisis management in the Danube Delta, under the auspices of the Convention's Assistance Program (Frank Candreva, 2015).

The justification of the studies was to

- ✓ Ensure that at all times, fuel transfer and storage operations are carried out safely in order to avoid an accident at the depots.
- ✓ Identifying already existing or potentially hazardous conditions, and record hazards for corrective action.
- ✓ To communicates knowledge to the operators and other companies involved in fuel transfer that should examine again their safety inspections routines and carry out in accordance to high standard guiding principles

and put into practice specific procedures and protocols that meet those principles.

# CHAPTER 2: LITERATURE REVIEW

This chapter provides a comprehensive review of documented information about safety inspection routines of petroleum storage facilities. It also provides a review of project management practices in the engineering field. According to Kara (2012) literature review is very essential for any meaningful study. It provides a basis for the identification of gaps in the literature. Identification of gaps ensures the researcher does not duplicate the work of others. Rather, there is new information added to the existing pool of information. This chapter is divided into various sections including theoretical framework, the types of oil storage tanks, construction, and Oil tank maintenance and oil tanks inspection.

## 2.1 Theoretical framework

Petroleum and chemical products are primary resources in our life and considered one of the most important basic building blocks for sustainable development. The growing demand of hazardous chemicals has brought a significant increase in risk to human and its environment. Hazardous chemicals have intrinsic hazards for the environment, which may damage it the human and properties around the accident area. OSHA as defined a hazardous chemical as any chemical, which has a physical hazard such as (fire and explosion) or a health hazard such as (acute or chronic effects). The results of a historical analysis have shown that 17% of major accidents in the chemical industries were during storage processes. According to the NFPA report in 2009 [5], 13% of the fire accidents that occurred in the USA took place in storage causing death or injury for workers, tens million dollars as losses and cause huge environmental pollution. Fuel Storage Tank System consist of all the connecting piping, including pumps, product transfer system, barriers, overfill protection equipment and spill containment system associated with a fuel storage tank (Petroleum Products Storage Facility Regulations 2017, 2017). The protection facilities against hazards in bulk depots shall be achieved by good engineering design and construction standards. Safe operational procedures and efficient plant and

equipment maintenance shall be such that it is highly improbable that fire will break out. Accidents has been happened at petroleum storage facilities (tanks) every year from Between 1997 and 2013, there have been numerous incidents at storage facilities that have caused serious injuries and fatalities to employees (OSHA-03 2017, 03 2017). For example:

- ✓ In 2013, a facility that stored and distributed compressed propane gas was largely destroyed by a series of fires and explosions. After receiving spent propane gas cylinders, employees would "bleed" any remaining gas into the air before the cylinders were cleaned and reused. On the night of the incident, investigators believe, this practice resulted in a cloud of flammable propane gas at the facility, which was ignited by a spark from a forklift operating in the area. The resulting explosions and fires injured several employees—four critically (www.osha.gov/Publications/osha3132.pdf www.osha.gov/pls/oshaweb/owadisp.show_document?)
- ✓ In 2008, a nearly 90-year-old storage tank catastrophically failed and released approximately 2.1 million gallons of liquid fertilizer. The collapsing tank seriously injured two employees, and the chemicals flowed over containment berms. Investigators determined that defective welds likely caused the tank failure, and inspectors condemned another tank at the same facility that presented an "imminent danger" of failure. Major contributing factors were the inadequacy of tank weld inspections and overestimates of the maximum liquid levels that the tank could safely accommodate. Further, some tank inspection and testing activities did not follow recognized and generally accepted good engineering practices. This is a recurring category of incident: between 1995 and 2008, 16 tanks at other facilities catastrophically failed, killing one employee and hospitalizing four others. Faulty welding caused 11 of these tank failures (CSB, 2009)
- ✓ In 2005, a fire and subsequent explosion(s) destroyed a facility that stored and distributed compressed gas, and propelled debris and projectiles. The incident was traced back to propylene gas cylinders in the facility's storage area that were directly exposed to sunlight. High temperatures from the sunlight exposure

increased cylinder pressure enough to cause flammable vapours to leak from the cylinders and catch fire. Heat from the initial fire caused other cylinders to leak gas. The fire spread throughout the storage area and eventually consumed nearly 8,000 cylinders of compressed gas.

Studies have been undertaken through literature review with the aim to perform statistical analyses of accident occurrence in storage tanks. The conclusions of such studies are that fire out bursting is the most frequent type of accident in this type of installations, caused primarily by lightning and, in the second place, by maintenance errors. To keep facilities, employees, and surrounding communities safe, facilities operators must have a comprehensive and active risk management plan that encompasses six key areas: hazard evaluation, engineering controls, release prevention measures, employee training, spill and fire emergency planning, and a rigorous inspection and preventative maintenance program (Creager, 2021).

### 2.1.1Hazard Evaluation

These following areas have been identified by the American Petroleum Institute (API) as the main causes of petroleum-related releases:

- ✓ Physical damage to tanks, valves, pumps and ancillary equipment
- ✓ Tank and equipment leak from mechanical failure, corrosion, and faulty valves or seals
- ✓ Improper product handling and employee or contractor negligence
- ✓ Poor housekeeping practices

Every facility should conduct routine visual surveys of tanks and equipment and containment. Beyond observations, hazard assessment should include current operating procedures, maintenance activities, and security to measure the effectiveness and exposures of each area. Key questions include whether employees are handling materials properly and what operational vulnerabilities exist.

### 2.1.2 Engineering control

In the event of a leak or potential accident, you need the ability to contain the problem. Shutdown systems, ventilation, block valves, and fire-retardant systems are essential. Your facilities should also have the following in place:

-Centralized controls for continuous monitoring and reporting

-Pressure relief devices to protect against failures and leaks

-Intermediate alarms that allow time for corrective action

-Automatic shutdown for selected equipment

-Backup instrumentation for all critical controls

### 2.1.3Release--Prevention

There are a variety of causes of spills and accidents that cannot be eliminated. However, you can reduce spill frequency and severity by combining comprehensive written operating procedures with best practices for your facilities.

- ✓ Shutting off tank trucks and chocking wheels and grounding equipment during transfer of flammable liquids reduces the risk of explosion.
- ✓ Check all hoses and fittings. Are they in good condition? Are the connections secure?
- ✓ Also, verifying the available free tank volume is a basic, but essential step in avoiding overfill releases.
- ✓ When there are other tanks in the storage area, confirming fill ports/piping during product transfer can help avoid putting the wrong product in a tank.
- ✓ Tank, truck, rail car product transfer areas should be provided with secondary containment, catch basins and drip pans to prevent a release to the environment.
- ✓ Maintain maximum safety and response time by requiring an attendant to be present during all transfers.

In order to assist operators and authorities in the ECE region to ensure fully sufficient safety level at petroleum storage facilities, the secretariat to the Convention on the Trans boundary Effects of Industrial Accidents established in March 2012 an international expert group to elaborate safety guidelines for OTs. aims at improving the cooperation between the three countries in the Danube Delta region through enhancing and, where possible,

harmonizing the mechanisms and approaches for efficient and effective hazard and crisis management, in particular at oil storing and processing facilities. These Safety Guidelines and Good Industry Practices apply to all OTs in the ECE region (Frank Candreva (DNV Oil and Gas, 27 August 2013).

During Mutual Joint Visit (MJV) on Seveso Inspections in petroleum storage depots, held on 7 to 9 December 2005 in Brussels hosted by the Belgian competent inspection services in Brussels and co-sponsored by the European Commission aimed to reach common agreement on the minimum necessary measures for a number of major accidents hazards typical for a petroleum depot, on technical as well as on organisational and managerial level. Several countries agreed that Safety Management System is necessary in a petroleum depot ((European Commission Research Centre and Belgian Federal Public Service Employment, 2008) Therefore, countries have specific requirements for SMS functions for example in

- ✓ Belgium All sites must have a safety advisor and an environmental co-ordinator.
- ✓ Czech Most sites are required to designate a safety officer. He/she makes a yearly report of safety activities.
- ✓ Germany There must be a designated officer responsible for Seveso II implementation on Seveso II establishments.
- ✓ Italy a safety officer for the site has to be identified and his/her role in the organisation specifically defined.

The problem encountered is that several countries have their own specific requirements for SMS functions for example SMS functions During Mutual Joint Visit (MJV) on Seveso Inspections in petroleum storage depots, held on 7 to 9 December 2005 is not the same from safety guidelines for OTs developed by ECE member countries. Using uniform standard safety measures around the world might be very secure and easy to go after. Therefore, it is important to conduct a profound and adequate hazard analysis of the oil storage facility to figure out the potential scenarios having damage to life and property as well as provides a clear picture for the decision makers to be satisfied with the safety levels in the storage tank site. Hazard Analysis is an important process and has a vital role in studies related to hazardous chemicals handling. Hazard identification (HAZID) is the

initial step in any hazard analysis process and includes the identification of all possible accidents in the facility. The most used technique in HAZID is HAZOP study. HAZOP is a systematic review of the design and operation of the system to predict the possible accidental leaks of hazardous material.

The defined hazards can be analysed using many tools such as FTA and ETA. FTA is a systematic and deductive approach that focuses on hazardous outcomes (top event) and develops further to the basic causes (bottom event) that lead to such unwanted outcomes. FTA is also used widely in hazard analysis of the various storage facilities. ETA is a graphical and inductive tool that presents all the final consequences resulting from a particular initiating event, with considering the states (failure/success) of the installed safety barriers. The accidents frequencies can be estimated by ETA if the data about initiating and heading events are known. Otherwise, it can be derived from databases such as OGP or HSE. The major goals of this study were

I. preventive goals to provide all possibilities, which assist to prevent accidents and injuries in the crude oil storage tank farm,
II. Protective goals to provide protection for workers, equipment and maintain workplace safety.

## 2.2 Types of oil storage facilities (Tanks).

This Part shall apply to all matters relating to the processing, enforcement and construction of storage facilities of all liquid fuels and gas in Malawi (*Regulations of Liquid Fuels and Gas Amendment 2017.Pdf*, n.d.). There are various types of oil storage tanks that players in the oil and gas industry can choose from. The choice of the storage tank is informed by the intended use (Oil Care 2019). In most of the cases, above ground oil storage tanks are made of polyethylene or steel. These tanks come in different types, including single skinned tanks, double skinned or integrally bundled tanks (Oil Care 2019). Description of each of these types of tanks is provided below:

**2.2.1 Single Skinned Oil storage tanks:** These types of tanks are comprised of a single layer of plastic or steel. It is recommended that these tanks together with their pipework should be placed in a secondary containment system. This system is commonly known as the bund. These tanks are a great risk

because in case of leaks, the product goes directly to the environment (Oil Care 2019). It is because of these risks that these tanks should only be used for above-the-ground storage. This is to enable physical monitoring and easy detection of any form of leaks. It is also recommended to perform frequent internal inspections to enable prompt identification of any wear arising from corrosion (Oil Care 2019).

2.2.2 **Double skinned tanks:** These tanks are comprised of two layers of plastic or steel. The space between the two layers is normally very small and thus ancillary equipment is placed outside the 2nd skin. The second skin also provides structural support to the tank. This considerably reduces the chances of failure while at the same eliminating the need for frequent maintenance procedures (Oil Care 2019). These tanks are particularly recommended for underground oil storage. This is because the space in-between the outer and the inner skins can be used in monitoring any leaks. This is unlike in single-skinned tanks where leaks can be directly absorbed by the ground without the owner noticing (oil care 2019)

2.2.3 **Integrally bundled tanks:** These tanks are comprised of both a primary container and an integral secondary containment. Any ancillary equipment is placed in the secondary containment. One of the major advantages of these types of tanks is that they are well designed to guarantee environmental protection (Oil Care 2019). In case of internal leaks, the stored product does not get to the surrounding environment. Considering the high safety measures imposed on these types of tanks, they are highly recommended for oil storage (Oil Care 2019).

Malawi energy regulatory liquid fuel and gas production and supply acts about of Storage tanks specifications it states that All Storage Tanks shall be made of mild steel or any other approved material designed and protected according to the standards approved by the Authority in conjunction with the Malawi Bureau of Standards. All storage sheds shall be prepared, constructed and maintained in the manner prescribed in Part II of the Fifth

Schedule hereto(*Regulations of Liquid Fuels and Gas Amendment 2017.Pdf*, n.d.) And all gas storage plants, sheds and cylinders shall be constructed or installed, as the case may be, and maintained, in the manner set out in Part III of the Fifth Schedule hereto

### 2.3 Construction of fuel storages facilities

To ease and standardize inspected- on, maintenance and repair procedures of oil and gas tanks, the Malawi Energy Regulatory Authority (MERA) has developed very stringent measures (production and supply act. Cap.50:03). These measures are supposed to be observed at all stages of oil storage, including during material selection of the storage tanks, design, actual construction and safe management of the operational storage tanks ('Regulations of Liquid Fuels and Gas Amendment 2017). The development of the MERA guidelines was motivated by international standards of API. Storage tanks may be constructed entirely below, partially above or completely above the surface of the ground.

Storage tanks entirely below the ground shall be covered with soil or any other material approved by the Authority to a minimum depth of three hundred millimeters with the exception of manhole covers. Where there is possibility of water supplies, courses or drainage systems being contaminated, in the event of serious leakage from the storage tank, such tank shall be completely surrounded by concrete of such thickness as the Authority may deem sufficient.

Modes of construction of storage tanks are specified by MERA that Storage tanks constructed partially above the surface of the ground may be set in any one of the following approved ways set out herein below.

I. The storage tank may be left exposed in a pit excavated in the ground, the sides of which shall be carried out to easy slopes and any such pit must be capable of holding at least ninety per cent of the total holding capacity of the tanks of the brand of liquid fuel in question. Any such storage tank may be bundled with clay or any other impermeable core as the case may be.

II. Where the storage tank is not more than 13.7 meters in height, the same shall be sunk below the surface of the ground at a depth being not less

than sixty per cent of its diameter and mounded over completely with soil to a minimum depth of three hundred millimeters, with the exception of the manhole covers.

III. The storage tank may be sunk less than 1.5 meters below the surface of the ground and constructed and mounded over completely with soil to a minimum depth of three hundred millimeters, with the exception of the manhole covers. above and the soil shall be supported by retaining walls constructed in brick, concrete or any other material approved by the Authority: Provided that where, in the event of serious leakage, there is a possibility of water supplies, courses or drainage systems being contaminated, the following additional conditions shall apply:

IV. The Minimum distances between any storage tank and the boundary of the storage area shall be at least three meters and the minimum distance between storage tanks constructed partially above or completely above the surface of the ground shall also be at least three meters and the minimum distance between storage tanks constructed wholly below the surface of the ground and mounded over with soil to a depth of not less than three hundred millimeters shall be one meter.

It is lawfully that All Storage tanks for liquid fuels and gas shall be prepared and constructed in the manner prescribed above.

### 2.4 Oil tank maintenance

Maintenance of oil storage tanks should be a scheduled routine. It is a practice that ensures the storage tanks are always in good working condition and do not pose a safety risk to users or workers ('Steel Tank Institute' 2011). Maintenance of oil and gas tanks is especially very essential because of the catastrophic nature of oil and gas incidents which have been experienced in the past. The ease of maintenance is influenced by the type of oil storage tank under consideration ('Steel Tank Institute' 2011). Installation of a proper storage tank is the first measure to an easy maintenance experience. For instance, a double walled tank will require less maintenance than a single-walled tank. This is because the latter is more prone to failure compared to the former ('Steel Tank Institute' 2011). It is worth-noting maintenance on oil storage tanks should be scheduled. This means the

maintenance procedures have to be performed regardless of the condition of the tank. However, there are some cases when maintenance procedures can be performed prior to the scheduled time. One of such instances is when there are signs of oil drips. This might be an indication of a leak which might worsen if not promptly repaired ('Steel Tank Institute' 2011). The second sign that would call for prompt maintenance procedures is the smell of fuel. This is an indication of leakage. However, it is not uncommon to have the smell of fuel when a tank is being refilled. This is because of the oil vapour that escapes during the process. Therefore, at such times, the smell may be ignored and maintenance procedures performed as scheduled ('Steel Tank Institute' 2011).

## 2.5 Oil Tank Inspection

Oil and gas tank inspection is an inevitable routine for oil and gas companies. It is a proactive measure aimed at checking the integrity of storage tanks. This in turn prevents the occurrence of major catastrophes that follow unfortunate incidents such as oil and gas leakages and bursts. While this has been observed by most of the oil and gas companies, the time taken in the exercise has resulted in financial losses (Papasalouros et al 2011). This is because the storage tanks are put out of service until the exercise is completed. Fortunately, technological advances have not only reduced the time taken during inspection, but also the exercise can be done while the tanks are still in use. Improved ultrasonic (UT) inspection techniques are convenient and effective for storage tank inspection. The methods are capable of monitoring and assessing the integrity of the tank without necessarily removing the tanks from service. This means there is no loss of productivity when these methods are used (Papasalouros et al 2011). The UT methods basically work by collecting large quantities of UT data and subjecting it to intensive analysis using the readily available data analysis tools. This analysis gives a detailed report about the integrity of the tanks. However, these methods are applicable to the aboveground storage tank (AST) floors (Papasalouros et al 2011). Electronic advances experienced in the past one decade have greatly enhances floor inspection for the aboveground storage tanks (Schempf et al 2005). The in-service robotic technology used in these tanks has not only improved inspection and cleaning capabilities, but it has also

considerably improved operational efficiency. It is estimated that over 2000 in-service robotic inspections were done by 2009. This means by 2020, the number will have tripled (Raisutis et al 2017). It is important to note that some tanks may need out-of-service inspections, despite the robotic technology being capable of performing in-service inspections. The decision to perform either in-service or out-of-service inspections is determined by various factors, including their age, inspection history and their condition. In cases where these factors are not favourable, it is advisable to put the tanks out-of-service before performing the inspections (Schempf et al 2005). However, it is anticipated that given the difficulties experienced in removing a tank from full service, the robotic inspection technology, which is compliant with the API standard 653 provisions will be extensively used in the near future (Schempf et al 2005). The following section details because oil tank inspection procedures are very important to every oil and Gas Company and individual oil tank owners.

Tank inspection is a proactive measure undertaken by players in the oil and gas sector. There are various reasons that inform frequent oil tank inspections. The first reason is to reduce the probability of a catastrophic tank failure (De Simini and Raymond 2010). Inspections are meant to ensure that the condition of the storage tank is closely monitored. It is through this monitoring that it is possible for inspectors to notice any conditions that can result in catastrophic tank failure. An example is corrosion which weakens the tank over time, hence increasing the chances of a catastrophic failure (De Simini and Raymond 2010). The second reason for conducting the inspection is to identify problems and perform the necessary repairs before any significant amount of oil is lost. In most cases, oil is stored in underground tanks (De Simini and Raymond 2010). This means cracks or holes in the tanks as a result of corrosion can lead to loss of fuel to the ground. This would result in great financial losses if this occurs for a long period of time without detection. It is therefore advisable to conduct such inspections to ensure that the integrity of the tank is intact and thus not prone to such losses (De Simini and Raymond 2010). Another important reason for inspections is that they are cost-saving. This is because they enable tank owners to detect problems when they are still at their early stage. At this time, the repairs needed are small, easy to perform and less costly to remedy. Additionally, since the repairs are minimal, the tank only requires to be put out

of service for a very short duration of time ('Health and Safety Executive' 2009). This is unlike when the problems are detected when it is too late. In such cases, major repairs which are usually too expensive may be required. The tank would also be put out of service for a very long duration of time. This would translate to massive financial losses in terms of the expenses incurred during the actual repair and loss of productive time for the period the tank would be out of service ('Health and Safety Executive' 2009). The following sections detail the conventional and the modern oil tank inspection methods.

# CHAPTER 3: METHODOLOGY

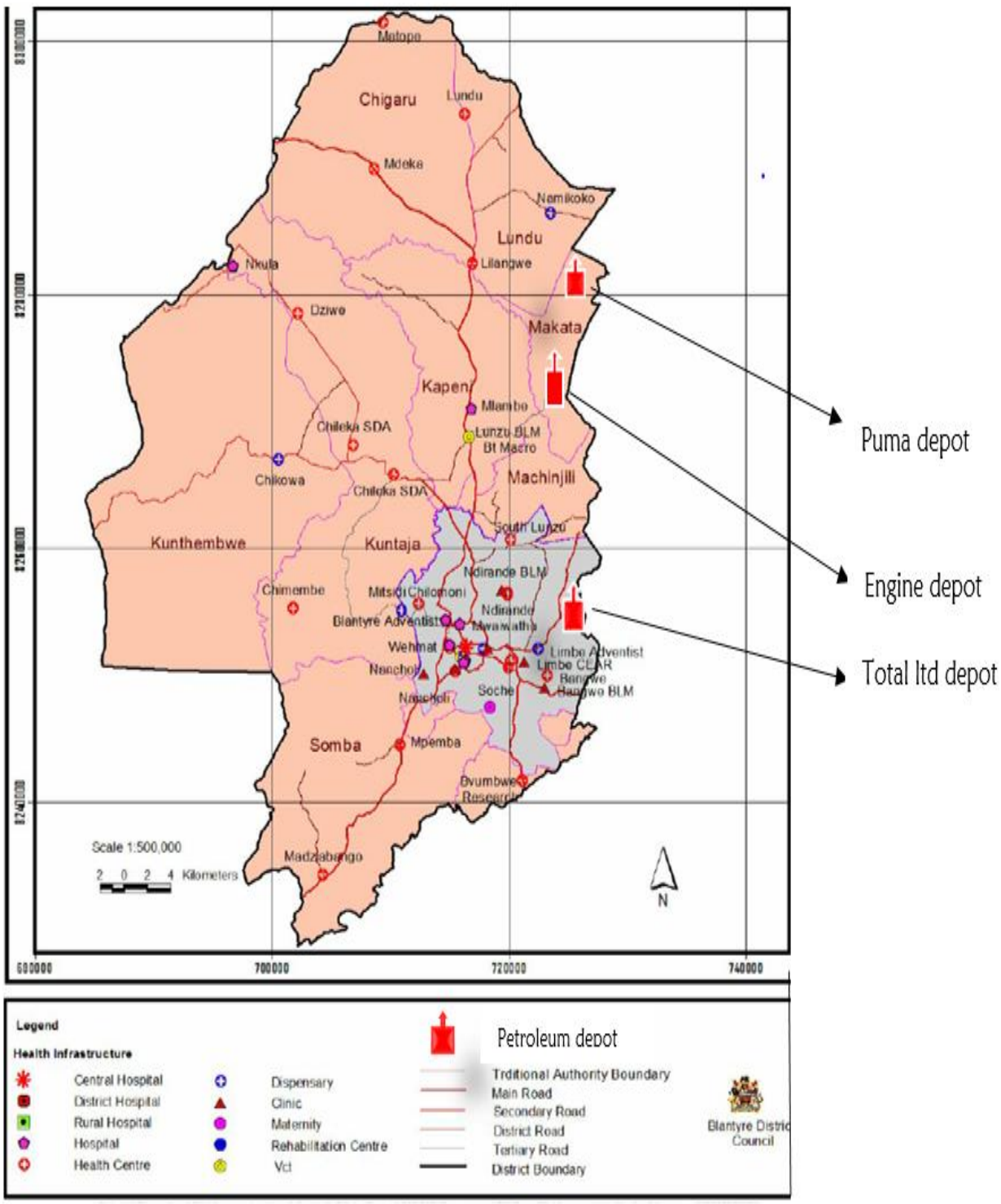
In this chapter, a detailed description of the methods applied in the study is provided. Creswell (2014) observes that the methods used in a study are very critical. They influence the reliability of findings. As such, it is highly recommended that all the methods, techniques and procedures used should be justifiable. In agreement with this statement, the methods used in this study have been adequately justified. The chapter is divided into several sections. These include study area, the research design, data sources, data collection methods, reliability, data analysis methods, ethical considerations, limitations and the data analysis procedures.

## 3.1 Study area.

Blantyre district is located in the southern region of Malawi with a total area of about 2100km2. Blantyre City is the oldest and second-largest city in Malawi. It was established by the Scottish missionaries in the 1870s and declared a planning area in 1897. It is the main commercial city hosting most of the private sector headquarters in the country. Because of higher commercial activities and cooperation in the city makes most oil marketing companies to establish their investment in Blantyre.

There is higher commercial activities and cooperation that makes most oil marketing companies to establish their investment in Blantyre.

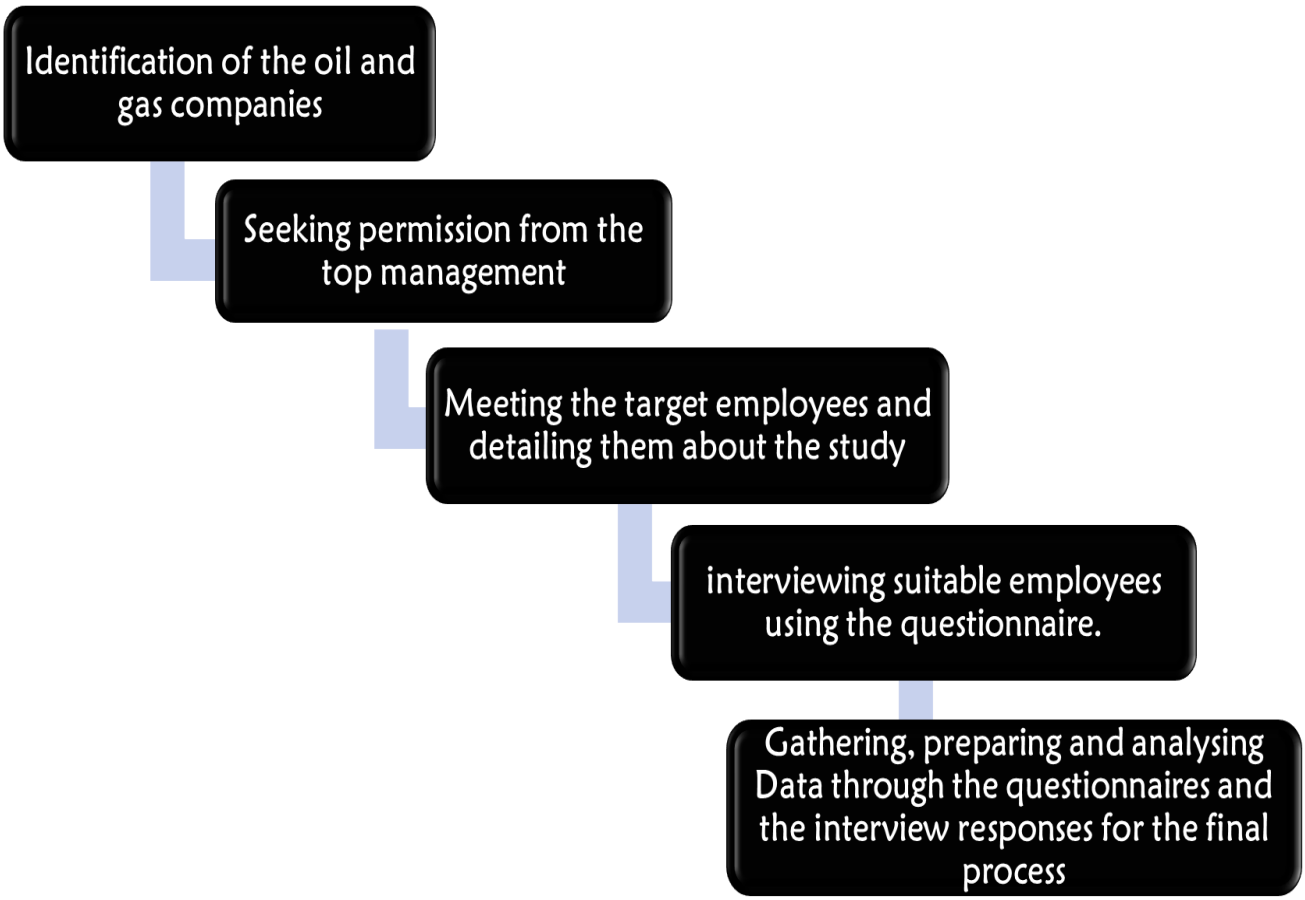
*Figure 1: map showing location of Blantyre district.*



### 3.2 Data collection methods

Kara (2012) recommends a systematic or procedural data collection process. Systematic in this context implies that the procedure must be justifiable. They should not be an arbitrary set of stages.

In this regard, the data collection procedure used in this study was characterized by several steps




The first step was the identification of the oil and gas companies from where the data would be sourced. After the companies had been identified, the second step involved seeking permission from the top management about the intention of engaging some of their staff and inspecting the area. This was necessary to avoid cases where the employees would be stigmatized for participating without the approval of the top management. The third stage was meeting the target employees and detailing them about the study. This was followed by purposive sampling, where the most suitable employees were identified. The fourth stage was interviewing suitable employees using the questionnaire.

This was very important because it helped reduce the amount of time spent in data collection. The respondents decide the time convenient time for the interviews.

The interviews were conducted inside the storage area and 16meters outside the area and session took approximately 1hour and 30 minutes. This was done in order to observe other satisfaction of the authority by those who are not employed by the company but are in connection with the storage area.

Following successful administration of the questionnaires and the interview questions, the data was gathered through the questionnaires and the interview responses and was prepared and analysed for the final process.

### 3.3 Data analysis method

Creswell (2014) defines data analysis as the process of getting meaning from data. The quality of analysis influences the reliability of the conclusions. Qualitative and quantitative data analysis methods were used in this study. The use of these two data analysis methods was justified because of two main reasons. The first reason is that the responses collected through the questionnaires are quantifiable and this allows for quantitative data analysis methods to be used. On the other hand, the data collected through interviews was qualitative in nature.

Thematic analysis was used for qualitative analysis. According to Kara (2012) thematic analysis entails identifying data patterns or common themes. There are several reasons why a thematic analysis was justified in this study. Advantage of this method is its simplicity to make reliable findings. Thematic analysis involved a number of steps. The first step was familiarizing with the data collected from different respondents. This means varying responses were obtained and especially for the interviews. It was therefore important to read the responses to get an idea of what the responses contained. Finally, the identified themes were explained in relationship to the study objectives.

### 3.4 Ethical consideration

Kara (2012) notes that ethical considerations are essential in studies involving human subjects.

Human subjects were involved in this study. Therefore, adherence to ethical standards helped cultivate a cordial interaction with the respondents. It is also because of adhering to acceptable ethical standards that conflicts were avoided contributing to a successful incident-free study.

Informed consent is the first ethical consideration made in this study. In line with the requirements of informed consent, all the participants were comprehensively informed about what the study involved. This was done three weeks prior to the start of the study. This gave them sufficient time to decide whether they were willing to participate or not.

Confidentiality was also observed during the study. This was achieved in two main ways. First, the respondents were advised against including any personal details in the questionnaires. Personal details in this case include information such as the name, phone numbers or physical addresses. On the same note, the researchers did not record identifying information of any respondent. The reporting has also been done in a way that it is not possible to link the responses to the respondents. The use of information for the intended purpose was another ethical consideration that was made in this study. The respondents were informed about the purpose of the study and the intended use of the information. This means using the information for any other purposes would be unethical. Therefore, the information was protected and strictly used for the intended use.

Finally, the research cited all information obtained from secondary sources. In this research, both primary and secondary sources were used. It is an ethical practice to acknowledge the work of others rather than presenting it as one's own work.

### 3.5 Limitations and the data analysis procedures

Creswell (2014) describes limitations as the occurrences beyond the control of the researcher and which negatively affects the reliability of findings. Similar to any other study, several limitations were experienced in this study.The first limitation arose from

the unavailability of some of the respondents at the scheduled time for interviews. The busy work schedules made some of the respondents to keep on postponing or changing their scheduled interview time. Additionally, the respondents demanded rushed interviews as they had other activities to attend to. This affected their concentration during the interviews. This is an aspect that I believe might have negatively affected the reliability of findings.

The second limitation was Distance to the study area. Most petroleum depots are installed there far from where peoples live, this gives the study limit in terms of transport in times of interview and discussion times.

# CHAPTER 4. RESULTS

This chapter details the results obtained following the application of the methodology described in the previous chapter. The chapter is divided into two major sections. The quantitative section provides an analysis of quantitative data. The qualitative section presents an analysis of the qualitative data. Each of these sections is divided into a number of sub-sections

## 4.1 Quantitative Analysis

This are Numerical data that comprise of numbers that used to analyse the data collected.

### 4.1.1 Adherence to the MERA standards.

Despite the introduction of the MERA guidelines in 2004, not all petroleum industries in Malawi run through it some follow international standards while only local companies follow the local standards which are MERA standards. It is based on such occurrences that this question sought to determine the percentage compliance to these standards

| *COMPANIES* | MERA standards | API standards |
|---|---|---|
| *TOTAL PUMA* | | |
| *VIVO-ENERGY* | | |
| *NOCMA* | | |
| | 1 | 2 |

*Table 1: shows the compliance to MERA standards*

Sample size of three depots were used to calculate the percentage of compliance n! =N! *n/N

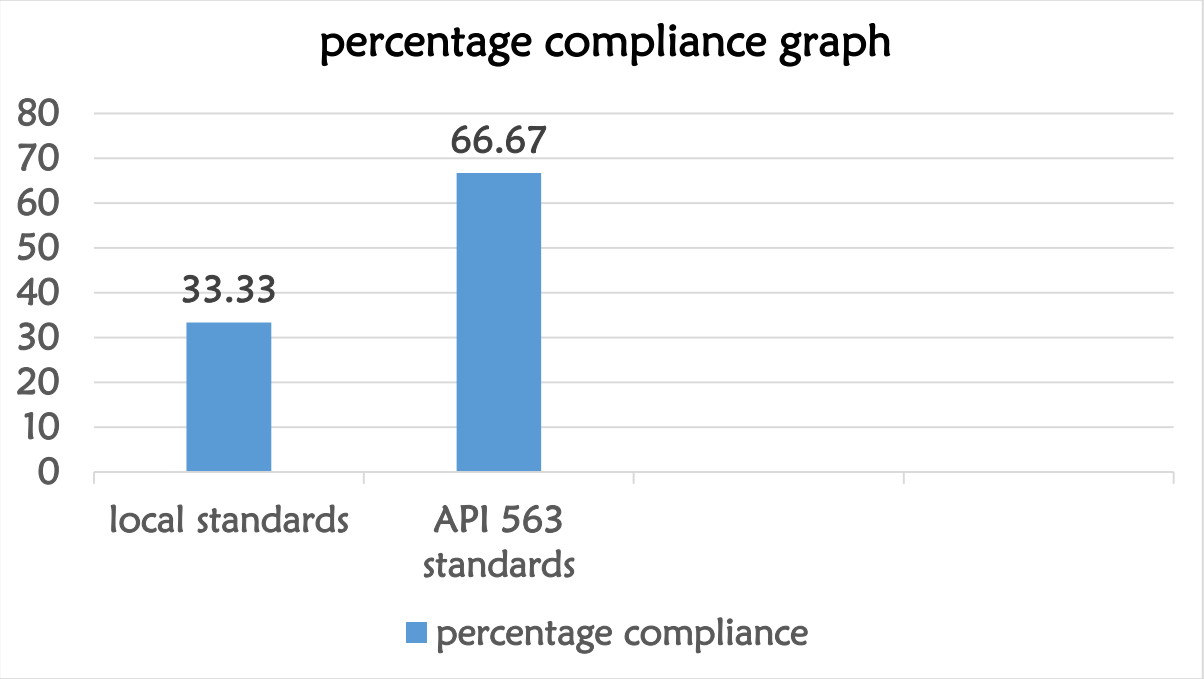
N! = percentage of subjects to be drawn from stratum I,

Ni=population in stratum I,

n= required sample size,

N =overall population.

*Figure 2 bar chart showing percentage of compliance*




### 4.1.2 Number of human casualties.

The types of human casualties collected and recorded between the years (2019-2022)

| *Personnel casualties* | *Deaths* | *Seriously injured* | *Slightly injured* | *Total* |
|---|---|---|---|---|
| *Number* | *1* | *9* | *21* | *31* |

**Table 2: number of death, serious and slight injuries at the depot**

The information shown in the table above indicates that slightly injured is the most casualties recorded between four years.

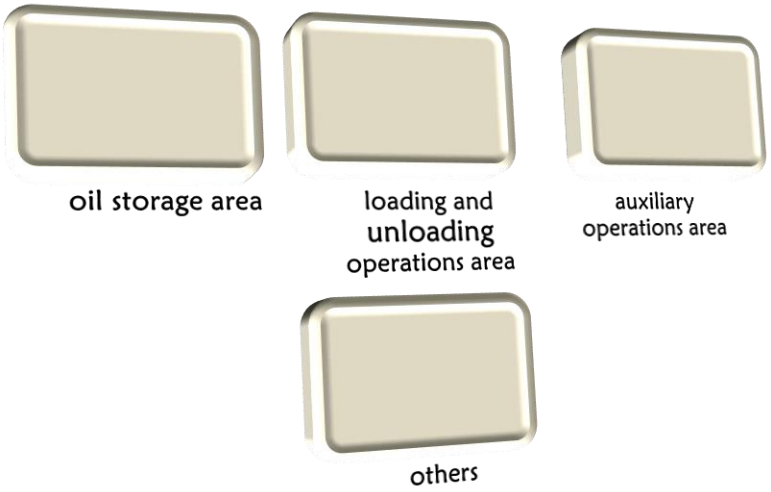
### 4.2 Qualitative Analysis

This are categorical data. They are not numerical in nature, and comprise names or categories. For example, names of Areas that are very vulnerable to accidents and categories of accidents occurred at the depot.

### 4.2.1 Vulnerable Areas of Accidents at the Depot.

This were names of areas to occur accidents at the petroleum deport and names were listed and collected for final analysation.

***Figure 3: shows name of area that are very prone to accidents***



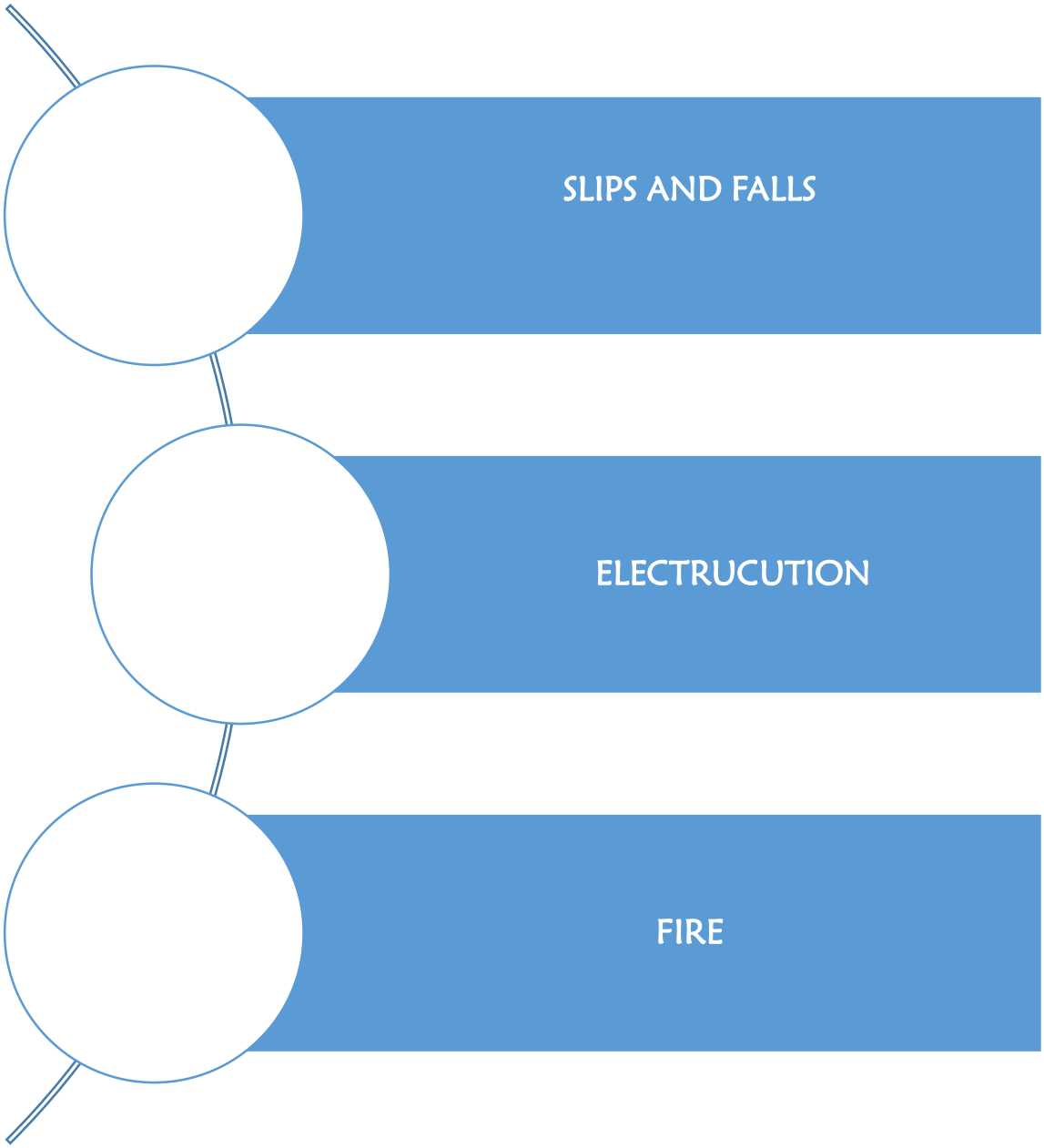

### 4.2.2 Common Accidents at the depots.

This are categories of accidents occur at the depot during their normal operation.

This were accidents recorded at the depots from period of four yeas (2019-2020).

The figure below shows the most common accidents to occur at the storage depot

*Figure 4: common accidents at the depot*



# CHAPTER 5. CONCLUSION AND RECOMMENDATIONS

Safety inspections routine of oil and gas storage tanks are very crucial exercises. The goal of these procedures is to prevent the catastrophic failures of oil and gas storage tanks. It is the severity of the effects of tank failures that motivated the MERA to develop standard guidelines to be observed by oil and gas companies and the storage tank owners in Malawi. It is also the need for effective inspection and review the procedures that oil and gas companies and the storage tank owners in Malawi have been followed and to determine how the MERA standard guidelines affect project management Procedures during inspection, maintenance and repair of oil storage tanks. Findings revealed that there is need to increase compliance by oil and gas companies and tank owners. Frequent monitoring and auditing are one of the approaches that can be used to improve compliance.

The inadequacy of the personnel was one of the reasons attributed to non-compliance with the set guidelines. It is therefore advisable for the institute to remove the hurdles the inspectors face when looking for certification. This would increase the compliance level and subsequently increasing the safety standards of the storage facilities.