Mitigating risks associated with Lockout/Tagout (LOTO) of Hazardous Energy in Nigeria - A tracker approach

EA AGHENTA

20977549

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Supervisor:

Prof J.H. Wichers

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PREFACE

This Research focuses on the mitigation of risks present in the lockout and tagout of hazardous energy. The Occupational Health and Safety Code 2009 Explanation Guide, defines hazardous energy as " *electrical, mechanical, hydraulic, pneumatic, chemical, nuclear, thermal, gravitational, or any other form of energy that could cause injury due to the unintended motion energizing, start-up, or release of such stored or residual energy in machinery, equipment, piping, pipelines, or process systems".*

There are risks associated with electrical hazards, which according to (NFPA 70E, 2004) is defined as "*a dangerous condition such that contact or equipment failure can result in electric shock, arc-flash burn, thermal burn, or blast*". The study is carried out using questionnaires and oral interviews. Relevant electrical books, manuals, standards, publications and internet resources were also used to gather the required information needed to carry out this study.

The Power Holding Company of Nigeria (PHCN) was used as a case study. During the course of this research, it was found that the Lockout/Tagout procedure and documentation in PHCN is not adequately managed in such a way that would help to mitigate risks associated with the unintentional release of hazardous energy. The Company seems to have a written energy control procedure which is not so clear, with a good percentage of workers not so sure of its availability. This leaves many workers without the guidance to perform LOTO procedures effectively.

What was therefore done, as a direct outcome of this research was to develop a LOTO procedure that tracks the implementation of LOTO by all involved with a view to creating a clear and consistent means for energy control, hence, improving safety.

The findings / results of this research were used in the development of the LOTO procedure, which could be used by electrical personnel saddled with the responsibility of isolating hazardous energy to ensure reduction in exposure to electrical hazards.

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ABSTRACT

Lockout and tagout is a means of preventing the uncontrolled release of hazardous energy. Electrical accidents are not as few as statistics show in Nigeria as many accidents remain unreported. Underreporting of electrical accidents causes lack of information about existing electrical safety problems, and prevents mitigation actions to be carried out.

The use of written LOTO procedures by Power Holding Company of Nigeria (PHCN) electrical personnel is not encouraging in Nigeria. In order to decrease the exposure of personnel to electrical accidents, there is a need for more information about the risks associated with LOTO of hazardous energy.

The main objective of the study was to determine the risk(s) associated with lockout/tagout of hazardous energy and propose a new LOTO procedure which tracks the implementation of LOTO to mitigate against identified risks as a basis for promotion of safety. The study focuses on electrical personnel working in PHCN. Only electrical accident risks are examined, not other types of risk e.g. mechanical, chemical, and nuclear.

To gather material for this study, a questionnaire was distributed amongst electrical workers in PHCN and their supervisors were interviewed. Relevant literature and publications were studied as reference.

According to electrical personnel experience, electrocution, arc flash, arc blast, burns and lockout and tagout of the wrong electrical circuit are seen as the biggest electrical safety risk with regards to LOTO of hazardous energy.

The research reveals new information about electrical accident risks. This information is used to create a procedure for tracking LOTO of hazardous energy. The procedure can be utilized in the mitigation of electrical risks and promotion of electrical safety.

KEYWORDS

Lockout and Tagout (LOTO)

Power Holding Company of Nigeria (PHCN)

Electrical Personnel

Hazardous Energy

Electrical Isolation

De-energisation

Tracking

Risk

Mitigation

Electrocution

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LIST OF ABBREVIATIONS

AC:	Alternating Current
ANSI:	American National Standards Institute.
CEO:	Chief Executive Officer
DOE:	United States Department of Energy
GE:	General Electric
IEC:	International Electrotechnical Commission
IEEE:	Institute of Electrical and Electronic Engineers
JSA:	Job Safety Analysis
LOTO:	Lockout Tagout
LV:	Low Voltage
MA:	Milliamp
NEPA:	National Electricity Power Authority
NIOSH:	National Institute for Occupational Safety and Health
NFPA:	National Fire Protection Association
NERC:	Nigerian Electrical Regulatory Commission
OSHA:	Occupational Safety and Health Administration
PHCN:	Power Holding Company of Nigeria
PPE:	Personal Protective Equipment

CHAPTER 1

INTRODUCTION

1.1) Background of the Study

The purpose of lockout and tagout (LOTO) is to save lives and prevent damage to equipment. LOTO is the practice of shutting down and disconnecting power from machinery or equipment and placing locks and tags on energy-isolating devices to prevent activation of the equipment during maintenance or servicing (OSHA 3120, 2002).

According to (Jeffrey & Fontaine, 2012), the risk of injury can depend on circuit conditions or on the degree (capacity) of the hazard. Unless an electrically safe work condition exists, some risk of injury from an electrical hazard exists. However, for an electrically safe work condition to exist, LOTO of hazardous electrical energy needs to be done correctly.

Injury statistics as a result of contact with electricity in Nigeria is not readily available. However, (Jeffrey & Fontaine, 2012) gives an idea of the worldwide statistics by stating that approximately 30,000 nonfatal electrical shock accidents occur each year. The National Council estimates that about 1000 fatalities each year are due to electrocution, more than half of them while servicing energized systems of less than 600 volts.

From 2003 to 2009, contact with electricity was the seventh leading cause of total occupational fatalities, making up about 4 percent of all occupational fatalities (Jeffrey &

Fontaine, 2012). During this period there were 38,124 fatalities from all causes, and 1,573 of those were due to contact with electric current. In 2009, contact with transformers or other electrical components amounted to around 36 percent of the fatalities, and contact with overhead power lines amounted to around 38 percent of the fatalities. Coming in contact with an electrical voltage can cause current to flow through the body, resulting in electric shock and burns (Figura, 1996). Serious injury or death may occur.

1.2) The Problem

The National Institute for Occupational Safety and Health (NIOSH) in an alert (DHHS NIOSH, 1999) request assistance in preventing the death or injury of workers exposed to the unexpected or uncontrolled release of hazardous energy. In that alert, hazardous energy is regarded as any type of energy in sufficient quantity to cause injury to a worker. Common sources of hazardous energy include electricity, mechanical motion, pressurized air, and hot and cold temperatures.

When electrical equipment has been de-energized, OSHA Part 1910.147 (c) and 1910.333 (b) (2) requires Lockout/tagout procedures be followed. Failure to follow Lockout/tagout procedures is also consistently listed as one of the top ten OSHA violations. Craft workers, machine operators and labourers are among the 3 million workers who service equipment and face the greatest risks (OSHA 3120, 2002). Workers injured on the job from exposure to hazardous energy lose an average of 24 workdays for recuperation.

Injuries attributed to improper Lockout/Tagout are often serious or fatal. According to the same NIOSH Alert, out of the 152 fatalities investigated in 20 states of the United States of America during the years 1982-1997, the factors that contributed to these deaths were: Failure to completely de-energize the power source was 82% of the 152 deaths, failure to Lockout/Tagout was 11% of the 152, and failure to check to make sure all power sources were locked out/ tagged out were 7% of the 152 fatalities.

Injuries and deaths still occur when LOTO is performed on equipment to be worked on in Nigeria. The PHCN is the Utility Company responsible for the generation, transmission, distribution of electricity in Nigeria, as well as carry out maintenance work to ensure availability of electricity to consumers. The likelihood that risks still exist is there. This research is done with the aim of finding out the risks encountered by the electrical workers in PHCN while working on electrical equipment. The problem to be researched therefore is the risks associated with the inadequacies in the execution of LOTO of electrical hazardous energy and the mitigation thereof.

1.3) Solving the Problem

The problem of risks associated with the unexpected release of hazardous energy can probably be solved by the adherence of electrical personnel to procedures on LOTO of hazardous energy. The question is, 'are the electrical workers working according to procedure?' In view of this, the solution might be to develop a new LOTO procedure which has a provision for tracking the implementation of the procedure. This would be the purpose of the newly developed LOTO procedure to help mitigate the identified risks.

1.4) Aims of the Research

The overall aim of the study is to promote electrical workers' safety. This is done by identifying causes of perceived electrical accident risks with regards to LOTO of hazardous energy, and developing a new lockout and tagout procedure aimed at tracking the implementation of LOTO by electrical workers to mitigate the associated risks. By tracking, the researcher means that the procedure shall have a provision for a dedicated individual(s) to monitor and confirm that all steps in the procedure are followed.

The starting point of the research was knowledge of the immediate causes of electrical accidents, that is, failure to follow Lockout/Tagout procedures. This had already been identified by previous research, standards, and experts from the electrical field. Keeping the main objective in mind, the initial research questions of the study were:

1. Why are LOTO procedures not followed?

- Why is de-energizing not done?

- Why is voltage testing not done?

2. How can the implementation of LOTO of hazardous energy be tracked to ensure safety of electrical workers?

The previously identified immediate causes of electrical accidents were used as basis for the first research question. The second research question was formulated in order to develop a new LOTO procedure which allows for tracking the execution of LOTO of electrical hazardous energy.

The main aim of this research is therefore to:

1. Identify the risks involved in the control of electrical hazardous energy.
2. Develop a new LOTO procedure to mitigate risks associated with control of electrical hazardous energy.

1.5) Research Procedure

To carry out this research, two methods were chosen; the use of questionnaires and interviews. Using the Power Holding Company of Nigeria (PHCN) as a case study for the purpose of this research, questionnaires were distributed amongst electrical workers who repair, maintain and service electrical equipment.

Interviews were also conducted with PHCN supervisors in different business units with the aim of gaining a deeper understanding of the LOTO procedure(s) being used.

A final conclusion based on questionnaire and interviews feedback was then made, forming the basis for the development of the new LOTO procedure.

1.6) Beneficiaries

The research would be beneficial to electrical personnel working in PHCN, especially those in the Maintenance units as it emphasizes the need to follow the procedure while performing LOTO of equipment in an effort to mitigate against electrical hazards.

1.7) Scope and Limitation of the study

This research has been limited to a single organization, the PHCN. The Eko Zone of PHCN has been used as the case study to be evaluated.

The major limitation was the difficulty of gathering information from the PHCN. As a government organization, it was not easy getting access to vital statistics. The questionnaire used was done on a no-name, no-blame basis, to encourage the respondents to answer the questions in the most honest manner.

The time taken to distribute the questionnaires and receive feedback was also a major constraint on the part of the respondents and researcher due to the nature of their work. Their work requires constant movement of personnel to attend to electrical issues and rectify them. Hence, not all the questionnaires were filled out. A breakdown of the questionnaire feedback is given in chapter 4. Arranging of interviews with Supervisors of the Operations and Maintenance Units in the different business units was also not easy, as they were not always in their offices, due to the numerous meetings, and travels they embarked upon. Eventually though, the interviews were conducted, with some taking less time than others.

CHAPTER 2

LITERATURE REVIEW

2.1) Introduction

The enactment of the lock-out/tag-out standards by OSHA and other bodies was done to prevent hundreds of accidental deaths and injuries from the accidental start-up of electrical equipment and exposure of workers to hazardous energy (OSHA, 2000). Even with federal and state regulations, injuries and deaths continued. This chapter will review relevant literature and sources to examine if there is a relationship between employee accidents and LOTO of hazardous energy.

2.2) Accidents and their effects

Several case histories are reported to describe the tragedy of employees injured or killed while on the job when exposed to electrical equipment which were not de-energized or partly de-energized prior to performing work:

An employee was crushed when a scissors lift powered by hydraulic energy descended onto him. One of the findings from the resulting inspection indicated a lack of training in lock-out/tag-out (Sanchez, 2002).

The California Fatality Assessment and Control Evaluation reported that a recycling packer died after becoming crushed inside of a paper-recycling bin. A mechanical ram exerting 118 tons of force was accidentally triggered by the employee while he was inside of the bin (Mullen, 2004). Although there were no witnesses to the accident, it is hypothesized that the victim entered the bin to try to manually dislodge or retrieve obstacles inside. The investigator concluded that deficiencies and contributory factors to the accident included the employer's lack of following effective lock-out/tag-out procedures, and that the main power source for the recycling bin was located in an area difficult to access.

OSHA conducts investigations following serious occupational accidents and deaths. Many of the inspections result in significant penalties and citations against the employer for violations against established regulations and standards (Williamson & Feyer, 1998). The regulations pertaining to lock-out/tag-out are clearly defined. The proposed citations often relate to a lack of written programs and employee training for following energy control.

Fig.1 Accidents due to exposure to hazardous energy (*Source: CCPS, 2005*)

In the case of the employee killed by the descending scissors lift, OSHA proposed penalties of $102,000. The serious penalties included a lack of enforcing lock-out/tag-out procedures and failure to conduct periodic inspections of energy control procedures (Sanchez, 2002).

2.3) PHCN Electrical Accident Statistics

Power holding company of Nigeria (PHCN) formally known as National Electricity Power Authority (NEPA) is a public corporation owned by the federal government of Nigeria to generate, transmit and distributes electricity to the population. The history of electricity (power generation) in Nigeria dates back to 1898 when electricity was first produced in Nigeria. Therefore, several other towns established electricity supply by the installation of isolated generation in each town (NERC, 2007)

Like most state-owned enterprises, NEPA has suffered from severe under-funding and under-capitalization, inappropriate capital structure, excessive executive interference, and sub-optimality and decision making (Aidelomon, 2010).

NEPA equipment is subjected to vandalism and theft by groups of cabals in different parts of the country. Equipment is expensive to repair, mostly due to their obsolete status. NEPA was formally changed to power holding company of Nigeria (PHCN) in January 2004 in readiness for privatization.

Eko Electricity Distribution Plc., or Eko Disco, located in Lagos state, serves Lagos: Nigeria's commercial and financial hub, and the Agbara industrial region. Eko Disco franchise includes Festac, Ijora, Lagos Island, Ajah and Agbara/Badagry districts of the Lagos South Zone, with Benin Republic as a potential export market. Within the Zone, Eko

Disco owns and maintains electrical installations and the distribution network from its base on Victoria Island, the very heart of the Lagos business district.

Eko Disco has a total staff holding of 4,022. The Company was established as a public limited liability company on November 7th, 2005 and is managed by a Chief Executive Officer (CEO) who reports directly to the CEO, Power Holding Company of Nigeria (PHCN) Plc. On July 1, 2006, Eko Disco became a stand-alone company a step toward privatization.

In a presentation by the Commissioner of Engineering, Standards and Safety in Nigeria (NERC, 2007), an outline on safety statistics was given. It was confirmed that baseline safety statistics do not exist. The commissioner went on to say that industry sector statistics were being compiled by the NERC, but the general belief is that they are poor. A table was presented showing a total of 12 fatalities within three months in 2007.

Table.1 PHCN Reported Incidents.

Month	**2007 Reporting**			**Interrupted Service Hours**	**No. Incidents Reported**	**No. Fatalities**
	Yes	**No**	**% Response**			
June	9	16	36.0	77	11	2
July	12	13	48.0	734	16	8
August	2	23	8.0	0	2	2
Total	**23**	**52**	**30.7**	**811**	**29**	**12**

(*Source: NERC 2007*)

A breakdown of the status of safety programs in the Utility Company PHCN shows that:

- Current Standards date back to the 1980s
- Existing Standards do not exist as codes
- Standards are unevenly applied
- Many facilities have no formal safety programs
- Corporate policy towards safety does not exist
- Enforcement is lacking

A report released by the Nigerian Electrical Regulatory Commission (NERC) has shown that 187 people died in accidents occurring on Power Holding Company of Nigeria (PHCN) installations and other power infrastructure nationwide in the past three years. This accounts for 27 percent out of the 703 reported cases of accident. 318 people suffered various degrees of injuries according to the statistics.

The report listed causes of the accidents to include employees' bad working practices, operators disregard for safety regulations, public disregard for safety regulations such as encroachment of public on PHCN right of way and vandalism.

For example, in 2008, 171 cases of accidents were received by the NERC, out of which 45 deaths and 141 injuries were recorded. Out of this, 17 deaths were as a result of public disregard for safety regulations, three died due to vandalism of facilities, operators disregard for safety regulations was responsible for the death of 15 while 10 died due to employees bad working practices, the report said.

In 2009, a total of 244 reports were received, 49 deaths was recorded representing 17 percent while 106 were injured. 12 died due to bad employees, 14 deaths were due to operators disregard for safety regulations, 15; public disregard for safety regulations and 8 died vandalizing public utilities, the report affirmed.

In 2010, a total of 288 reports were received out of which 93 deaths and 73 injuries were recorded. According to the report, a copy of which Daily Trust obtained, 23 died due to employees' bad working practices, 25 were due to operators disregard for safety regulations, 42 died due to public disregard for public safety regulations and three died in vandalism incident.

Before 2007, there was hardly any record on safety in the power sector. Where available, they were often inadequate (Daily Trust, 2011). The Nigerian Electricity Regulatory Commission (NERC) started collating and analyzing safety record in the sector in June 2007, records from the commission show.

2.4) Lockout and Tagout Procedures

2.4.1) OSHA LOTO Requirements

In the early 1970’s, OSHA adopted various lockout-related provisions of the then existing national consensus standards and Federal standards that were developed for the specific types of equipment or industries (OSHA, 2000). When the existing standards require lockout, the new rule supplements these existing standards by requiring the development and utilization of written procedures and periodic inspections of the use of the procedures. The rule requires that, in general, before service or maintenance is performed on machinery or equipment, the machinery or equipment must be turned off and disconnected from the energy source, and the energy-isolating device must be either locked or tagged out. OSHA estimates that adherence to the requirements of this standard can eliminate nearly 2% of all workplace deaths (Senor, 2002).

OSHA defines Lockout as the placement of a lockout device on an energy-isolating device, in accordance with an established procedure, ensuring that the energy-isolating device and the equipment being controlled cannot be operated until the lockout device is removed (Bulzacchelli et al, 2007). Tagout is defined as the placement of a tagout device on an energy-isolating device, in accordance with an established procedure, to indicate that the energy-isolating device and the equipment being controlled may not be operated until the tagout device is removed.

OSHA requires that energy control procedures be developed, documented, and used to control potentially hazardous energy sources whenever workers perform activities covered by the standard (NIOSH, 1987). The written procedures must identify the information that authorized employees must know in order to control hazardous energy during service or maintenance. If this information is the same for various machines or equipment or if other means of logical grouping exists, then a single energy control procedure may be sufficient. If there are other conditions – such as multiple energy sources, different connecting means, or a particular sequence that must be followed to shut down the machine or equipment – then the employer must develop separate energy control procedures to protect employees.

The energy control procedure must outline the scope, purpose, authorization, rules and techniques that will be used to control hazardous energy sources as well as the means that will be used to enforce compliance (Lawton, 1998). At a minimum, it includes but is not limited to, the following elements:

- A statement on how the procedure will be used;
- The procedural steps needed to shut down, isolate, block and secure machines or equipment;
- The steps designating the safe placement, removal, and transfer of lockout/tagout devices and who has the responsibility for them; and
- The specific requirements for testing machines or equipment to determine and verify the effectiveness of locks, tags, and other energy control measures.

The procedure must include the following steps: preparing for shutdown; shutting down the machine(s) or equipment; isolating the machine or equipment from the energy source(s); applying the lockout or tagout device(s) to the energy-isolating device(s); safely releasing all potentially hazardous stored or residual energy, and verifying the isolation of the machine(s) or equipment prior to the start of service or maintenance work.

2.4.2) General Electric (GE) LOTO Procedure

According to (GE, 2010) unexpected release of hazardous energy can include any unintended motion, energisation, start-up or release of stored energy, deliberate or otherwise, from the perspective of the person(s) at risk. The General Electric LOTO program provides for decision-making flexibility regarding hazardous energy control methodology. Alternative methods, when used, are based upon risk-assessment. The most important element of the LOTO program is that General Electric personnel and contractors shall not perform activities with equipment energized.

GE emphasizes in their LOTO procedure the need for stored energy to also be taken into consideration. Stored energy, such as motion, pressure, gravity, capacitance or temperature, is a potential hazard that still exists after a primary energy source has been locked out. For example, a pump motor for a hydraulic system may be locked out, effectively stopping fluid flow, but energy in form of pressure may still exist in an accumulator. This pressure in the accumulator should be bled off before work proceeds. All stored energy must be controlled to ensure complete machine safety.

LOTO applies to all sources of energy, including, but not limited to, those energy sources listed below

- Primary and Secondary Energy Sources
    - Electrical
    - Pneumatic
    - Hydraulic
    - Gases

- Water
- Steam
- Chemical/Coolant
- Radiation
- Magnetic

- Stored Energy Sources
  - Rotation (mechanical motion that can cause machine or equipment movement): flywheels, circular blades.
  - Gravity (suspended material or parts that will move when energy is disconnected): elevators, heads.
  - Mechanical Energy (stored mechanical energy that can cause machine or equipment movement): compressed or extended springs.
  - Thermal Energy (extreme heat over 140 degrees Fahrenheit, or cold below 41 degrees Fahrenheit): ovens, boiling water, chillers.
  - Electrical Energy (stored electricity): batteries, capacitors.

GE maintains that the site/operation/service organization shall establish a written program for hazardous energy control that details the requirements of the LOTO program and the development and approval of alternative methods where appropriate. The written program shall be based on this LOTO program and the General Electric Framework Workplan for Health and Safety Framework. The purpose of the program is to ensure that risk of exposure to hazards will be eliminated or minimized before any authorized individual performs any activity where the unexpected energizing, start-up or release of stored energy could occur and cause injury.

2.4.3) United States Department of Energy (DOE) LOTO Program

Before implementing a lockout/tagout program, it is necessary to identify the method of equipment control used within the facility (DOE-STD-1030-96, 1996). According to the DOE, there are two approaches to equipment control, individual-controlled and centrally controlled.

For the Individual-controlled LOTO in some DOE facilities, individual workers operate equipment for the purpose of producing, assembling, testing, or packaging components or products. The equipment used may include milling machines, lathes, presses, test benches, and other machines. Each worker may be responsible for operation and routine maintenance of an individual piece of equipment.

For these workers, protection from hazardous energy sources simply means preventing the power from being inadvertently or accidentally turned on while they are performing the maintenance. The simplest and most effective method for controlling the hazardous energy is the individual-controlled lockout/tagout (Stephenson, 1993). Departments shall establish a system for employees to obtain locks, multi-locking hasps, tags and other LOTO devices. Employees shall be instructed of these procedures (DOE/ID-10447, 1993)

Under an individual-controlled lockout/tagout, the individual worker is responsible for taking all necessary actions to ensure personal safety and the safety of others during the maintenance. To aid the worker, OSHA and DOE Order 5480.19 require the following:

Locks will be used whenever possible to secure energy or hazardous material isolating devices. New equipment and major equipment modifications will be designed to permit the use of locks. Tags should be used to identify the person who placed the lock and the purpose of the lock. If locks cannot be used, installation of tagout devices is required.

Only designated personnel should have access to keys for locks that are integral to control devices (DOE-0336, 1996). If the worker deactivates equipment by removing the key from the control switch, it is essential to ensure that no additional keys are available to unauthorized personnel. Additionally, the control switch should be tagged. Isolation from an energy or hazardous material source must be verified.

Specific techniques for verification should be established by facility procedures. The initial verification should include a review of pertinent controlled drawings or manuals, and a hands-on physical check of the equipment. The drawings should be used to help identify the sometimes obscure sources of power or pressure (e.g., control power, indication or interlock circuits, and sensing lines) that may be present in equipment even though the main (and obvious) sources have been isolated. If a physical check is not possible because of hazards in the area or an existing lockout/tagout, other verification, such as observation of a reliable position indicator, is required (CRD O 5480.19, 1998).

Periodic checks should be performed to ensure that isolating components remain in the proper position and that locking devices remain properly attached. If it is necessary to unlock an isolating device or place it in a position other than the prescribed position during maintenance, specific authorization should be obtained and documented. Before the change is made, persons who will perform maintenance while the deviation is in effect must clearly understand the change in protection level and any additional restrictions necessary to ensure safety.

Other DOE facilities have a central organization that is responsible for operation of the facility or process, or interrelated systems that are not necessarily under a single individual's control (DOE-STD-1030-96, 1996). The facility may contain highly complex specialized equipment, such as a reactor or a particle accelerator, or it may contain equipment spread over a large area, such as electrical distribution systems. In facilities like these, certain process and specialized safety functions may be required to ensure the safety of personnel, equipment, and the environment, even though maintenance is being performed on other parts of the system. This is known as the Centrally Controlled Lockout/Tagout

In these facilities, lockout/tagout is more clearly a part of the overall program for control of equipment and system status, and therefore must involve operations personnel and supervision in the approval and implementation process. Maintenance personnel are not normally trained in the requirements for safe operation of the process systems; therefore maintenance personnel are not normally authorized to operate facility equipment, except within the requirements of specific maintenance procedures (Brian, 2010).

Lockout/tagout in centrally controlled facilities requires effective coordination between operations and the personnel performing maintenance to ensure that appropriate safety functions are maintained and that a safe work environment is provided. Coordination is also required when a lockout/tagout in one facility could affect systems or site utilities in another facility. In some cases, operations may define equipment that can be turned over to maintenance for all work-related activities, including lockout/tagout control. In these cases maintenance must comply with all lockout/tagout requirements, including documentation and restoring the equipment to operable condition (MSC-PRO-006, 1994).

Whether the lockout/tagout is performed by operations or maintenance personnel, the process for approval and centralized control should be the same. Many of the requirements for a centrally controlled lockout/tagout are similar to those for an individual-controlled lockout/tagout. Requirements of both programs are described in the following sections.

Anyone involved with the lockout/tagout process, including preparing, placing, verifying, or accepting a lockout/tagout must be aware of the requirements for safely isolating hazardous energy or material sources (e.g., electrical circuits, fluid lines, capacitors, material storage tanks) (DOE-5480.19, 2002). The following standard practices should be supplemented by specific practices applicable to facility systems.

A lockout/tagout must isolate all sources of energy or hazardous materials that may cause personnel injury or equipment damage (US CFR, 1999). For example, isolating a pump motor for bearing maintenance should also include shutting and tagging the pump suction and discharge valves to prevent possible rotation from fluid flow.

Only controlled drawings, controlled system schematics, or other controlled documents should be used as references for determining or verifying isolation points. In the absence of controlled drawings, a physical walkdown should be performed by a qualified person to ensure that isolation will be achieved by the planned lockout/tagout (US CFR, 2001).

Facilities are required to use administrative procedures to ensure uniformity in applying their lockout/tagout program. In addition, each lockout/tagout requires a specific written technical procedure in which the isolation points and other instructions for installing and removing tags are identified. The technical procedures containing lockout/tagout instructions can be developed in any one of the following three ways:

Maintenance procedures may identify the isolation and tag locations required for a job or for a piece of equipment. In centrally controlled facilities, development of these procedures should involve operations personnel to ensure that the protection is adequate and that other systems or equipment are not inadvertently affected.

Operating procedures may be prepared and approved in advance for isolation of specific systems or equipment. Lockout/tagout instructions may be prepared and approved by the responsible supervisor or manager to meet a specific work requirement. A generic procedure for similar types or like pieces of equipment can be used as a technical procedure.

2.4.4) PHCN LOTO Procedure

According to (NERC, 2008), several occupational safety and health investigations have documented a number of fatalities whose circumstances suggest that the victims were unaware of the electrocution hazard from feedback electrical energy that were assumed to be de-energized.

An approved procedure should be developed, implemented and followed when applying a lockout/tagout. Lockouts and tagouts are attached only after the equipment is turned off and tested to ensure that power is off. The standard procedure for equipment lockout/tagout according to the NERC is:

- Prepare for machinery shutdown
- Machinery or equipment shutdown
- Machinery or equipment isolation
- Lockout and tagout application
- Release of stored energy; and
- Verification of isolation

2.5) Electrical Hazardous Energy

Coming in contact with an electrical voltage can cause current to flow through the body, resulting in electrical shock and burns. Serious injury or even death may occur. (Jeffrey & Fontaine, 2012) says that even the act of creating an electrically safe work condition can expose a worker to either electrocution and /or arc flash. Until the electrically safe work condition has been established, including the task of testing for the absence of voltage, the worker must wear Personal Protective Equipment suitable for the maximum degree for all associated hazards.

2.5.1) Electric Shock

An electric shock is the pathophysiological effect of an electric current through the human body (Batra & Ioannides, 2001). Its passage affects essentially the muscular, circulatory and respiratory functions and sometimes results in serious burns. The degree of danger for the victim is a function of the magnitude of the current, the parts of the body through which the current passes, and the duration of current flow (Kowalski & Barrett, 2007).

IEC publication 60479-1 updated in 2005 defines four zones of current-magnitude/ time-duration, in each of which the pathophysiological effects are described (see Fig.2). Any person coming into contact with live metal risks an electric shock. Curve C1 shows that when a current greater than 30 mA passes through a human being from one hand to feet, the person concerned is likely to be killed, unless the current is interrupted in a relatively short time (Schneider Electric 2010).

The point 500 ms/100 mA close to the curve C1 corresponds to a probability of heart fibrillation of the order of 0.14%. The protection of persons against electric shock in LV installations must be provided in conformity with appropriate national standards and statutory regulations, codes of practice, official guides and circulars, etc. Relevant IEC standards include: IEC 60364 series, IEC 60479 series, IEC 60755, IEC 61008 series, IEC 61009 series and IEC 60947-2.

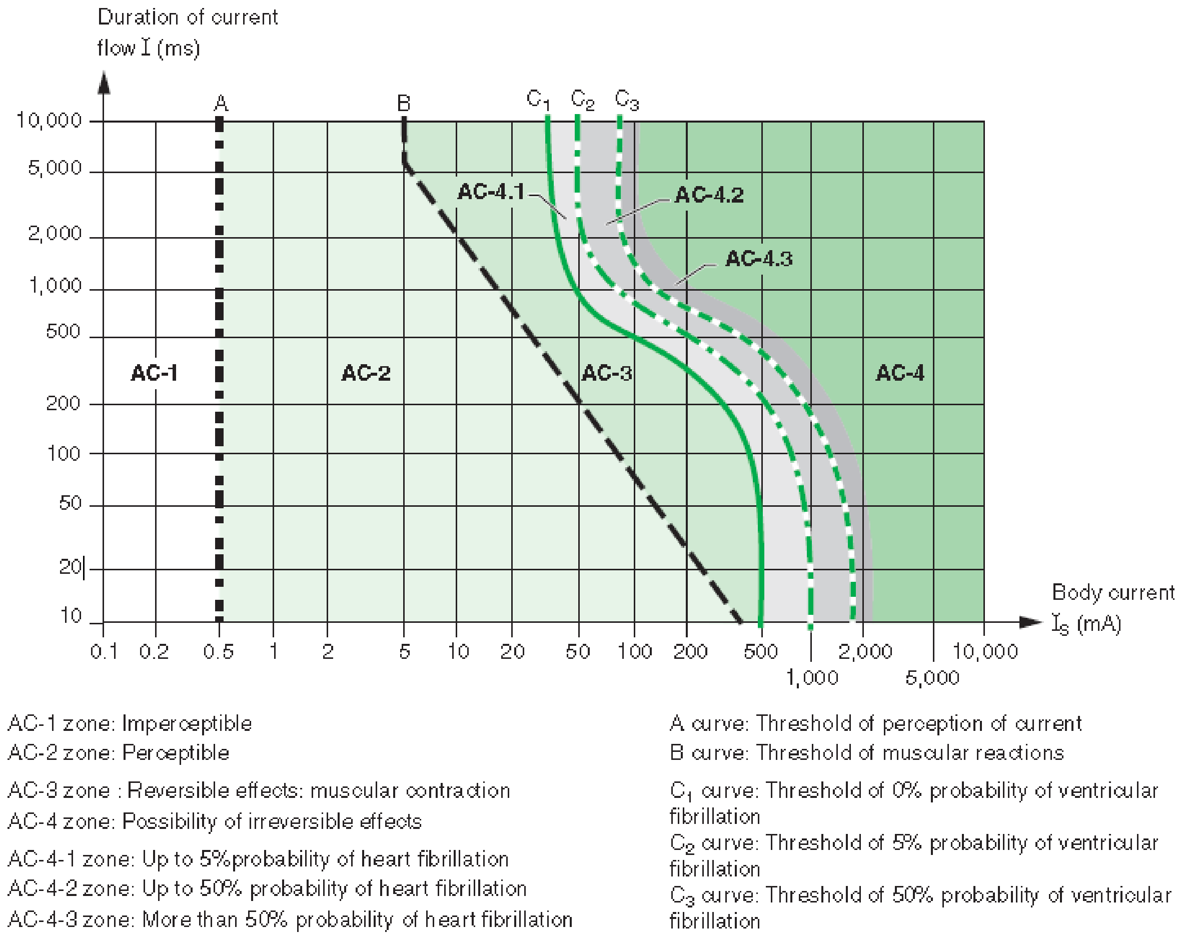

Fig.2 Zones time/current of effects of AC current on human body when passing from left hand to feet.

Source: Schneider Electric - Electrical installation guide 2010

2.5.2) Electric Arcs and Blasts

An Arc-Flash is an unexpected sudden release of heat and light energy produced by electricity traveling through air, usually caused by accidental contact between live conductors (IEEE 1584, 2002).

Temperatures at the arc terminals can reach or exceed 35,000 degrees Fahrenheit (F), or four times the temperature of the sun's surface (NFPA 70E, 2004). The air and gases surrounding the arc are instantly heated and the conductors are vaporized causing a pressure wave called an Arc Blast.

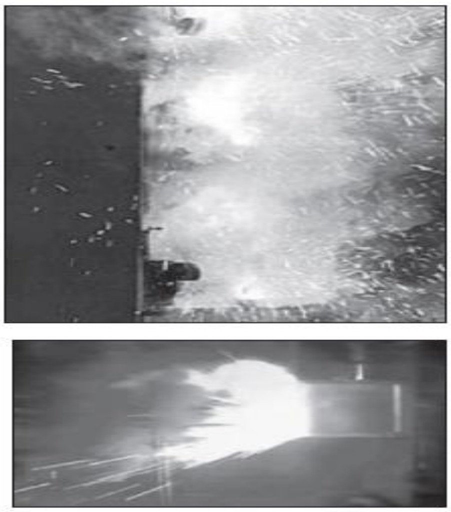

Fig. 3 Arc Flash (*Source: Cawley & Homce, 2003*)

Personnel directly exposed to an Arc-Flash and Arc-Blast events are subject to third degree burns, possible blindness, shock, blast effects and hearing loss (Cooper, 1998). Even relatively small arcs can cause severe injury. The secondary effect of arcs includes toxic gases, airborne debris, and potential damage to electrical equipment, enclosures and raceways. The high temperatures of the arc and the molten and vaporized metals quickly ignite any flammable materials (Lee, 1982). While these fires may cause extensive property damage and loss of production, the hazards to personnel are even greater.

Any energized electrical conductor that makes accidental contact with another conductor or with ground will produce an Arc-Flash (Covello & Merkhofer, 1997). The arcing current will continue to flow until the overcurrent protective device used upstream opens the circuit or until something else causes the current to stop flowing.

2.6) Hazard Analysis, Risk Estimation and Risk Evaluation

When assessing the level of risk, an understanding of at least the following four definitions from ANSI/AIHA Z10, Occupational Health and Safety Management Systems 2005, is necessary (Rundmo, 1996):

- Hazard. A condition set of circumstances, or inherent property that can cause injury, illness, or death.

- Exposure. Contact with or proximity to a hazard, taking into account duration and intensity

- Risk. An estimate of the combination of the likelihood of an occurrence of a hazardous event or exposure(s), and the severity of the injury or illness that may be caused by the event or exposures.

- Risk Assessment. The identification and analysis, either qualitative or quantitative, of a likelihood of the occurrence of a hazardous event or exposure and the severity of injury that may be caused by it.

Hazard identification and risk assessment are analytical processes consisting of a number of discrete steps intended to ensure that hazards are properly identified and analyzed with regard to their severity and the probability of their occurrence (Burt, 1998) Once hazards have been identified and analyzed, the risk associated with those hazards can be estimated using specialized methods (Rasmussen & Svedung, 2000). Appropriate protective measures can then be implemented and evaluated in order to determine if adequate risk reduction has been achieved.

Hazard identification and risk assessment include a comprehensive review of the hazards, the associated foreseeable tasks, and the protective measures that are required in order to maintain a tolerable level of risk, including the following:

- Identifying and analyzing electrical hazards
- Identifying tasks to be performed
- Documenting hazards associated with each task
- Estimating the risk for each hazard/task pair
- Determining the appropriate protective measures needed to adequately reduce the level of risk.

In a general sense, risk can be described as the potential that a chosen action or activity will lead to some type of loss or harm. For the purpose of electrical safety, risk is defined as an estimate of the combination of the likelihood of occurrence of a hazardous event and the severity of injury that may be caused by that event (Glendon & McKenna, 1995). The type of injury of concern is harm (either directly or indirectly) that can be caused by contact with exposed energized conductors and circuit parts, and the harm (either direct or indirect) that can be caused when an arc flash occurs.

2.7) Chapter Summary

This literature review has focused on identifying conditions and events that have resulted in injuries from employee contact with energy. While the accidents described were unfortunate, they were largely preventable, as determined by the analyses provided from the accident investigations. LOTO procedures from several organizations have been reviewed to gather information on methods being employed. It is worth noting that the PHCN procedure is lacking in procedural detail compared to the likes of GE and the US Department of Energy. It is also important to implement a comprehensive and on-going energy control procedure.

CHAPTER 3

RESEARCH DESIGN AND METHODOLOGY

3.1) Research Design

In defining design with regards to research, (Creswell, 2003) stated that designing implies outlining the name of equipment and other materials the research intends using, applying some to successfully execute the practical aspect of the research study.

According to (Kinnear, 1989) a research design is the basic plan which guides the data collection and analysis phases of a research project. It is the framework which specifies the type of information to be collected and source of data collection procedure.

A descriptive survey method was used for the purpose of this research. According to (Johnson, 1953) the descriptive method of educational research is defined as the general procedures employed in studies that have for their chief purpose the description of phenomena, in contrast to ascertaining what caused them or what their value and significance are.

The descriptive method is very popular among students of education, and frequently a descriptive approach is the first thought when a problem or situation is to be investigated. Thus questionnaires, surveys, interviews, check-lists and the like are frequently employed in attempts to solve problems or explore problem areas.

It is important to determine the methodology and procedure used in this research as it gives the reader good background information on how to evaluate the findings and conclusions.

The problem statement given in Chapter one starts by stating that the problem of risks associated with the unexpected release of hazardous energy can probably be solved by the adherence of electrical personnel to procedures on LOTO of hazardous energy. Furthermore, there is a need to track the execution of electrical isolations and LOTO. This would be the purpose of the newly developed LOTO procedure to help mitigate the identified risks.

This chapter presents the methods adapted in investigating the research problem as identified in previous chapters. The proposed solutions from this investigation are introduced.

3.2) Sources of Data

3.2.1) Primary Sources of Data

The primary source of data for this research was by the use of oral interviews conducted in 5 different business units of the PHCN Eko Zone. The interviews were conducted in Lagos, in the Islands BU, Ijora BU, Festac BU, Lekki BU and Orile BU. Another primary source of data was the questionnaire distributed to Operations and Maintenance staff of PHCN in the Eko Zone.

3.2.2) Secondary Sources of Data

The secondary sources from which data was collected include: manuals of the PHCN, NFPA 70E Handbooks, OSHA standards, NIOSH standards, Nigerian Electricity Regulation Commission (NERC), Institute of Electrical and Electronic Engineers (IEEE) and different safety related websites on the internet.

3.3) Population of the Study

According to (Throne, 1980) population is the totality of any group, person or objects which is defined by some unique attributes. What this implies, is that a population is a group which a researcher focuses on during a research study.

Due to the large number of locations and diversity of the PHCN group, the researcher chose to focus on a particular zone, the Eko Zone as the population under study in order to find a solution for the research problem stated in Chapter 1. This zone has a population of 4000 employees. However, the Operations and Maintenance Units have a total population of 1600 employees. This is the population directly related to the research study, and hence would be the desired population.

3.4) Determination of Sample Size

Sampling is the process of selecting a given number or any portion of that population for the purpose of obtaining information for generalization about the large population (Nwabuoke, 1986). Sampling a population is a method used to avoid possible errors in dealing with a population. The population size was narrowed down to determine the sample size. A statistical formula was used in determining the sample size.

To determine the sample size (Nwabuoke, 1986) made use of the Yaro Yamani formula for determining a sample size, and this states that

$$n = N/ [1+N (e)^2]$$

Where n=sample size

N=total population size

1 is a constant

e = the assumed error margin or tolerable error, taken as 5% (0.05)

Using the formula $n = N/ [1+N (e)^2]$

Where N=1600

$e = (0.05)^2 = 0.0025$

$n = 1600 / [1 + 1600(0.0025)]$

$n = 1600/ 5$

$n = 320.$

The sample size for this research was determined to be 320.

3.5) Methods of Data Collection

One of the two data collection methods used for this research as stated earlier in the chapter is the questionnaire. A questionnaire is used when factual information is required (Yin, 1989). This is a list of questions given to individuals to complete by answering either a yes or a no. This plan was selected in order to ease the work of the researcher when classifying and analysing the responses.

The researcher also used the interview to get a clearer understanding of certain areas requiring clarity and to complement the use of the questionnaire, all in an effort to gather relevant and accurate data not readily available in the PHCN database.

3.5.1 Questionnaire Design, Distribution and Collection.

The questionnaire was created with the aim of collecting electrical workers views on the electrical isolations, de-energisation and LOTO of hazardous energy. The questionnaire was based mainly on electrical experts' views on the topic under research. It was sent to five electrical and safety experts for comments.

The questionnaire was validated twice; first with two electrical professionals and two Safety professionals working at the Escravos Gas Project, later with another four. The questionnaire was further revised after both tests. The final questionnaire had 15 questions.

Questions with "yes or no" responses were included in the questionnaire. Questions capable of attracting multiple interpretations were intentionally avoided. The questionnaire was also a no-name no-blame type questionnaire to encourage the respondents to honestly answer the question, given the environment where they work, an environment which does not easily make statistics available openly to the public.

The questions dealt with Lockout/Tagout of hazardous energy, training, voltage testing and lots more. The questionnaire questions are presented in Appendix A.

3.6 Method of Data Analysis

In analysing the data collected using the questionnaire; the researcher used the simple percentages method of data analysis. The analysis was represented in tabular form for easy understanding and it consists of the number of respondents and the corresponding percentage.

3.7) Chapter Summary

This chapter emphasized on the methodology to be used to carry out the research using PHCN as a case study. The data collected had both depth and precision. The questionnaire and interviews were carried out to complement one another while providing input to the development of the new LOTO procedure.

Results from the findings will be reported in Chapter Four. Chapter Five will discuss the results and attempt to draw conclusions and provide recommendations for preventing employee injuries with regards to exposure to hazardous energy and LOTO.

CHAPTER 4

Data Presentation and Analysis

4.1 Data Presentation and Interpretation

This chapter is designed to present and analyse the response to the research hypothesis formulated from the stated problems in Chapter One of this study. It deals with the presentation, analysis and interpretation of the data collected. They were analysed using tables.

4.1.1 Distribution and Collection of Questionnaire

Out of three hundred and twenty (320) questionnaires distributed to the staff of Power Holding Company of Nigeria(PHCN) Eko zone, two hundred and ninety one (291) of them were duly completed and returned representing (91%) and thirty four(34)questionnaire were unreturned representing (9%).

Table 2 Distribution and Collection of Questionnaire

BUSINESS UNIT	NUMBER OF QUESTIONNAIRES DISTRIBUTED	NUMBER OF QUESTIONNAIRES RETURNED	PERCENTAGE RETURNED (%)
Agbara	29	29	100
Ajele	29	29	100
Apapa	29	25	86

Festac	29	27	93
Ibeju	29	20	69
Ijora	30	30	100
Island	29	20	69
Lekki	29	29	100
Mushin	29	26	90
Ojo	29	27	93
Orile	29	29	100
Total	320	291	91

Table 3 Distribution of Respondents by Gender

Sex	No of respondent	Percentage (%)
Male	280	96
Female	11	4
Total	291	100

The above table shows that 280(96%) respondents were male while 11(4%) respondents were female. This clearly shows that the majority of the respondents are male.

Table 4. Distribution of Respondents by Age

Age	No of respondents	Percentage (%)
18-29	55	19
30-39	99	34
40-49	93	32
50 & above	44	15
Total	291	100

This table reflects that 55(19%) of the respondents fall within the age bracket of 18-29; 99(34%) of the respondents fall within the age bracket of 30-39; 93(32%) of the respondents fall within the age bracket of 40-49; while 44(15%) of the respondents fall within the age bracket of 50 and above.

Table 5. Distribution of Respondents by Years of Experience

Years	No of respondents	Percentage (%)
0-2	84	29
3-5	93	32
6-10	70	24

11 & above	44	15
Total	291	100

From the above table, 84(29%) of the respondent falls within 0-2 years of experience; 93(32%) of the respondent falls within 3-5 years of experience; 70(24%) of the respondent falls within 6-10 years of experience; while 44(15%) of the respondent falls within 11 years and above.

Table 6 Presentation According to key research questions

Research Question One

Does your organisation have a written Lockout/Tagout procedure in use?

Options	No of Respondents	Percentage (%)
Yes	120	41
No	50	17
Not sure	121	42
Total	291	100

Source: Field Survey 2012.

From the above table, 120 (41%) respondents were of the opinion that the organization has a documented LOTO procedure; 50 (17%) respondents were of the opinion that the organization does not have a LOTO procedure in place; while 121 (42%) respondents were not sure if the organisation had a documented LOTO procedure.

TABLE 7 Research Question Two

Have you ever performed Lockout/Tagout of hazardous energy?

Options	No of respondents	Percentage (%)
Yes	100	34
No	191	66
Total	291	100

Source: field survey 2012.

The above table shows that 100(34%) of the respondents have performed LOTO of hazardous energy; while 191(66%) of the respondents have not performed LOTO of hazardous energy.

Table 8 Research Question Three

Have you attended training in Lockout/Tagout?

Options	No of respondents	Percentage (%)
Yes	246	85
No	45	15
Total	291	100

Source: field survey 2012.

From the above table, 246(85%) respondents have attended a LOTO training; while 45(15%) of the respondents are yet to attend a LOTO training.

Table 9. Do you make use of the procedure during the process of de-energizing and isolating to make equipment safe to work on?

Options	No of respondents	Percentage (%)
Yes	38	13
No	253	87
Total	291	100

Source: field survey 2012.

In the above table, the whole 38(13%) respondents were of the opinion that they make use of the LOTO procedure for isolations; while 253(87%) were of the opinion that they do not make use of the procedure during isolation and de-energisation.

Table 10 Do you perform a hazard analysis before commencing work on electrical systems?

Options	No of respondents	Percentage (%)
Yes	100	34
No	191	66
Total	291	100

Source: field survey 2012.

From the above table, it is observed that 100(34%) of the respondent agree to performing a hazard analysis prior to commencement of work; while 191(66%) agree that they do not perform a hazard analysis prior to commencement of work.

Table 11 Do you perform a Job Safety Analysis before commencing work on electrical systems?

Options	No of respondents	Percentage (%)
Yes	110	38
No	181	62
Total	291	100

Source: field survey 2012.

From the table above 110(38%) of the respondents perform a JSA before commencing work; while 181(62%) of the respondents do not perform a JSA before commencing work on electrical systems.

Table 12 Do you confirm that the circuit to be worked on is completely de energized and safe to work on, before work commences?

Options	No of respondents	Percentage (%)
Yes	264	91
No	27	9
Total	291	100

Source: field survey 2012.

From the table above, it was observed that 264(91%) respondents agree to confirming that circuits are safe to work on; while 27(9%) respondents do not confirm.

Table 13 Do you make use of single-line and diagrammatic drawings to identify sources of energy?

Options	No of respondents	Percentage (%)
Yes	115	39
No	176	61
Total	291	100

Source: field survey 2012.

The above table indicates that out of 291 respondents, 115(39%) agreed that they make use of electrical drawings to identify sources of energy; while 176(61%) say they do not make use of electrical drawings to identify energy sources.

Table 14 Do you know that de-energizing an electrical conductor or circuit part and making it safe to work on is, in itself, a potentially hazardous task?

Options	No of respondents	Percentage (%)
Yes	212	73
No	79	27
Total	291	100

Source: field survey 2012.

From the table above, 212(73%) respondent suggested that they know that de-energizing an electrical conductor or circuit part and making it safe to work on is, in itself, a potentially hazardous task; while 79(27%) respondent suggested they do not know that de-energizing an electrical conductor or circuit part and making it safe to work on is, in itself, a potentially hazardous task

Table 15 Are you aware that procedures are to be used as tools to identify the hazards and to develop plans to eliminate/control the hazard?

Options	No of respondents	Percentage (%)
Yes	243	84
No	48	16
Total	291	100

Source: field survey 2012.

From the above table, 243(84%) of the respondent are aware that procedures are to be used as tools to identify hazards and to mitigate them; while 48(16%) say they are not aware.

Table 16 Can the risks you face while working on electrical systems be prevented by making use of LOTO procedure?

Options	No of respondents	Percentage (%)
Yes	253	87
No	38	13
Total	291	100

Source: field survey 2012.

From the above table, 253(87%) of the respondents are of the opinion that risks involved while working on electrical systems can be prevented by making use of LOTO procedure;

while 38(13%) of the respondents are of the opinion that risks involved while working on electrical systems cannot be prevented by making use of LOTO procedure.

Table 17 Are you aware that it is the responsibility of the employer to provide complete and accurate circuit diagrams and other published information to the employee prior to the employee starting work (the circuit diagrams should be marked to indicate the hazardous components?

Options	No of respondents	Percentage (%)
Yes	117	40
No	174	60
Total	291	100

Source: field survey 2012.

From the above table, 117(40%) of the respondent are aware that it is the employers responsibility to provide necessary information on jobs to be performed; while 174(60%) are not aware of this responsibility of the employer.

Table 18 Are you aware that people who are not involved in the work task can be exposed to an electrical hazard when the work task is being executed?

Options	No of respondents	Percentage (%)
Yes	274	94
No	17	6
Total	291	100

Source: field survey 2012.

From the above table, 274(94%) of the respondents are aware that people who are not involved in the work can be exposed to an electrical hazard; 17(6%) of respondents are not aware that people who are not involved in the work can be exposed to an electrical hazard.

4.2 Interviews

4.2.1 Interview Highlights

The total number of interviewees was 5. The interviews were done with the sole purpose of clarifying some of the feedback from the questionnaire, with a view to providing input data in the development of the procedure for tracking LOTO.

Presented below are the findings (highlights) from the interviews conducted with Supervisors in the Operations and Maintenance Unit of PHCN, Eko zone.

Engr. Olatunji (Supervisor Maintenance, Ijora Business Unit)

- There are always risks with LOTO
- Electrocution, de-energising the wrong circuits and Arc blast are some of those risks.
- Yes, PHCN has a written LOTO procedure.
- It's up to the workers to make use of the procedure. They know how to get it. They are responsible for their safety.
- We train our workers to de-energise systems to be worked on where possible.
- LOTO training is done every year.

- Accidents and near misses are documented. Near misses are not always reported.
- Workers are not working to the plan.
- Training and one on one coaching are the methods we use to mitigate electrical accidents here.
- Voltage testing is always carried out. It is indeed part of the procedure.
- We provide the right personal protective equipment and provide up to date training for our employees.
- Accidental equipment start-up can be prevented by proper LOTO, and adherence to the procedure.
- We already have a LOTO procedure. I don't think we need another one.
- The electrical diagrams are available. Employees know exactly how to request for them if needed.
- We have a dedicated unit for reviewing work to be done in all areas.

Engr. Ajide (Supervisor Maintenance, Islands Business Unit)

- Performing LOTO comes with various risks.
- Electrocution, Arc flash and Arc blast are the risks.
- PHCN has a well written and documented LOTO procedure.
- Our employees always work according to the procedure.
- De-energizing of electrical systems to be worked on is part of the procedure.
- LOTO training is done when required.
- Accidents and near misses are documented.

- Workers are not making use of the right tools.
- By using the correct tool for the job, accidents will not happen.
- Voltage testing is always done.
- Focus on the task at hand will surely ensure safety of personnel.
- Accidental equipment start-up can be prevented by employees having the proper safety mind-set and skills.
- Any procedure that ensures the work is done safely is welcome, but is must be approved by the NERC.
- The electrical diagrams are always provided.
- We have a central unit made up of experienced employees.

Engr. Eze (Supervisor Maintenance, Festac Business Unit)

- There are risks associated with LOTO of hazardous energy.
- Electrocution and explosions are some of those risks.
- PHCN has a written LOTO procedure.
- The procedures are used during jobs.
- We de-energise equipment and installations if possible.
- LOTO training is done whenever there is an opportunity.
- Accidents and near misses are documented. We try to encourage reporting.
- Workers do not always have the right skills and the right tools for the job.
- Training and the use of the correct PPE are the methods we use to mitigate electrical accidents here.

- Voltage testing is done.
- We provide the right personal protective equipment and provide up to date training for our employees.
- Accidental equipment start-up can be prevented by LOTO.
- PHCN will gladly welcome the right procedure.
- The electrical diagrams are provided as a matter of professionalism.
- We have a dedicated unit for reviewing jobs.

Engr. Abdullah (Supervisor Maintenance, Lekki Business Unit)

- Yes, LOTO has its own risks.
- Electrocution and arcing are some of those risks.
- PHCN has a written LOTO procedure.
- Our workers must make use of the procedure.
- Our workers de-energise systems to be worked on.
- LOTO training is done every year.
- I believe accidents and near misses are documented.
- Workers are not always working according to the procedure.
- Job reviews and lessons learnt are some methods we use to mitigate electrical accidents here.
- Voltage testing is always carried out.
- We provide up to date training for our employees and encourage feedback.
- Accidental equipment start-up can be prevented by adequate preparation for the job at hand.

- We have a LOTO procedure already in use.
- The electrical diagrams are readily available.
- There is a dedicated unit for reviewing work to be done in all areas.

Engr. Agholor (Supervisor Maintenance, Orile Business Unit)

- LOTO has risks which can be managed with the right practices.
- Electrocution and burns are some of those risks.
- Yes, PHCN has a written LOTO procedure.
- It is a requirement for procedures to be used in all situations..
- We train our workers to de-energise systems to be worked on where possible.
- LOTO training is done regularly.
- Accidents and near misses are well documented.
- Workers do not always adhere to the procedures.
- Training and working as a team are some methods we use to mitigate electrical accidents here.
- I believe voltage testing is always carried out.
- We provide the right personal protective equipment.
- Accidental equipment start-up can be prevented by good supervision.
- Our LOTO procedure is effective, why have another?
- Electrical diagrams are available to the workforce.
- Yes there is a dedicated unit for review of LOTO related documentation.

4.3 CHAPTER SUMMARY

Both methods utilized in this study evaluated various elements of the PHCN energy control program. The questionnaire probed employee activities with regards to LOTO implementation and training, verifying compliance with the current written procedure. The interviews were used to clarify grey areas in the questionnaire response, particularly with the availability of a properly written LOTO procedure at PHCN. The results collected indicate inconsistencies in adherence to the use of the procedure.

Chapter five shall evaluate the results collected in this chapter, based upon data collected from the methodology described in Chapter three.

CHAPTER 5

RESULTS DISCUSSION AND INTERPRETATION

5.1) Introduction

This chapter will evaluate the results collected in Chapter Four, based upon data collected from the methodology described in Chapter Three. The data and observations will be compared with research conducted and reported in Chapter Two. A discussion of the findings reported will elaborate on previous research data. Conclusions will be drawn summarizing the results received from utilizing the questionnaires and interviews applied during this study in the concluding chapter. Recommendations will be provided to conclude the study, outlining methods for improving the PHCN energy control program and reducing the possibility of employee contact with electrical hazardous energy.

5.2) Results and Analysis

A review of literature described in Chapter Two reported on injuries and losses associated with employee contact with energized equipment. A summary of the conclusions drawn from the cases reported indicated the deficiencies and contributory factors listed in Table 19. The main basic causes are listed in table 19.

Table 19. Basic Causes Resulting in Lockout/Tagout Related Injuries.

S/N	Basic Causes
1	Employees by-passing procedure
2	Inadequate or ineffective employee training
3	Lack of a written energy control program or procedures
4	Employees' bad working practices
5	Lack of communications regarding how to perform lockout/tagout
6	Operators disregard for safety regulations

In reviewing some of the available accident reports that occurred at the PHCN locations, many of the same basic causes listed in Table 19 were identified on the incident reports as contributory in these cases. The frequency or severity of the incidents did not directly correlate with any one factor. Rather, it was a combination of several of the basic causes that contributed to the events. In addition to the injuries and losses, regulatory action in the form of NERC inspections also occurred, with subsequent citations and fines. There could also be other indirect consequences, such as negative publicity.

The questionnaire findings include:

- Majority of the respondents are male representing 96% of the respondents
- A majority of the respondents' ages lie between 30 and 49
- A majority of the respondents have work experiences between 3-5 years, 32%
- 41% of respondents say PHCN have a written LOTO procedure, while another 42% are not sure the company has a written LOTO procedure in place.

- Majority of the respondents have never performed a LOTO of hazardous energy, 66%
- 85% of the respondents have attended LOTO training
- Majority of the respondents, 87% do not make use of the procedure during the process of de-energizing and isolating to make equipment safe to work on
- Majority of the respondents, 66%, do not perform a hazard analysis before commencing work on electrical systems
- Only 38% of the respondents perform a job safety analysis prior to commencing work
- Majority of the respondents, 91% confirm that circuit to be worked on in completely de-energised and safe to work on prior to start of work
- 61% of respondents do not refer to electrical drawing and diagrams to identify sources of energy
- Majority of the respondents, 73%, are aware that de-energizing an electrical conductor or circuit part and making it safe to work on, is a potentially hazardous task
- 84% of the respondents know that procedures are to be used as tools to identify the hazards and to develop plans to eliminate/control the hazard
- 87% of respondents are of the opinion that risks faced while working on electrical systems can be prevented by making use of LOTO procedure.
- 60% of respondents are not aware that it is the responsibility of the employer to provide complete and accurate circuit diagrams and other information.

- 94% of respondents are aware that people who are not involved in the work task can be exposed to an electrical hazard when the work task is being executed

Findings from the interviews can be summarized as follows:

- There are risks associated with LOTO of hazardous energy, and these include electrocution, de-energising of the wrong circuits, burns, arc flash and arc blasts.
- PHCN has written LOTO procedure, workers are trained on LOTO but the frequency of training is not fixed.
- De-energising and voltage testing is performed as part of the LOTO process.
- Accidental start-up is prevented by proper use of LOTO and adherence to procedure.
- A new LOTO procedure might not be necessary mainly due to the fact that there is a procedure already in use, and any new procedure must be approved by the NERC.
- Electrical diagrams are readily available for use by the workers, whenever required.
- There is a dedicated unit responsible for LOTO documentation.

Information gathered from the questionnaires clearly show that performance of a job safety analysis and job hazard analysis is below expectation, with more than half of the respondents not carrying out these tasks prior to commencement of work.

From the interviews conducted, it was also gathered that there is a documented PHCN procedure for the implementation of LOTO. However, the questionnaire feedback says otherwise. Half of the respondents are not quite sure of the existence of the LOTO procedure, with a staggering 87% of respondents confirming that they do not make use of the procedure during the process of de-energising and isolating hazardous energy to make equipment safe to work on. This shows that the LOTO procedure was not implemented 100% in PHCN.

Another observation worth noting is that more than half of the respondents do not refer to electrical drawings and diagrams to identify sources of energy even when the interviews confirmed the availability of such diagrams and drawings.

Therefore following from the above, a new LOTO procedure was developed to mitigate the risks which were identified: electrocution, de-energising of the wrong circuits, burns, arc flash, and arc blast. Taking into consideration that the PHCN might not require a new procedure immediately, something extra was included in the procedure to get the attention of the NERC. That something extra was the tracking of the implementation of the procedure to ensure that the identified risks are mitigated.

The tracking comes in the form of a checklist used by the authorized person in charge during LOTO. Work must not commence on the electrical equipment or system until the tracking checklist is signed.

5.3) Questionnaire Validation

The methods used to validate the Questionnaire included Content validity and Face validity while the test-retest method was used for the reliability test.

5.3.1) Content validity

Content validity was chosen to ascertain that the content of the questionnaire was appropriate and relevant to the study purpose. Content validity shows that the content reflects a complete range of the attributes under study (Nasrin & Dunning, 2009). To estimate the content validity of the questionnaire, the researcher clearly defined the conceptual framework of lockout/tagout risks by undertaking a thorough literature review and seeking expert opinion.

Once the conceptual framework was established, eight experts in the areas of safety engineering and electrical engineering in the Escravos Gas Project team were asked to review the draft questionnaire to ensure it was consistent with the conceptual framework. Each reviewer rated the relevance of each item on the questionnaire using a 4-point Likert scale (1=not relevant, 2=somewhat relevant, 3=relevant, 4=very relevant). The Content Validity Index (CVI) was used to estimate the validity of the items (Lynn, 1996).

5.3.2) Face validity

Face validity indicates the questionnaire would be appropriate to the study purpose and content area. It is an easy validation process to undertake but it is also a weak form of validity. It evaluates the appearance of the questionnaire in terms of feasibility, readability, style and formatting, and the clarity of the language used (Nasrin & Dunning, 2009). To determine the face validity of the questionnaire, an evaluation form was developed to help respondents assess each question in terms of:

1) Clarity of the wording,

2) Likelihood the target audience would be able to answer the questions,

3) Layout and style.

Thirty electrical workers of the PHCN Eko distribution Zone were randomly selected from two units (Lekki and Island) and completed the face validity form on a Likert scale of 1-4, strongly disagree= 1, disagree= 2, agree= 3, and strongly agree= 4.

5.3.3) Reliability

Once the validity procedures were completed, the final version of the questionnaire was examined to assess its reliability. Reliability refers to the ability of a questionnaire to consistently measure an attribute and how well the items fit together (Nasrin & Dunning, 2009). Two estimators of reliability are commonly used: internal consistency reliability and test-retest reliability: test-retest was used to examine the reliability of the questionnaire.

5.3.3.1) Test-retest Reliability

Test-retest reliability is estimated by administering the same tool to the same sample on two different occasions on the assumption there will be no substantial change in the topic under study (Nasrin & Dunning, 2009). Test-Retest reliability of the questionnaire was undertaken by randomly administrating the questionnaire to thirty PHCN employees in the Eko distribution zone.

5.4) Results of questionnaire validation

5.4.1) Content validity

According to the CVI index, a rating of three or four indicates the content is valid and consistent with the conceptual framework (Lynn 1996). For example, if five of eight content experts rate an item as relevant (3 or 4) the CVI would be 5/8=0.62, which does not meet the 0.87 (7/8) level required, and indicates the item should be dropped (Nasrin & Dunning, 2009).

Therefore, three items on the draft questionnaire were noted as irrelevant to the study and hence invalid because they yielded CVIs of 4/8=0.50 to 6/8=0.75 and were removed from the questionnaire. Those items were:

1) 'Current greater than 75milliamps cause ventricular fibrillation (very rapid, ineffective heartbeat). Have you ever experienced a shock greater than 75milliamps?' (CVI = 6/8=0.75)

2) 'Do you carry out self-work permitting?' (CVI=4/8=0.50).

3) 'Have you ever performed the duty of a safety observer, to ensure that each step the switch operator is about to perform is correct?' (CVI=6/8=0.75).

All the remaining items were valid with CVIs ranging from 0.87 (7/8) to 0.100 (8/8) and were retained.

5.4.2) Face validity

All respondents rated each parameter at three or four on a Likert scale of 1-4. Ninety three percent indicated they understood the questions and found them easy to answer, and Ninety seven percent indicated the appearance and layout would be acceptable to the intended target audience.

5.4.3) Test-retest

Four weeks after data collection, twenty blank questionnaires were re administered to the maintenance personnel of PHCN Lekki business unit to confirm consistency with the original data collected from the same business unit. Comparing the twenty re-administered questionnaires to twenty randomly selected questionnaires from the original twenty-nine administered requiring a yes or no answer; the results showed a 5% deviation from the original data collected.

5.5) Conclusion of questionnaire validation

The questionnaire is a valid and reliable research tool which can be generalised to a wider population of PHCN maintenance and operations workers.

5.6) Chapter Summary

The two instruments utilized in this study evaluated various elements of the PHCN lockout/tagout and energy control program. The results collected indicate inconsistencies in hazardous energy control and administration.

The methods used in validating the questionnaire were also shown in this chapter. Chapter Six will highlight the development of the new LOTO procedure based upon the interpretation of the data collected.

CHAPTER 6

THE NEW LOCKOUT TAGOUT PROCEDURE

6.1) New LOTO Block Diagram

The block diagram of the newly developed LOTO procedure is shown in Fig. 4 below. It shows a step by step flow of what the newly developed procedure sets out to achieve.

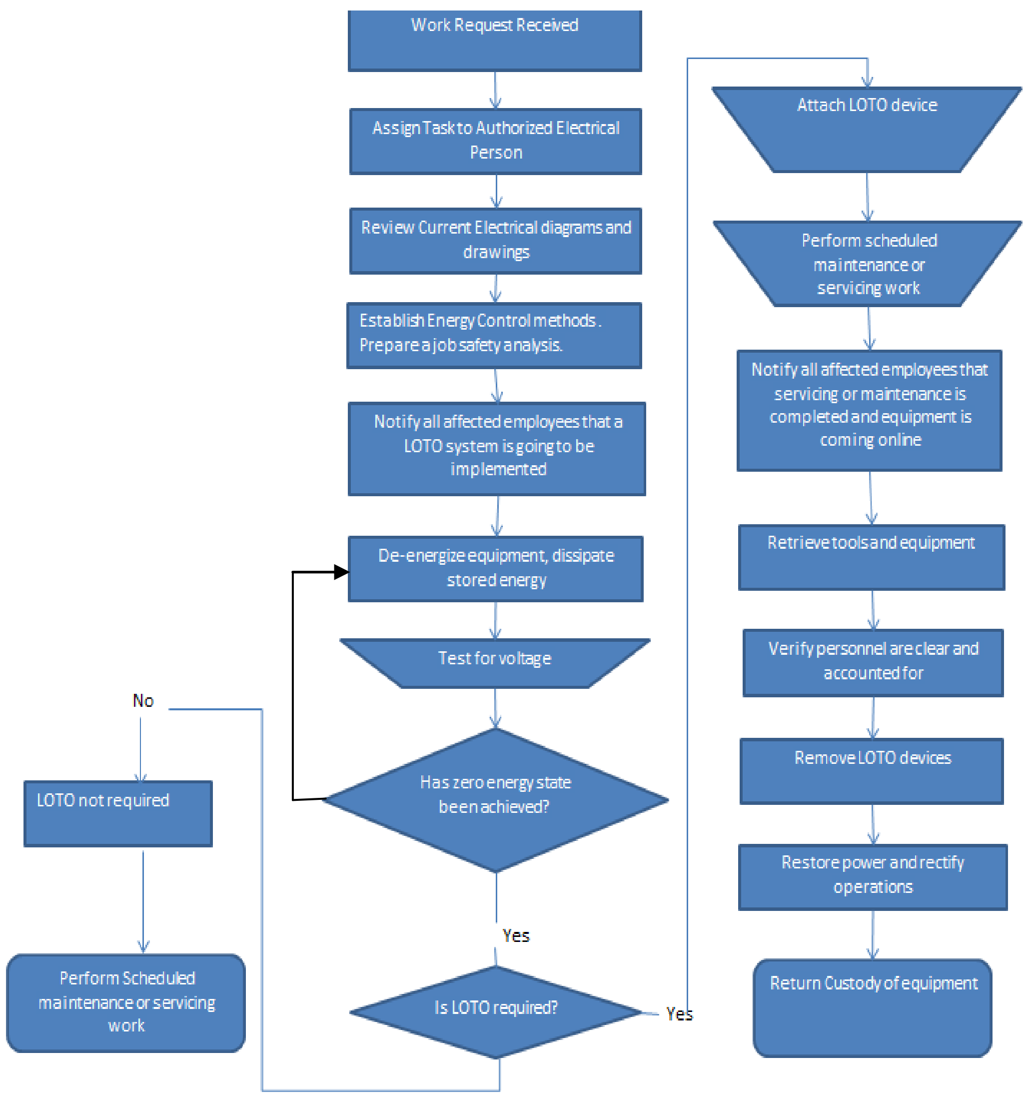

Fig. 4 New Lockout/Tagout Flow diagram.

6.2) The New LOTO Tracking Sheet

LOTO Tracking Sheet

	Yes	No	Sign
Have up-to date electrical drawings been reviewed?			
Have energy control methods been established?			
Has a Job Safety Analysis been prepared?			
Have all affected employees been notified?			
Has equipment been de-energised and stored energy dissipated?			
Has a test for voltage been performed to verify zero energy state?			
Has LOTO device been placed on the correct circuits?			
Is it safe to commence work?			

Job may proceed.

Sign_______________
Designation:
Date:

Fig. 5. New LOTO Tracking Sheet.

The Person In Charge whose duties are defined in the newly developed LOTO procedure (Section 2.5) shall ensure that this LOTO tracking sheet is completed and each item implemented and signed off by the Authorized Electrical Responsible Person (definition in Section 2.1). The job can proceed after the Person In Charge signs off this sheet.

This tracking sheet shall be archived in the permit office for future reference, in case of any root cause analysis, incident and for audit purposes.

6.3) LOCKOUT (TAGOUT) PROCEDURE FOR POWER HOLDING COMPANY OF NIGERIA

6.3.1. Purpose

This procedure establishes the minimum requirements for lockout/tagout of electrical energy sources in PHCN. It must also to be used to ensure that conductors and circuit parts are disconnected from sources of electrical energy, locked/tagged, and tested before work commences where employees could be exposed to dangerous conditions. Sources of stored energy, such as capacitors or springs, shall be relieved of their energy, and a mechanism shall be engaged to prevent the reaccumulation of energy.

6.3.2. Responsibility

All employees shall be instructed in the safety significance of the lockout and tagout procedure. All new employees and all other persons whose work operations are or might be in the area shall be instructed on the purpose and use of the procedure. This procedure shall ensure that appropriate personnel receive instructions on their roles and responsibilities. All persons installing a LOTO device shall sign their names and the date on the tag.

6.3.2.1. Authorized Electrical Person – An individual who is competent in isolation of hazardous energy and is capable of recognizing hazards, the person is given training, authority and responsibility to perform specific assignments in an electrical area before being assigned to any electrical work. An authorized electrical person is not necessarily competent to perform the duties of a qualified electrical person.

6.3.2.2. Electrical Standby Person – An authorized person whose responsibilities are to observe the actions of a person performing a task, ensure his or her safety, assist if in danger, and to exercise stop work authority.

6.3.2.3. Permit Approver – A competent individual who has been trained, tested and authorized by the Company to review and, where applicable, sign and approve the relevant permits.

6.3.2.4. Permit Issuer – A competent and trained individual who has been authorized by the Company to complete, review and issue work permits for the unit.

6.3.2.5. Person in Charge – A competent individual who is responsible for an assigned area and for the safe execution of work in that area. The designated person may vary, depending on the work specified. The person in charge shall ensure that this procedure is carried out by the work crew and sign-off after LOTO is performed and circuits de-energized and verified to be safe to work on.

6.3.2.6. Qualified electrical Person – One who has skills and knowledge related to the construction and operation of the electrical equipment and installations and has received safety training to recognize and avoid the hazards involved.

6.3.3. Preparation for Lockout and Tagout

6.3.3.1. Review current diagrammatic drawings (or their equivalent), tags, labels, and signs to identify and locate all disconnecting means to determine that power is interrupted by a physical break and not de-energized by a circuit interlock. Make a list of disconnecting means to be locked and tagged.

6.3.3.2. Review disconnecting means to determine adequacy of their interrupting ability. Determine if it will be possible to verify a visible open point, or if other precautions will need to be put in place.

6.3.3.3. Review other work activity to identify where and how other personnel might be exposed to sources of electrical energy hazards. Review other energy sources in the physical area to determine employee exposure to sources of other types of energy. Establish energy control methods for control of other hazardous energy sources in the area.

6.3.3.4. Provide an adequately rated voltage detector to test each phase conductor or circuit part to verify that they are de-energized (see Section 11.3). Provide a method to determine that the voltage detector is operating satisfactorily.

6.3.3.5. Where the possibility of induced voltages or stored electrical energy exists, call for grounding the phase conductors or circuit parts before touching them. Where it could be reasonably anticipated that contact with other exposed energized conductors or circuit parts is possible, call for applying ground connecting devices.

6.3.4. Sequence of Lockout/Tagout Procedure

6.3.4.1. The employees shall be notified that a lockout/tagout system is going to be implemented and the reason thereof. The qualified employee implementing the lockout/tagout shall know the disconnecting means location for all sources of electrical energy and the location of all other sources of stored energy. The qualified person shall be knowledgeable of hazards associated with electrical energy.

6.3.4.2. If the electrical supply is energized, the qualified person shall de-energize and disconnect the electric supply and relieve all stored energy.

6.3.4.2. Lockout and tagout all disconnecting means with lockout and tagout devices.

6.3.4.3. Attempt to operate the disconnecting means to determine that operation is prohibited.

6.3.4.4. A voltage-detecting instrument shall be used. Inspect the instrument for visible damage. Do not proceed if there is an indication of damage to the instrument until an undamaged device is available.

6.3.4.5. Verify proper instrument operation and then test for absence of voltage. This device should be calibrated at an acceptable frequency and the calibration period should still be valid.

6.3.4.6. Verify proper instrument operation after testing for absence of voltage.

6.3.4.7. Where required, install a grounding equipment/conductor device on the phase conductors or circuit parts, to eliminate induced voltage or stored energy, before touching them. Where it has been determined that contact with other exposed energized conductors or circuit parts is possible, apply ground connecting devices rated for the available fault duty.

6.3.4.8. The equipment, electrical source, or both are now locked out and tagged out.

6.4. Restoring the Equipment, Electrical Supply, or Both to Normal Condition

6.4.1. After the task or job is complete, visually verify that the job or task is complete

6.4.2. Remove all tools, equipment, and unused materials and perform appropriate housekeeping.

6.4.3. Remove all grounding equipment/conductors/devices.

6.4.4. Notify all personnel involved with the job or task that the lockout and tagout is complete, that the electrical supply is being restored, and that they are to remain clear of the equipment and electrical supply.

6.4.5. Perform any quality control tests or checks on the repaired or replaced equipment, electrical supply, or both.

6.4.6. Remove lockout and tagout devices. The person who installed the devices is to remove them.

6.4.7. Notify the owner of the equipment, electrical supply, or both, that the equipment, electrical supply, or both, ready to be returned to normal operation.

6.4.8. Return the disconnecting means to their normal position.

7. Complex lockout and tagout.

A complex lockout/tagout plan is required where one or more of the following exist:

1) Multiple energy sources (more than one)
2) Multiple crews
3) Multiple crafts
4) Multiple locations

5) Multiple employers

6) Complex or particular switching sequences

7) Lockout/tagout continues for more than one shift; that is new shift workers

7.1 All complex lockout/tagout procedures shall require a written plan of execution. The plan shall include the requirements in 1.0 through 3.0. 5.0. and 7.0.

7.2 A person in charge shall be involved with a complex lockout/tagout procedure. The person in charge shall be present at the work location.

7.3 The person in charge shall develop a written plan of execution and communicate that plan to all persons engaged in the job or task. The person in charge shall be held accountable for safe execution of the complex lockout/tagout plan. The complex lockout/tagout plan must address all the concerns of employees who might be exposed, and they must understand how electrical energy is controlled. The person in charge shall ensure that each person understands the hazards to which they are exposed and the safety-related work practices they are to use.

7.4 All complex lockout/tagout plans identify the method to account for all persons who might be exposed to electrical hazards in the course of the lockout/tagout.

One of the following methods is to be used:

(1) Each individual shall install his or her own personal lockout or tagout device.

(2) The person in charge shall lock his/her key in a lock box

(3) The person in charge shall maintain a sign-in/sign-out log for all personnel entering the area

7.5 Where the lockout/tagout is continued on successive shifts, the person in charge shall identify the method for transfer of the lockout/tagout and of communication with all employees.

8. Discipline

8.1. Knowingly violating this procedure shall result in disciplinary actions taken against those involved by the Company

8.2. Knowingly operating a disconnecting means with an installed lockout device shall result in disciplinary actions taken against those involved by the company.

CHAPTER 7

RECOMMENDATIONS AND CONCLUSIONS

7.1) Conclusions

Conclusions drawn from both the questionnaire survey and interviews are that there is a LOTO procedure being used in the PHCN Eko zone. All interviewees confirmed to this, while 41% of the questionnaire respondents also agreed to the availability of the LOTO procedure. However, 42% of the respondents were not sure of its existence. This could be due to the fact that 66% of the respondents have not actually participated in a job requiring the use of LOTO.

The use of the existing procedure is not followed strictly by the workers. 87% of the respondents agree to not making use of the procedure during the process of de-energizing and isolating to make equipment safe to work on. This value includes those employees who have never performed a LOTO operation.

Adequate use of a job safety analysis and hazard analysis is lacking from the statistics obtained. 61% of the respondents do not refer to electrical drawings and diagrams to identify sources of energy. Interviews however show that these diagrams are readily available. Another interesting statistic shows that 60% of the respondents are not aware that it is the responsibility of the employer to provide complete and accurate circuit diagrams. Clearly, this is a case of breakdown in communication between the employer its employees.

There are risks associated with LOTO of hazardous energy. These include electrocution, de-energizing of the wrong circuits, burns, arc flash and arc blast.

The ability for the PHCN Eko Zone to prevent future, particularly catastrophic injuries will depend on following the recommendations discussed in this chapter. Continuing with a 'business as usual' approach, where a procedure on hazardous energy control is unclear or procedures are vague, will at best leave the absence of incidents or near misses to chance. Operating an effective Utility facility will require the PHCN to establish and maintain a sound, well-designed and well-communicated energy control and LOTO procedure.

The developed procedure was never implemented due to the on-going privatisation efforts by the government, in a bid to make the PHCN a more effective power company. However, the implementation must be done to test and validate its applicability. It can as a result then, be enhanced based on inputs from industry after implementation. This validation therefore falls outside the scope of this study and will be done by the researcher in conjunction with the PHCN over the next year.

7.2) Recommendations

The research set out to mitigate risks associated with LOTO of hazardous energy. In Chapter one, the identified problem centred on the risks associated with the inadequacies in the implementation of LOTO of hazardous energy and the mitigation thereof.

To achieve the purpose for which the research was carried out, aims and objectives were set. The first aim of the research was to identify the risks involved in the control of electrical hazardous energy. From the research findings, this aim was achieved. The findings revealed that there are risks associated with LOTO: electrocution, de-energising of the wrong circuits, burns, arc flash and arc blast.

The second aim of the research was to develop a new LOTO procedure to mitigate the identified risks. This was done in Chapter six. The procedure comes with a checklist for tracking LOTO implementation which aids in promoting electrical workers' safety; the overall aim of the research.

One recommendation following this study would be for the PHCN to apply the developed LOTO procedure and receive commendable results or responses from future surveys performed. Focus should be placed on ensuring that the LOTO implementation is tracked, especially by the Person in Charge. It is suggested that continually reinforcing expected behaviours would result in safe work practices and good scores on future surveys. The recommendation then would be to determine if exposure and contact with energized equipment could be prevented by employees' strict adherence to the procedure.

On the issue of not conducting a proper job safety analysis, it is recommended that a proper JSA be developed for every job requiring a LOTO. This would be particularly relevant should an injury occur. In the event of a lock-out/tag-out related injury, part of the incident review analysis would include a review of the JSA. If the safe procedures were followed and the injury still occurred, then the JSA might not have captured all the hazards and it must be re-evaluated and changed to reflect the safe procedures.

Other means for following established safe practices and procedures could also be applied. This could include taking disciplinary action against an employee observed not working according to the procedure. Implementing an effective energy control plan requires commitment and ownership by management and employees alike.

APPENDIX A

QUESTIONNAIRE

INSTRUCTION: please tick (   ) inside chosen box

SECTION 1: PERSONAL DATA

1) Sex :
   a) Male [ ]
   b) Female [ ]

2) Age :
   i) 18-29 [ ] (ii) 30-39 [ ] (iii) 40-49 [ ]
   iv) 50 and above [ ]

3) Years of Experience:
   a) 0-2 [ ]
   b) 3-5 [ ]
   c) 6-10 [ ]
   d) 11 and above [ ]

SECTION TWO

1) Are you a PHCN Staff?
   a) Yes [ ] b) No [ ]

2) Does your organisation have a Lockout/Tagout procedure in use?
   b) Yes [ ] b) No [ ] c) Not sure [ ]

3) Have you ever performed Lockout/Tagout of hazardous energy?

a) Yes [ ] b) No [ ]

4) Have you attended training in Lockout/Tagout?

a) Yes [ ] b) No [ ]

5) If your answer to the above is yes, how long ago? ………………………………………………………

6) Do you make use of the procedure during the process of de-energizing and isolating to make equipment safe to work on?

b) Yes [ ] b) No [ ]

7) Do you perform a documented hazard analysis before commencing work?

a) Yes [ ] b) No [ ]

8) Do you perform a Job Safety Analysis before commencing works?

a) Yes [ ] b) No [ ]

9) Do you always confirm that the circuit to be worked on is completely de energized and safe to work on, before work commences?

a) Yes [ ] b) No [ ] c) Not my duty [ ]

10) Do you make use of single-line and diagrammatic drawings to identify sources of energy?

a) Yes [ ] b) No [ ]

11) Do you know that de-energizing an electrical conductor or circuit part and making it safe to work on is, in itself, a potentially hazardous task??

a) Yes [ ] b) No [ ]

12) Are you aware that procedures are to be used as tools to identify the hazards and to develop plans to eliminate/control the hazard?

a) Yes [ ] b) No [ ]

13) Are you aware that it is the responsibility of the employer to provide complete and accurate circuit diagrams and other published information to the employee prior to the employee starting work (the circuit diagrams should be marked to indicate the hazardous components??

a) Yes [ ] b) No [ ]

14) Are you aware that people who are not involved in the work task can be exposed to an electrical hazard when the work task is being executed?

a) Yes [ ] b) No [ ]

15) Prior to starting work on machines or equipment that have been locked or tagged out, does the authorized employee verify that isolation & de-energisation of the machine or equipment have been accomplished.

a) Yes [ ] b) No [ ]

APPENDIX B

INTERVIEW QUESTIONS

1. Are there risks associated with the lockout/tagout of electrical energy?
2. If your answer to question 1 is yes, what are these risks?
3. Does your facility have a written LOTO procedure in place?
4. Do your workers make use of the procedure when performing LOTO of hazardous energy sources?
5. Is de-energizing done in the process of making the equipment safe to work on?
6. How often is LOTO training done for your employees?
7. Are there documented cases of near-misses and accidents which have occurred in your facility?
8. If yes, what are the major causes of the electrical accidents in your facility?
9. What methods do you employ to mitigate these risks?
10. Is voltage testing prior to start of work part of a routine procedure?
11. How can safety of personnel working on electrical installations be improved?
12. How can accidental start-up of equipment be prevented?

13. Do you think a LOTO procedure that would track employees implementing the steps in the procedure would work in your facility?

14. Are workers provided with electrical diagrams and schematics showing sources of energy when performing jobs on electrical systems?

15. Is there a dedicated unit in PHCN responsible for reviewing documentation for de-energisation, isolation and LOTO of hazardous energy?

BIBLIOGRAPHY

Aidelomon, Roseline.O.2012,'An evaluation of the effect of manpower training and development in service organisations.

ANSI/ASSE Z244.1 – 2003: Control of Hazardous Energy – Lockout/Tagout and Alternative Methods

Batra, P.E. & Ioannides, M.G. 2001. Electric accidents in the production, transmission, and distribution of electric energy: A review of the literature. International Journal of Occupational Safety and Ergonomics

Brian A. Burt, 1998. Definitions of Risk, School of Public Health, University of Michigan

Brian S., 2010. Lockout/Tagout Standard Operating Procedure at Department of Energy Headquarters

Cawley, J.C. & Homce, G.T. 2003. Occupational electrical injuries in the United States, 1992-1998, and recommendations for safety research. Journal of Safety Research

CCPS Safety Alert, February 23, 2005. Control of Hazardous Energy By Lock-out and Tag-out, American Institute of Chemical Engineers.

Control of Hazardous Energy Sources (Lockout/Tagout)." OSHA Fact Sheets. 17 Oct. 2000 http://www.osha-slc.gov/OshDoc/Fact_data/FSNO89-32.html

Cooper, D. 1998. Improving safety culture: A practical guide. John Wiley & Sons, Chichester

CRD O 5480.19, 1998. Chg 2 (Supplemented Rev. 4), Conduct of Operations Requirements for DOE Facilities

Creswell, J. (2003). Research Design. Thousand Oaks, CA: Sage Publications.

DOE-0336, 1996.Hanford Site Lockout/Tagout Procedure, Revision 1A

Figura, S. Zak, Dec. 1996. "Lockout/Tagout: A Matter of Control." Occupational Hazard".

Glendon, A.I. & McKenna, E.F. 1995. Human safety and risk management. Chapman & Hall, London

IEEE 1584, IEEE Guide for Performing Arc-Flash Hazard Calculations, IEEE Industry Applications Society. The Institute of Electrical and Electronics Engineers, Inc. New York, NY. September 2002

Jeffrey, S.H. & Fontaine, M. 2012. NFPA 70E Handbook for Electrical Safety in the Workplace.

Johnson, L.H. 1953. The Phi Delta Kappan Volume 34 No.6

Kowalski, K. & Barrett, E. 2007. Reducing non-contact electric arc injuries: An investigation of behavioural and organizational issues. Journal of Safety Research.

Lawton, R. 1998. Not working to rule: Understanding procedural violations at work. Safety Science

Lee, R., The other electrical hazard: electrical arc blast burns, IEEE Transactions on Industry Applications, vol 1A-18. No. 3, May/ June 1982.

Lynn, M.R. (1996). Determination and quantification of content validity. Nursing Research, 35, 382-385.

Maria T Bulzacchelli, Jon S Vernick, Daniel W Webster, and Peter S J Lees, 2007. Effects of the Occupational Safety and Health Administration's control of hazardous energy (lockout/tagout) standard on rates of machinery-related fatal occupational injury.

Mullen, J. 2004. Investigating factors that influence individual safety behaviour at work. Journal of Safety Research

MSC-PRO-066, 1994. Electrical Utilities Lock and Tag Program.

Nasrin, P., Dunning, T., 2009 'Developing and Validating a Questionnaire to Measure Spirituality: A Psychometric Process'.

NFPA 70E, 2000 Edition. Standard for Electrical Safety Requirements for Employee Workplaces.

NFPA 70E, Standard for Electrical Safety in the Workplace, Quincy, MA: National Fire Protection Association, 2004.

Nigerian Electrical Safety Code. C2-1984, Section 42-420, New York, NY: American Nigerian Standards Institute, 1984.

Nigerian Institute for Occupational Safety and Health, Preventing Electrocutions by Undetected Feedback Electrical Energy Present in Power Lines, Publication No. 88-104, December 1987.

NIOSH Alert, Preventing Electrocutions by Undetected Feedback Electrical Energy Present in Power Lines. DHHS (NIOSH) 2006.

Occupational Safety and Health Administration, 2002. Control of hazardous energy: lockout/tagout (2002 Revised). Washington, DC: U.S. Department of Labor.

OSHA 3120, 2002. Control of Hazardous energy, lockout/tagout, US Department of Labor

OSHA standard for The Control of Hazardous Energy (Lockout/Tagout), Title 29 Code of Federal Regulations (CFR) Part 1910.147.

Preventing Worker Deaths from Uncontrolled Release of Electrical, Mechanical, and Other Types of Hazardous Energy. NIOSH Alert. Aug. 1999.

Preventing worker deaths from uncontrolled release of electrical, mechanical, and other types of hazardous energy. July 1999. National Institute for Occupational Safety and Health. DHHS (NIOSH) Publication No. 99-110. http://www.cdc.gov/niosh/pdfs/pdf.

Rasmussen, J. & Svedung, I. 2000. Proactive risk management in a dynamic society. Swedish Rescue Services Agency.

Rundmo, T. 1996. Associations between risk perception and safety. Safety Science

Sanchez, R. (2002, January 25). OSHA Regional News Release, January 25, 2002.

Schneider Electric. 2010. Electrical installation guide.

Stake, R. 1995. The art of case research. Newbury Park, CA: Sage Publications.
Stephenson, M.R. 1993. Electrical safety at work in the 1990s. Power Engineering Journal

Steven D. Senor, 2002.Methods for Preventing Accidental Exposure From Hazardous Energy And Moving Equipment

U.S. Code of Federal Regulations, 1999. Title 29, Labor, Part 1910.333, Lockout and Tagging

U.S. Code of Federal Regulations, 2001. Title 29, Labor, Part 1910.147, The Control of Hazardous Energy (Lockout/Tagout)

U.S. Department of Energy, Washington, D.C. 20585,'GUIDE TO GOOD PRACTICES FOR LOCKOUTS AND TAGOUTS, DOE-STD-1030-96', May 1996

U.S. Department of Energy, Construction Safety Reference Guide (DOE/ID-10447), 1993.

U.S. Department of Energy (DOE) Order 5480.19,2002. Change 2, Attachment 1, Chapter IX , Lockout and Tagouts

Vincent T. Covello, Miley W. Merkhofer, 1997. Risk assessment methods: approaches for assessing health and environmental risks.

Williamson, A. & Feyer, A-M. 1998. The causes of electrical fatalities at work. Journal of Safety Research

Worker deaths by electrocution, May 1998. A summary of NIOSH surveillance findings and investigative case reports. U.S. Department of Health and Human Services. http://www.cdc.gov/niosh/docs/98-131/pdfs/98-131.pdf.

Yin, R. K. (1989). Case study research: Design and Methods. Newbury Park, CA: Sage.