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Investigation of the Safety Conditions of Voltage in High Voltage Network Poles: A Case Study of Benin City, Nigeria

Elaigwu V.O[a], Olodu D.D[b*] and Okagbare G.O[b]

Department of Electrical Engineering, Benson Idahosa University, Edo State, Nigeria
[b]Department of Mechanical Engineering, Benson Idahosa University, Edo State, Nigeria
*Corresponding Author- dolodu@biu.edu.ng

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Abstract

This study focused on the investigation of the safety condition of voltage in high voltage network pole. The study involved the use of 132KV transmission line and the safety level during which it operates under certain power condition. The interview conducted showed that when the power is on or in a stressful condition, there is high potential hazard which puts workers' safety at risk; hence hazard identification is essential at every stage of the process. The goal of this study is to identify the sources of potential workplace risks based on the four impacted classifications: the general public, work-related technical staff, installations, and the environment. The interview conducted revealed the potential hazards for the general public safety and the control measures required. The preliminary findings of this study indicate that falling objects, flash over, injured workers, scorching temperatures, improperly built aluminum and bulkhead ladders, and the existence of stressful conditions on each conductor are the sources of hazard when operating at 132 KV voltage. Hence, for the implementation of work in a 132 KV voltage state, it is recommended that every technician follow the SOP (Standard Operating Procedure), wear complete Personal Protective Equipment (PPE), and be cautious when doing work and socializing with the surrounding community.

1. Introduction

One of the resources that the community requires to promote its well-being is electricity. Electrical energy is used in a variety of ways to support people's daily activities, including lighting, motor power, and heating. The usage of various electrical resources to promote a better existence was made possible by the development of increasingly advanced technologies at this time. The distribution system for electricity is well-equipped. Working currents and voltages energize the distribution system under typical conditions, this may cause existing equipment to function poorly. Internal and external factors can cause disturbances in distribution equipment.

The operating components of distribution such as insulators, conductors, transformers, and the connections in overhead lines are extremely vulnerable to load current interference and damage. Load currents can induce losses and raise the temperature of distribution system equipment,

lowering its efficiency and limiting its lifespan [1]. In addition to disrupting load currents, sparks (flashover) created by the space between phases can cause damage to distribution equipment, causing the equipment on the 132 KV high Voltage Air Line distribution network to heat up. Maintenance is essential to increase the distribution system's dependability and avoid any disruptions. The goal of routine maintenance and maintenance of distribution network equipment is to prevent loss of efficiency and damage so that the equipment can function properly.

In terms of network maintenance and repair by the power supply company which sometimes had a system without voltage supply (blackout). This have become a critical issue for businesses making use of electricity supplied The continuous diminished services of electricity power supply company hinders manufacturing processes to their full potential since electricity is not distributed due to outage of power. The power company maintains a 33/11KV distribution network with a hot line maintenance system [2] to reduce blackouts by increasing the SAIDI (System Average Interruption Duration Index) and SAIFI (System Average Interruption Frequency Index). Working in a high-voltage setting poses a significant risk to worker safety, public safety, installation safety, and environmental safety. Besides being useful, electrical power can be dangerous sometimes, according to the explanation of Indonesian Law No.30 Year 2009. As a result, electric power installations must use electrical equipment's that meet the equipment standards in the electricity sector in order to better ensure general safety, work safety, installation security, and the preservation of environmental functions in the supply of electricity and the utilization of electric power [3].

Electricity safety must be implemented by electricity business organizations in order to reduce the danger of electricity accidents (general public accidents, work accidents, installation accidents, pollution, and/or environmental damage) in all electricity activities. Occupational safety and health are critical components in minimizing any hazards associated with business operations [4]. Work accidents can occur as a result of actions in the implementation of a manufacturing process in an industry [5]. In addition, Article 1 paragraph 2 of Law Number 32 of 2009 on Environmental Protection and Management defines planning, utilization, control, maintenance, supervision, and law enforcement as a systematic and integrated effort to conserve environmental functions and prevent pollution and/or damage to the environment [6, 7].It is vital to examine the safety of electricity network to prevent undesirable occurrences and minimize potential dangers in order to achieve effective and efficient electricity safety at work in voltage. As a result, the authors are interested in investigating the safety of electricity at work in stressful situations, particularly in the maintenance of electricity distribution networks, specifically the process of replacing pedestal insulators on strained medium voltage grid poles [8, 9].The specific objective of this research is to analyze the potential hazards in the installation of the R phase pedestal insulator on the medium voltage grid pole in a voltage state using the direct touch method.

The formulation of the problem in this research is to investigate the potential hazards that can occur at work in voltage by using the electricity safety analysis method in the high Voltage Network Maintenance Team at Benin city, while the specific objective is to analyze the potential hazards in the installation of the R phase pedestal insulator on the medium and high voltage grid pole when the transmission line is energized, therefore, this study focused on the investigation of the safety condition of voltage in high voltage network pole.

2. Methodology

The interview approach was utilized in this study as a sort of qualitative research with the goal of examining the potential hazards of electricity operations. This study is broken down into five stages: preliminary, collection of information through interview, processing of information obtained from the interview, analysis, discussion, and recommendations.

i. Research in the Field

The initial stage in this inquiry is to make observations in order to gain a sense of the object's current state. This will be extremely beneficial to researchers because it will provide them a clear image of their work. Researchers can learn about the company's challenges based on the findings of this field investigation.

ii. Formulation of the Problem

The problem of electrical safety at work in voltage conditions at the medium or high voltage network maintenance team in Benin City poses great challenges, and it is at this stage that research is being conducted through interview. Potential dangers during work in a medium/high voltage environment are investigated through interview in order to avoid unwelcome events and eliminate potential hazards

iii. The goal of the study

The goal of this study is to find, analyze, and make suggestions for improvement.

iv Information Collection Stage

Observations and interviews are part of the information collection stage. The information was gathered and entered into the processing stage. Following the acquisition of the essential information, processing of the obtained information was carried out using the appropriate procedures for the challenges at hand. Electricity safety analysis was employed as the method

2.1 The Stages of Information Processing in this Study

The stages of information processing that were completed were as follows:

2.1.1. Select a Job to be examined

Selecting a work or task to be analyzed is the first step in the electricity safety analysis procedure. When you have limited time and resources to study all stages of the employment process, choosing a job to analyze may seem straightforward, but it can be a critical issue. Almost every type of job necessitates a risk assessment. However, there are several factors that need to be considered in determining work priorities that must be analyzed first, including:

i. The job with the highest accident rate
ii. Work that has the potential to cause serious and deadly injury, even for jobs for which there is no previous accident history
iii. Work where one minor negligence of the worker can result in a fatal accident or serious injury
iv. Every new job or job that has undergone a change in work processes and procedures
v. The work is quite complex and requires written instructions.

The various factors above can help in determining what jobs should be prioritized and must be analyzed first.

2.1.2. Describe the Steps of the Job from Start to Finish.

Each project must be detailed in order to conduct a proper and thorough electrical safety analysis. These procedures are not only unique to a single job, but also to a distinct work environment. If the work environment changes but the sort of work remains the same, the job steps must also adapt. It's critical not to describe the job too narrowly (in detail) or too generally

(in general). Each job usually has no more than ten tasks. If the duties on the safety analysis turn out to be more than this, consider splitting the job into two or more parts.

2.1.3. Break Down of the Job into Basic Steps

In the process of replacing the Phase R fulcrum insulator, the direct touch method consists of various stages according to the Standard Operating Procedure was used, the stages were; preparation of materials and equipment, installation of a no voltage detector and protector, removal of the pin type insulator cover on phase R to untie the tied wire and move the conductor to the cross arm. The replaced R Phase fulcrum insulator was replaced and the conductor was returned to the insulator trench. The conductor with tied wire and close to the Phase R insulator with the Pin Type insulator cover, is followed by removing the conductor cover, insulating type pins on both sides and insulating blanket on the cross arm and removing the no voltage detector. This ends with restoring equipment and materials.

2.1.4. Identifying Potential Risks and Impacts

Any potential hazards/impacts should be identified as soon as possible after the observation and details of each work step have been completed. If one or more work steps need to be repeated, it is best to do them immediately, if possible. Identification of potential hazards/impacts is the most important part in carrying out an electricity safety analysis. Here are some things you can consider when identifying hazards:

vi. The cause of the previous accident (if any)
vii. Other jobs located near the work area
viii. Regulations or regulations related to the work to be carried out
ix. Manufacturer instructions in operating work equipment.

2.1.5 Determine Control/Preventive Measures

Each potential hazard/impact that has been previously identified requires control. These controls describe how you will eliminate hazards in the work area or how you will significantly reduce your risk of injury. The hazard control hierarchy is a tool commonly used to develop occupational hazard control measures. The National Institute for Occupational Safety and Health (NIOSH) divides five hierarchies of hazard control in the workplace, including:

i. Elimination - eliminating or minimizing harm
ii. Substitution - replacing hazardous tools, machines, or other materials to become less dangerous.
iii. Engineering - isolating, installing additional ventilation systems, modifying tools, machines or workplaces to make them safer
iv. Administrative controls - procedures, rules, training, duration of work, K3 signs, K3 posters, labels, etc.
v. Personal protective equipment (PPE).

2.1.6 Analysis and Interpretation Stage

The information obtained from the interview in this study was analyzed, interpreted and used as a guide in making improvements. The improvement proposal is a general recommendation that can be applied in all types of accidents that occur. Figure 1 shows installation of pedestal isolators in a stressed state using the direct touch method.

Figure 1: Installation of pedestal isolators in a stressed state Using the Direct Touch Method (source: www.pdkb.id) [10]

3. Result and Discussion

The electricity safety analysis is carried out in the following stages:

3.1 Determine the Type of Work to be Analyzed

In this study, the type of job of replacing the phase R pedestal insulator with direct touch method. The observations made were when the work was carried out on 20th November, 2021 in Benin City, Edo State, Nigeria. This work was carried out by The Medium Voltage Network Maintenance Team at Benin city, with as many as 7 workers consisting of 1 team leader, 1 K3 supervisor and 5 PDKB technicians.

3.2 Identifying Potential Hazards in each Job

3.2.1 Controlling Danger

The results of the identification of potential hazards/impacts and control of electricity hazards for electricity safety analysis in terms of the safety of the general public, workers, installation and environmental were presented in Table 1, 2, 3 and 4 respectively.

Table 1: The Results of Electricity Safety Analysis for General Public Safety in the Installation of R-Phase Insulators with Direct Touch Method

No	Job Steps	Potential Hazards for the General Public Safety	Control Measures
1	Preparation of Materials and Equipment	• Hit by a sharp object	• Installation of barricades / safety lines and information boards
2	Installing No Voltage Detector and Protector	• Equipment fell	• Installation of barricades / safety lines and information boards
3	Removing Pin Type Insulator Cover on Phase R	• Equipment fell	• Installation of barricades / safety lines and information boards
4	Unfasten the tie wire and move the conductor to the cross arm	• Flashover	• Installation of barricades / safety lines and information boards
5	Replacing the phase R pedestal insulator	• Isolator falls	i. Installation of barricades / safety lines and information boards
6	Returns the conductor to the insulator trench	• Linesman slips	i. Installation of barricades / safety lines and information boards
		•	
7	Tie the conductor with tie wire	• Flashover	i. Installation of barricades / safety lines and information boards
8	Menutup isolator Phase R dengan Pin Type isolator cover	• Equipment fell	i. Installation of barricades / safety lines and information boards
9	Melepas conductor cover, pin isolator type pada kedua sisi dan insulating blanket pada cross arm dan melepas no voltage detector	• Equipment fell	i. Installation of barricades / safety lines and information boards

10	Mengembalikan peralatan dan material	• Stuck work equipment	i. Installation of barricades / safety lines and information boards

The results of the identification of potential hazards / impacts and control of electricity hazards for the analysis of electricity safety in terms of work safety are as in table 2.

Table 2: Results of the Analysis of Electricity Safety for Worker Safety in the Installation of the R Phase R Insulator with the Direct Touch Method

S/N	Job Steps	Potential Hazards for the Worker Safety	Control Measures
1	Preparation of Materials and Equipment	• Hands scratched by sharp objects • Slipped • Hit by a sharp object	• Wear cotton gloves • Pay attention to the placement of equipment and materials in a safe place
2	Installing No Voltage Detector and Protector	• Stung by tension • Equipment fell	• Make sure the PPE is installed properly • Make sure to install correctly
3	Removing Pin Type Insulator Cover on Phase R	• Stung by tension • Equipment fell	• Make sure the equipment is removed properly • Make sure the area of the closest tension has been installed protector perfectly
4	Unfasten the tie wire and move the conductor to the cross arm	• Gloves are leaking • Stung by tension • Flashover	• Fit to open the bonds using combination pliers • Roll the ties when untying • Make sure the cross arm is completely closed • Ensure that the conductor cover is properly connected to the line hose
5	Replacing the phase R pedestal insulator	• Hand spinched • Isolator falls • Gloves are torn	• Take care when removing or installing insulators • Make sure the insulator is bonded to the fabric slink • Hold the insulator by its intact parts
6	Returns the conductor to the insulator trench	• Linesman slips • Loose conductor	• Ensure an ergonomic working position • Hold the conductor firmly by the lineman
7	Tie the conductor with tie wire	• Gloves are leaking • Stung by tension • Flashover	• Make sure the tie wire ends are not sharp • Roll the ties while tying the knots • Make sure the cross arm is closed completely
8	Closing the R phase insulator with the Pin Type insulator cover	• Equipment fell • Stung by tension	• Make sure to install correctly • Make sure the area of the closest voltage has been installed protector perfectly
9	Removing the conductor cover, insulator type pins on both sides and the insulating blanket on the cross arm and removing the no voltage detector	• Equipment fell • Stung by tension	• Make sure to install correctly • Make sure the protector that is removed starts from the position furthest from the linesman
10	Return of equipment and materials	• Hands scratched by sharp objects • Slipped • Stuck work equipment	• Wear cotton gloves • Ensure gradual return of equipment and materials • Take care in returning work equipment

The results of the identification of potential hazards / impacts and control of electricity hazards for the analysis of electricity safety in terms of installation safety are as shown in table 3

Table 3: The Results of Electricity Safety Analysis for Installation Safety in the Installation of R Phase R Insulators with Direct Touch Method

No	Job Steps	Potential Hazards to Installations Safety	Control Measures
1	Preparation of Materials and Equipment	There is no potential hazards	There is no potential hazards
2	Installing No Voltage Detector and Protector	• The lift man touches the conductor and there is a leak to the grounding and flashover	• Installation of local grounding • Coordination with the Distribution Control Area Unit in anticipation of trip protection
3	Removing Pin Type Insulator Cover on Phase R	• The lift man touches the conductor and there is a leak to the grounding and flashover	• Installation of local grounding • Coordination with the Distribution Control Area Unit in anticipation of trip protection
4	Unfasten the tie wire and move the conductor to the cross arm	• The lift man touches the conductor and there is a leak to the grounding and flashover • The conductor touches the cross arm and flashes over	• Installation of local grounding • Coordination with the Distribution Control Area Unit in anticipation of trip protection
5	Replacing the phase R pedestal insulator	• The lift man touches the conductor and there is a leak to the grounding and flashover	• Installation of local grounding • Coordination with the Distribution Control Area Unit in anticipation of trip protection
6	Returns the conductor to the insulator trench	• The lift man touches the conductor and there is a leak to the grounding and flashover • The conductor touches the cross arm and flashes over	• Installation of local grounding • Coordination with the Distribution Control Area Unit in anticipation of trip protection
7	Tie the conductor with tie wire	• The lift man touches the conductor and there is a leak to the grounding and flashover	• Installation of local grounding
8	Closing the R phase insulator with the Pin Type insulator cover	• The conductor touches the cross arm and flashes over	• Coordination with the Distribution Control Area Unit in anticipation of trip protection
9	Removing the conductor cover, insulator type pins on both sides and the insulating blanket on the cross arm and removing the no voltage detector	• The lift man touches the conductor and there is a leak to the grounding and flashover	• Installation of local grounding
10	Return of equipment and materials	The conductor touches the cross arm and flashes over	Coordination with the Distribution Control Area Unit in anticipation of trip protection

The results of the identification of potential hazards/impacts and control of electricity hazards for the analysis of electricity safety in terms of environmental safety are as shown in table 4.

Table 4: Results of the Analysis of Electricity Safety for Environmental Safety in the Installation of R- Phase Insulator with Direct Touch Method

No	Job Steps	Potential Hazards to Environmental Safety	Control Measures
1	Preparation of Materials and Equipment	There is no potential hazards	There is none
2	Installing No Voltage Detector and Protector	There is no potential hazards	There is none
3	Removing Pin Type Insulator Cover on Phase R	There is no potential hazards	There is none
4	Unfasten the tie wire and move the conductor to the cross arm	There is no potential hazards	There is none
5	Replacing the phase R pedestal insulator	There is no potential hazards	There is none
6	Returns the conductor to the insulator trench	There is no potential hazards	There is none
7	Tie the conductor with tie wire	There is no potential hazards	There is none
8	Closing the R phase insulator with the Pin Type insulator cover	There is no potential hazards	There is none
9	Removing the conductor cover, insulator type pins on both sides and the insulating blanket on the cross arm and removing the no voltage detector	There is no potential hazards	There is none
10	Return of equipment and materials	There is no potential hazards	There is none

4. Conclusion

The electrical safety which involved the process of replacing a pedestal isolator on a medium or high voltage grid pole in a high voltage state had a considerable potential hazard. Therefore, control measures were analyzed based on four classifications; the general public, technical personnel who carried out the installation of pedestal isolators, installations and the environment. The interview conducted revealed the potential hazards for the general public safety and the control measures required. The preliminary findings of this study indicates that falling objects, flash over, injured workers, scorching temperatures, improperly built aluminum, bulkhead ladders, and the existence of high loading conditions on each conductor are the sources of hazard when operating at 132 KV voltage. Moreover, after observing the potential hazards that can occur and the control measures of these potential hazards, it was therefore recommended that there should be cooperation of all parties involved both from agencies, workers and the community. However, there is need for socialization and education in order to understand the potential hazards that can occur and how to control them by ensuring that workers comply with the Standard Operating Procedure (SOP) using calibrated and complete personal protective equipment.

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