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Full Length Research Paper

Risks Assessment of Electrical Installation High Voltage and Low Voltage for Power Generation/Distribution Operation

Peace, O. Ali*, Maureen, E. Wyse, Kayode, O. Odeniyi, Olusanya, E. Oludele, Erhuen, Ejomafuvwe, Andrew John, Doubra, A. Egbusta and Ikpesu, Ejovwokoghene Jasper

Department of Industrial Safety and Environmental Technology, Petroleum Training Institute, P.M.B 20, Effurun, Delta State, Nigeria.

*Corresponding author E-mail: ali-po@pti.edu.ng, doubraalfredo@gmail.com

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ABSTRACT: Electrical hazard is major concern for all sectors in Nigeria and even in residential areas. This makes it essential to evaluate the risk levels to which the population is exposed. This study assessed the risk of electrical installations for power generation/distribution operation in residential areas. The survey approach was employed in the risk assessment of electrical installations within the residential area where a detailed checklist was implemented in risk evaluation study on electrical installations. Result from inspection of low voltage installation such as switchboard and circuit breakers as well as schematic diagram display showed that there are possible damages which may alter safety. Inspection of main cables showed an acceptable level and only recorded a minor visible damage. While, visible damages were observed on the meter boards due to time of installation and low housekeeping level. Assessment of high voltage installations showed that transformers and earth system are also satisfactory and acceptable with proper ventilation to transformers, adequate maintenance test and insulating plate for live parts. High voltage installations were also observed to be electrically earthed and present a low — medium risk level. It can therefore be concluded that low and high voltage installations showed that only low voltage installation showed a high risk level due to absence of caution signs.

Keywords: Hazard, Electrical Installation, Risk Assessment, Safety Management.

INTRODUCTION

Electrical hazard is major concern for all sectors in Nigeria and even in residential areas. This is because of the resulting effects (fires, electric shocks, electrocutions and thermal burns) it poses both environmentally and economically. Issues of electrical safety have plagued many parts of the nation leading to death, first degree burn and loss of properties by locals. Because electricity is a familiar part of our lives, it is often not treated with enough caution (Adekunle et al., 2016). According to Brkic and Stajic (2021) in occupational places, electrical incidents can trigger certain harmful conditions such as gas explosion. In residential areas, it is observed also as likely due to its ability to create an electrical spark. Electrical hazards often occur due to inadequate equipment or its malfunction, negligence, lack of training, poor or incomplete maintenance. Research has found that this incident can also be created by electrical faults in Nigeria. This is why it is important to look at electrical safety when carrying out electrical installations in residential area. Electrical safety is of paramount importance and hence electrical installations must be carefully implemented. In electrical installations, electrical safety operations procedure (ESOP) and electrical safety rules (ESR) must be undertaken to prevent electrical hazards since electrical installations such as black wires and the red wire are at 220 volts. Any contact with such an energized wire leads to the flow of current through the body and subsequently an electrical shock (Building Biology Institute, 2008). Fatalities and injuries caused by electricity pose a serious public problem (Aneziris et al., 2010).

Study have reported that contact with electricity (high voltage cables) and working near overhead wires, rail tracks or high voltage cables were amongst the leading causes. This effect marks the need to minimize risk of electrical installations. Researchers are of the opinion that electrical safety is an indispensable component especially in homes because of the high level of risk associated with such operations (Adekunle et al., 2016). Most of the electrical accidents that occur are due either to carelessness or to a lack of awareness of some basic rules that should be observed when using electricity.

Some electrical safety measures applicable in residential areas includes installations such as circuit protection, grounding and protected electrical installations, proper choice of electrical cables and adequate installations, all of which have been found useful in prevent of electrical hazards. Ensuring electrical safety through risk assessment of electrical installations is important since it protects against negative effects (Saba et al., 2014). However, there is little available study on risk of electrical installations in most residential areas and hence it is important to assess this risk level in other to ascertain risk level and minimize them.

Literature review

Electricity

Electricity is a form of energy that results from the existence of charged particles. Electricity is used in many ways for both industrial and domestic activities such as lighting, cooling, heating and driving of electrical equipment and machines (Saba et al., 2014). As electricity has become an integral part of mankind, so have the incidents of electrocution due to electric current (Obi et al., 2020). Although electricity normally travels in closed circuits, through a conductor it can also come in contact with human body through either exposed part transmission which can lead to an electrical shock (electrical accident) (Obi et al., 2020). Despite the important of electricity to humans, its effect classifies it as a silent killer because it has no physical attribute. Electricity is a powerful and versatile energy but can be dangerous if it is not used properly managed. This is because it poses serious hazards to both workers in different industries and even in homes (Saba et al., 2014).

Hazards

Cadick et al., (2006) defines hazard as any potential or actual threat to the wellbeing of people, equipment, machinery or environment. To Breeding, (2011) it is a situation that poses a certain level of risk to life, property, or environment and remains dormant within any environment. In terms of electrical concern, it refers to potential source of danger such as naked electricity wires, electricity gadgets which are not switched off, unsafe acts, unprotected installation, over load socket outlet amongst others (Saba et al., 2014). Hazard may cause harm when they become active, or create an emergency situation. More directly, a hazard is a source of potential harm or negative outcome from past, current, or future exposures. Hazards may be classified as either safety hazards or health hazards. However, they may be of different types.

Types of Hazards

There are different types of hazards, most of which increases risk levels in a workplace. Martinelli (2019) specify them as:

Physical hazards

Physical hazards are factors within the environment that can harm the body without necessarily touching it. They include heights, electricity, noise, radiation, extreme temperature and pressure.

Chemical hazards

Chemical hazards are hazardous substances that can cause harm. They are present when a worker is exposed to any hazardous chemical either during preparation or use in the workplace in any form (solid, liquid or gas). They can be very dangerous but might not always be immediately identifiable in the workplace.

Biological hazards

Biological hazards are hazards associated with the use of infectious substances or agents. They include viruses, bacteria, insects, animals that can cause adverse health impacts. For example, blood and other bodily fluids, harmful plants, sewage, dust and vermin. Biological hazards may be present in workshops/laboratories in schools, colleges and universities, hospitals, laboratories, emergency response, nursing homes, outdoor occupations.

Ergonomic hazards

Ergonomic Hazard occur when the type of work, body positions and working conditions put strain on the body. It is a result of physical factors that can result in musculoskeletal injuries. They are often associated with a poor workstation setup in an office, poor posture and manual handling.

ELECTRICAL HAZARDS

An electrical hazard can be defined as a hazard that exposes workers to electrical injuries. Environment Health and Safety (2021) explains that such hazards usually come from electrical shock, fire and arc flash. Since electrical devices used in both homes and workplaces carry high voltage or high power requirements, there are high risk to hazards. According to Saba et al. (2014) there are no record of electric hazards causality by gender that is to say if male do become victim of electrical hazards such shock, electrocution and other hazards than female counterpart will be. They however, stated the relevance of electrical safety education to everyone on the use of electricity because electrical hazard poses a significant risk of death and injuries to individuals.

Categories of Electrical hazards

There are three principle types of electrical hazards. They are;

Shock hazards

Electrical shock often comes from inadvertent contact with energized conductors. This is because the body become part of an electric circuit through various ways or path. The effect of electric shocks ranges from stop of the heart or the breathing muscles, or both, burns, bleeding, neurological damage and ventricular fibrillation. According to Saba et al., (2014) the risk of receiving electrical shock is greater if one stands in a wet floor or touch live wire with wet body or coming in contact with live electrical source. Dennis (2015) indicated that fatality from this electric shock comes from three principle causal factors including failure to properly or completely de-energize systems prior to maintenance or repair work, intentionally working on energized equipment and improper or inadequate grounding of electrical system components either in homes or workplaces.

Flash hazard

it is estimated that 75% to 80% of all serious electrical injures are related to electrical arcs created during short circuits and switching procedures. An electrical arc is an electrical current passing through ionized air. As current flows, it releases a tremendous amount of energy as both radiated light and converted heat. The results of the arc hazard assessment are most useful when they are expressed in terms of the incident energy received by exposed personnel (Dennis, 2015).

Explosion hazard

This phenomenon occurs in nature as the thunder that accompanies lightning, a natural form of an electrical arc. The resulting expansion of the air and vaporized conductive material creates a concussive wave surrounding the arc. The pressures in this wave may reach several hundred lbs./ft2, destroying equipment enclosures and throwing debris great distances. Electrical hazards have been seen to occur in homes resulting in electrical accidents.

Electrical accidents

Many scenarios have shown the devastated effect of electrical hazards. According to Janick (2008) fires that occur in the home, market, offices and other places as a result of electricity are initiated as a result of improper and careless use of electrical equipment and improper protection of installation. Report from International Association of Oil and Gas Producers found out that 16.1% of all oil fatalities in 2010 were caused by an electrical accident, explosion or burn.

In the year 2020, it was reported that 26 persons died while 114 persons were injured in electricity-related accidents within the second quarter. The Nigerian Electricity Regulatory Commission (NERC) also reported a total of 114 accidents from the licensed operators during the second quarter of 2020. This heightens the risk associated with the use of electricity in any given environment especially in developing nations where health and safety practices are not fully adhered (Emmanuel, 2021).

RISK

Risk can be defined as a combination of the probability or possibility of an event happening and its consequences. It is stated as the likelihood that a hazard will cause a specific harm or injury to persons or damages to property (Segun, 2012). International Labour Organization (ILO), (2015) reported that risk increases accidents, health problems and create new problems. Owing to the complexity in structure and nature, engineering practice has been described risk to be fickle, unpredictable, volatile and fraught with risks. Risk levels are heightened by occurrence of hazards (Yadhushree et al., 2017). Risk represents the possibility (potential) of a future negative reality, which makes risk management a dynamic process. Risk is quantified by two significant negative possibilities in the future events which are the probability of an event (whether something is going to happen or not), and the consequences of the event (to what extent these will be catastrophic).

Risk assessment

Risk assessment is defined as a systematic procedure for analyzing systems to identify and evaluate hazard and

safety characteristics and helps in determining qualitative or quantitative values of risk for identified threat. Some of the risk assessment process are very complex and are best used in formal situations for specific purposes. For instance, fault tree analysis, failure mode and effects analysis irrespective whether it is a qualitative or quantitative risk assessment (Yadhusree et al., 2017). Risk assessment is one of the main pillars of the framework directive and other directives in respect of health and safety, it is the basis of an effective management of safety and health. There are various types of risk analysis all of which follows the basic steps of risk identification, risk analysis and risk evaluation;

Baseline risk assessment

The purpose of conducting a baseline risk assessment is to establish a risk profile or a set of risk profiles. It is used to prioritize action programmes for issue-based risk assessments. It must be emphasized that the baseline is an initial risk assessment that focuses on a broad overview in order to determine the risk profile to be used in subsequent risk assessments (SALG, 2019).

Issued based risk assessment

This type of assessment is normally focused on operational activities, processes and systems based functions. It focuses the identification of the risks within a certain task, process or activity and is usually associated with the management of change (SALG, 2019).

Continuous risk assessment

It is performed at an operational level where the system process and activities are monitored on a continuous basis (SALG, 2019).

Electrical risk assessment

Electrical risk assessment includes a review of the electrical hazards, the associated foreseeable tasks, and the protective measures that are required in order to maintain a tolerable level of risk. It is conducted to evaluate the probability of occurrence of electrical hazards. This is because electrical hazard posed a significant risk of death and injuries to individual therefore, attention to safety is the necessary as first step in any environmental set up. According to Environment Health and Radiation Safety (2020) it involves the following steps;

Identify the electrical hazards associated with the task and the electrical system, or electrical process involved.

Identify the electrical work to be performed within the electrical system or process.

Define the possible failure modes that result in exposure to electrical hazards and the potential resultant harm.

Assess the severity of the potential injury from the electrical hazards.

Determine the likelihood of the occurrence for each hazard.

Define the level of risk for the associated hazard.

If the level of risk is not acceptable, identify the additional measures or corrective actions to be taken.

Electrical accidents in residential areas

In today's society, electrical accident may occur from different activities. One study by Weihul (2000) highlights that in residential environment, it may arise from heavily loaded power transformers and hence there is need to raise safety interest. Others include exposed electrical parts and promotion of the presence of electrical hazards. Study by Obi et al., (2020) conducted to identify possible risk factors for lethal electrical injury, observed that reduced electrical risk levels due to reduction in injury rates and fatality rate. Study by Saba et al., (2014) supported the claim with result that showed the level of awareness of electrical hazards and safety measures knowledge among electricity users in urban residential environment such as Minna metropolis. Also, residents were found knowledgeable on proper electrical insulation and switching off and unplug equipment to be repaired.

Effects of electrical accidents in residential areas

In residential settings, electrical accidents normally occur due to inadequate knowledge of the electrical gadgets, information and ignorance on the part the consumers and operators, improper and nonexistent earthing system and improper designed of earthing system. Electrical installations such as the black wires and the red wires carry up to 220 volts. If a person comes in contact with an energized wire current will passes through your body (Obi et al., 2020).

According to study by Igweonu (2006) electrical accident in residential set up may also be caused by protection equipment failures, absence of protection devices in some cases, poor and aging transmission lines, aging distribution networks, pitiable response to complaints of damaged.

Table 1: Average rating for assessed area.

SECTIONS	Low Voltage Installation	High Voltage Installation
Switchboards, circuit breakers and main switches	55	42
Transformers	-	40
Earth	40	32
D.C Battery System	-	10
Main cable	65	18
Busbar trunking system including rising mains	70	-
Metre Board	50	-
Underground Cable lines	20	-
Distribution Board	50	-

Table 2: Calculation for risk assessment for low voltage installations.

	Severity/Likelihood	Likely	Score of total sample	Risk rate
Switchboard, circuit breakers and main switches	55	2	200	72.5
Earth	40	3	200	53.3
Main cable	65	2	200	67.5
Busbar trunking system including rising mains	70	2	200	65
Metre Board	50	2	200	70
Underground Cable lines	20	2	200	80
Distribution Board	50	4	200	50

Table 3: Calculation risk assessment for high voltage installations

	Severity/ Likelihood	Possible	Score of total sample	Risk rate
Switchboards, circuit breakers and main switches	42	2	200	79
Transformers	40	2	200	80
Earth	32	2	200	84
D.C Battery System	10	2	200	95
Main cable	18	3	200	60.5

Key Rating; 100 — 75	Low
75 — 50	Medium
50 — 25	High
25 — 0	Unacceptable

RESEARCH METHODOLOGY

MATERIALS

The survey approach was employed in the risk assessment of electrical installations within the residential area. A detailed checklist was implemented in risk evaluation study on electrical installations.

Approach

The structured checklist was used to assess various electrical installations around the residential areas through the use of visual inspections.

Checklist

The checklist used comprised of different sections to assess electrical hazards and associated risk of electrical installation within the residential area. These sections include Switchboards, circuit breakers and main switches, Transformers, Earth, D.C Battery System, Main cable, Busbar trunking system including rising mains, Metre Board, Underground Cable lines and Distribution Board

The checklist contains 3 major answer options which are; YES, NO, NOT APPLICABLE, and a comment option. Taking collection of various sample of checklist across all location where it was carried out we calculated our Risk Assessment Matrix to determine our occupational health and safety administration (OSHA) Rating stating account for lowest Risk at 100% and highest Risk Vulnerably at 0% with margin chat of 25% it each level.

Checklist inspection rating

(100-75) % =low
(75-50) % =medium
(50-25) % =high
(25-0) % =very high

RESULTS AND DISCUSSION

RESULTS

Average Results from electrical safety inspection within the study area is given in tables 1 to 3)

Risk assessments matrix for low voltage installation

Assessment of switchboard and circuit breakers as well as schematic diagram display showed that there are possible damages which may alter safety. This can be attributed to partially loss fittings and dust, and absence of a main distribution system display. Inspection also showed that exposed parts are not effectively earthed. Risk assessment matrix showed medium risk level due to the likelihood of accidents which may occur in the area. From (Tables 1- 3), the earth system of the low voltage installation recorded an acceptable checklist rating due to effective earthing of the distribution system and the availability of earth terminal which is appropriately protective. The associated risk level is medium which shows that risk level is conducive. Inspection of main cables showed an acceptable level and only recorded a minor visible damage. This is because the cables are protected with vibrated tested stabs as well as correct phase identification for workers. Risk levels are unlikely due to the established safety level implemented in the area. Assessment of busbar and meter board showed a low level of risk due to observed effective earth system, safe route access and insulating plates. However, visible damages were observed on the meter boards due to time of installation and low housekeeping level. Underground cable links were also observed to present medium risk levels due to its siting above a depth of 5m below the ground. However, the distribution boards were exposed, had no fuse installed in the neutral circuit and caution sign which may different electrical board from the telecom board. From (Table 1), assessment of switchboard and circuit breakers of high voltage installations were acceptable with a work record log book, padlock facility and maintenance test in accordance to standards. However, up-to-date schematic diagram was not on display to aid safe practice. This can be attributed to poor practice of housekeeping which may have led to removal or damage to preexisting display diagram. Transformers and earth system are also satisfactory and acceptable with proper ventilation to transformers, adequate maintenance test and insulating plate for live parts. Recorded risk levels were however, low due to high safety measures implemented including safety caution warning and additional auxiliary earth. Inspection of main cables showed an acceptable level and only recorded a minor visible damage. This is because the cables are protected with vibrated tested stabs as well as correct phase identification for workers. Risk levels are unlikely due to the established safety level implemented in the area.

Conclusion

Result from inspection of low and high voltage installations showed that only low voltage installation showed a high risk level due to absence of caution signs. However, its general observed risk levels were low to the general public due to safety installations implemented which prevent fire from electrical hazards and electrocution. high voltage installations were also observed to be electrically earthed and present a low — medium risk level.

Recommendations

It is recommended that;

i. Distribution boards should be cared for and caution signs assigned to direct residents on voltage levels.
ii. Repairs to visible parts of installations should be made.
iii. Periodical maintenance should be carried out on switch board at giving period due to degradation of component in switch board.

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Conflict of interest

The authors herewith declare no conflict of interest with respect to this publication.

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