Inspection of Residential Electrical Installations in Bayelsa State: A Review

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Abstract. The importance of initial verification and the need for periodic inspection and testing of the electrical installation of residential buildings cannot be overemphasized. Fire outbreak in residential buildings is very frequent in Bayelsa State and mostly attributed to electrical fault. The initial verification and periodic inspection and testing are unavoidable electrical procedures for the continuous safe use of any electrical installation. In this paper, a safe working procedure for periodic inspection is presented. The use of the schedule of circuit details, and the electrical danger notification (EDN) form is also presented. The periodic inspection and testing of the electrical installation in residential premises would definitely minimise the frequently witnessed electrical fire in residential buildings in Bayelsa State, and consequently guaranty the safety of both the building and the occupants of the property.

1. Introduction

Even the most experienced electrical engineers and electricians can be expected to make the occasional mistake when carrying out electrical installation work. This is one of the main reasons why every new electrical installation, and every alteration and addition to an existing installation, must be thoroughly inspected and tested, and any defects or omissions found must be corrected, before the installation is commissioned and put into use. It is common knowledge that all electrical installations and equipment’s do deteriorate with age, as well as wear and tear from use. Therefore, every electrical installation needs to be properly inspected and tested at appropriate intervals during its lifetime to establish that the installation is in a satisfactory condition to remain in service, at least until the next inspection is due.

In the developed world, the concept of initial verification and periodic inspection and testing, and its enforcement is not new, as there are regulations put in place to ensure compliance. Among such regulations are; the IET Wiring regulation; the IET ON-SITE
GUIDE: The requirement for electrical Installations; the Electricity Supply Regulations; the Electricity Safety, Quality and Continuity Regulations; the guide to the IET Wiring regulation. The Electricity Supply Regulations 1988 have been replaced by the Electricity Safety, Quality and Continuity Regulations 2002. Even before the replacement, there were five amendments to the 1988 Regulation including the amendments in 1990, 1992, 1994, 1994 No.2 and 1998. While the Electricity Safety, Quality and Continuity Regulations 2002 aimed at protecting the public and consumers from danger, the guidance on the Electricity Safety, Quality and Continuity Regulations 2002 provided guidance to duty holders on their responsibilities contained in the Electricity Safety, Quality and Continuity Regulations 2002. Again, while guidance intended to assist duty holders in meeting the requirements of the regulations, the primary interest was to practically help engineers (involved in the design, construction, operation or maintenance of power systems), technicians and their managers, to amplify the nature of the safety measures and procedures in general terms so as to help in the achievement of high standards of electrical safety in compliance with the duties imposed.

Bayelsa state is located in the Niger Delta region of Nigeria with a latitude of 4.75 (4/45’ 0 N) and longitude of 6.08 (6/4’ 60 E). It is one of the fastest growing state in Nigeria with constant construction of residential and commercial buildings, and an almost daily increase in energy demand spreading from the state capital to every part of the state [1]. In Bayelsa state residential electrical installations are neither properly tested before the installation is put to use, nor the installation periodically inspected to ensure its continuous safe use. There are various causes of electrical fires in residential and commercial buildings in Bayelsa State. Some of the causes of fire outbreak include electrical fires are caused by faulty electrical outlets, electrical fires can be caused by faults in appliance cords, electrical fires are caused by overloaded single extension cord, and incorrectly installed wiring. In Bayelsa State, it is common knowledge that most electrical installations are not properly designed and installed by competent personnel. Any installation done without regards to IEEE wiring regulations, standards and proper cable sizing is a threat. Several homes and offices have been brought low by electrical fire from installations carried out by incompetent electricians/installers.

In recent times, some researchers in Nigeria have carried investigations to ascertain the causes of fire outbreak in residential and commercial buildings. In [2], the authors employed statistical approach to determine the possible causes and effects of electrical fires in buildings. In their work, some areas covered include: amount lost due to electrical fire, number of fire injuries, number of fire deaths, month of occurrence, equipment involved in ignition. In their findings, the amount lost for residential building caused by electrical fire is more than double that for non-electrical fire in residential buildings. In addition, in [3], the sources of electrical fire in the residential home include; cooking and lighting equipment’s, faulty electrical equipment, and electrical heaters. According to [4], other factors responsible for electrical fire in the residential homes include use of substandard electrical materials, faulty electrical appliances, and bad workmanship (incompetent electrician).

Again, the authors in [5], highlighted some causes of electrical fire in the home which include:

- Incorrectly installed wiring: Any electrical installation that is not well planned, designed and installed poses a great danger for the end user. Installation done without regards to IEE regulations and proper cable sizing by unqualified and unlicensed Electricians is a risk. Many homes and offices have been raised down by fire resulting from installations carried out by “let there be light” Electricians.
Overloaded circuits and extension cords: Most users of electrical appliances and extension cords plug any load without considering its capacity. Every circuit is connected with cable and every cable has its current carrying capacity. Therefore, overloading any circuit above its capacity is a source of electrical fire.

Misuse and poor maintenance of lighting: Every lighting point has its capacity. The practice in some areas (especially places where there are regular voltage drops) is plugging 200W incandescent bulb in 60W lamp holders in other to solve poor illumination problem. Some consumers even connect socket extension to lighting point. It should be noted that lighting point connection is usually at the ceiling which have some inflammable materials that can burst into flame when excessive heat is generated around them.

In this paper, the importance of initial verification and the need for periodic inspection and testing for a residential electrical installation is presented. Section 2, discusses the periodic inspection of electrical installation in homes while section 3 discusses the measures needed to prevent dangerous situations building electrical installation.

2. Guide for Periodic Inspection of Electrical Installation in Bayelsa State

All persons carrying out initial verification or periodic inspection and testing of electrical installations must be competent to do so, unless under the direct supervision of a competent person [6]. Part 2 of BS 7671 defines a competent person as; “A person who possesses sufficient technical knowledge, relevant practical skills and experience for the nature of the electrical work undertaken and is able at all times to prevent danger, and where appropriate, injury to him/herself and others”.

A competent person must as a minimum;

a) have sufficient knowledge and experience of electrical installation matters to avoid injury to themselves and others.
b) be familiar with, and understand, the requirement of the current issue of BS 7671, including those sections relating to inspection, testing and reporting.
c) Be skilled in the safe application of the appropriate test instruments and procedures.
d) have a sound knowledge of the particular type of installation to be inspected and tested.
e) have sufficient information about the function and construction of the installation to allow them to proceed in safety.

In addition, the inspector is required to have above-average knowledge and experience of electrical matters to enable them to accurately assess the condition of an existing installation, especially when they do not have access to the design information relating to that installation. In performing periodic inspection and testing, the inspector must ensure his/her safety, and the safety of others workers and occupants in the building. Inspectors elsewhere have been known to remove accessories and consumer unit covers whilst the supply is energized. This practice is dangerous, and such dangerous practice can lead to unnecessary risk of electrical shock and is considered unacceptable by the Regulation (BS 7671). The periodic inspection and testing should almost always be carried out with the supply disconnected [7].

The inspection of an electrical installation should always be carried out in a safe manner. Indeed, Regulation 611.1 of BS 7671 requires that inspection precedes testing and is normally to be done with that part of the Installation under inspection disconnection from the supply [7]. In line with the IEE Wiring Regulations, Regulation 14 of The Electricity at Work
Regulation requires that ... “no person shall be engaged in any work activity on or so near any live conductor that danger may arise unless.

a) It is unreasonable in all circumstances for it to be dead; and

b) It is reasonable in all circumstances for him to be at work on or near it while it is live; and

c) Suitable precaution (including where necessary the provision of suitable protective equipment) are taken to prevent injury”. The protective equipment’s may include; gloves, coverall, well insulated screw drivers, and well insulated pliers.

In order for the inspector to work safely, the inspector must be able to identify circumstances he/she would work live. One of such unavoidable conditions for the inspector to work live may be a situation that the final circuit supplying an incubator housing a baby in the hospital is to be inspected, and electrically tested. Another instance the inspector may work live, is a situation where an electrical challenge is suspected to have been caused by a low voltage, requiring the inspector to want to measure the voltage magnitude at the load point, and points in-between. Furthermore, when there is a suspected discontinuity of electrical current in a given cable, the inspector would want to work live, to trace the location from where the discontinuity starts. In general, isolation of a circuit (s) must therefore precede inspection. Put different, the expected safe working procedure for the periodic inspection and testing is that, inspection precedes testing, but, isolation proceeds inspection.

In order to carry out a successful inspection and testing, some electrical information is required by the side of the distribution board. This information will help the inspector direct the inspection and testing process. The absence of a legible diagram, chart or table by the side of the distribution board (DB) may result in danger, such as if someone inadvertently switches off the supply to an important service, for example a lift, an incubator in a hospital. A distribution board or consumer unit should be provided with sufficient information to indicate, amongst other things, the type and composition of each final circuit. The information required at a distribution board or consumer unit should indicate the particular of the installation. A very convenient way of providing such information for a simple installation such as domestic or residential installation is by means of a separate copy of the completed Schedule of Circuit Details for the installation [7]. With the presence of the schedule of circuit details by the side of the DB, the inspector would isolate the specific final circuit to be inspected and tested.

3. Prevention of Dangerous Situations in building

During periodic inspection and testing, some electrically dangerous situations are identified. During the inspection and testing, Failure to carry out remedial work after discovering a dangerous electrical hazard, for example exposed live parts due to a missing blank in a consumer unit, could result in someone receiving a serious or even fatal electric shock. Such an omission by the inspector would be in breach of Regulation 4 (1) and 4(2) of the Electricity at Work Regulations 1989, which could result in prosecution [8] [6]. Some remedial work is usually necessary when a dangerous electrical hazard has been identified during inspection or testing of an electrical installation. Where a dangerous electrical hazard is identified, an amount of remedial work is required to make the situation safe before the contractor or the inspector leaves the site. For the example of the missing blanks in a consumer’s unit stated above, before leaving the site, the contractor would be expected to fit suitable blanks to remove the hazard.
As a further example, consider an energized circuit where the end of the cable had been fitted with an unenclosed connector block. In such a case, the contractor or the inspector would be expected to isolate the circuit and fit a suitable enclosure complying with the requirements of Regulation 526.5 of BS 7671 relating to terminations of live conductors [9]. In addition to making the hazardous situation safe, contractors, inspectors and domestic installers should complete an Electrical Danger Notification (EDN) form, as the EDN serves the following three purposes.

a) advise in writing to a person responsible for the safety of the electrical installation of the location and the nature of the dangerous condition, and
b) provide a record of the immediate action taken by the inspector to remove or minimize the danger, and
c) Provide a record of the advice given to remedy the deficiency as a matter of urgency.

Some typical electrically dangerous situations which require immediate remedial action during periodic inspection and testing in many residential homes include;

3.1. Light switches for a bathroom
Instances are found during periodic inspection and testing where wall mounted light switches have been installed in either zone 1 or zone 2 of a location containing a bath or shower. Like any other electrical equipment, a wall mounted switch exposed to water jets, should have a degree of protection. The wiring regulation for fitting light switches for a bathroom recommends that;

a) A switch installed in zone 1 or 2 is not permitted and should generally be attributed a Classification Code C2 Potentially Dangerous. This applies even if the switch has a degree of protection of IPX4, or higher. This is the typical case where light switches are installed inside the bathroom, as frequently observed in many residential homes in this country, particularly in Bayelsa State. In this situation of the light switch installed inside of the bathroom, though an immediate remedial work of relocating the switch may not be possible, the EDN form has to be completed, indicating the nature of the dangerous situation.

b) A switch installed outside zone 0, 1 or 2 and where water ingress to the switch is likely, should generally be attributed a Classification Code C2.

c) A switch installed outside zone 0, 1 or 2 and where water ingress to the switch is not likely, does not generally warrant any Classification Code. This is the recent practice where both light switches and water heater switches are mounted or installed outside of the bathroom, but near the door of the bathroom, taking advantage of the use of the hollow blocks used in the building.

3.2. Sizing of protective conductors
Instances are also found during periodic inspection are testing where a protective conductor has a cross sectional area (csa) less than that expected by the inspector for compliance with BS 7671. Many houses in Bayelsa State, the final circuits powering sockets, water heaters, air conditioners, and cooker units carry only live and neutral conductors, and no circuit protective conductor (cpc). In many other situations, though the circuits powering these electrical points have the cpc, but the size of the cpc is inadequate. The most common sizes of cpc used in Bayelsa state are the 1mm2 and 1.5mm2, even when the live and neutral conductors have both
2.5mm² and 4.0mm² as in the case of 13A sockets and air conditioners respectively. In such a situation, the inspector is faced with the problem of assessing whether the protective conductor meets the requirements of BS 7671. Normally, protective conductors other than bonding conductors are sized by calculation or by selection in accordance with the requirements of BS 7671 [5] [9]. Where the CSA of a protective conductor is less than that indicated in Table 54.7 of BS 7671 (sizing by selection), the inspector should carry out a calculation, using the adiabatic equation, (eqn. 1) to check if the CSA is adequate.

\[ S = \frac{\sqrt{\tau t}}{k} \]

Where;
- \( S \) = The calculated nominal cross sectional area of the earthing conductor, in mm²
- \( \tau \) = The earth fault current in amperes (calculated by dividing the nominal voltage in volts by the earth fault loop impedance (Zs) in ohms.
- \( t \) = the operating time of the device in seconds corresponding to the fault current in amperes
- \( k \) = is a factor taking into account the conductor material.

In many residential buildings, the as-installed cable size of the protective conductor as mentioned above is far less than both the tabulated size and the calculated size. This is because, electricians not minding the safety concerns during fault, use either 1.0mm² or 1.5mm² CSA for the protective conductor. During inspection and testing, the inspector is to inform the person ordering the inspection of the potential danger, and subsequently complete the electrical danger notification (EDN) form.

3.3. Water heater supplied from a socket outlet

In many residential homes, the water heaters are supplied either from a socket outlet, or supplied with inadequate cable size. Immersion heater connected to a socket outlet of a ring or radial final circuit may lead to an overload on the circuit, and therefore, should be supplied from their own circuits [11].

A 3kW immersion heater draws approximately 13A at a voltage of 230V. Because there are voltage fluctuations in the low voltage (LV) line, the voltage in the LV line is always not constant at 230V, but varies between about 170V and 240V in Bayelsa state. The same 3kW water heater will approximately draw 15A at a voltage of 200V, and draws about 17.6A at 170V. This current will persist for a significant period of time when the tank of water is being heated, during that time there is a potential for overload should the immersion heater be connected to a circuit containing other in-service current using equipment’s.

In deciding whether or not to attribute a Classification Code where an immersion heater is connected to a ring or radial socket-outlet final circuit, the inspector is expected to consider the following two questions [12] relating to the total load current of the circuit, including that the immersion heater.

1. Is the total current likely at any time to exceed the rating of the circuit cable and/or protective device for long periods?

2. Is the magnitude and duration of the total load current likely at any time to be sufficient to cause the circuit protective device to operate?
If the answer to either question is yes, generally, a Classification Code C3 is to be recorded by the inspector in the appropriate data entry box on the Electrical Installation Condition Report. This should also be the case for a socket outlet circuit serving a cooker unit in the kitchen.

3.4. Termination
For the case of termination, the regulation requires that terminations are done inside enclosure. But this regulation is not obeyed in Nigeria, particularly in Bayelsa state, when doing half conduct electrical installations. Most property owners, due to lack of funds, and lack of the awareness of the consequences of the half conduit wiring system, patronize the half conduit system; making electrical terminations on top of the ceilings, allowing cables to cross each other on the ceiling.

An inspector is expected to be knowledgeable in the regulations that concerns termination and uphold these regulations in practice, ensuring that terminations are only done inside enclosure, as this will reduce the issues of burnt houses attributed to electrical fire. The half conduit system of wiring is a dangerous system of wiring, and the inspector is expected to attribute the Classification Code C2, Potentially dangerous on the Electrical Danger Notification (EDN) form.

3.5. Cable Size Selection
It is common knowledge that most electricians and even engineers pay no attention to the current carrying capacity of cables when carrying out electrical installations in residential buildings in Bayelsa state. There are many instances that electricians supply air conditioners, cooker units, and water heaters with 2.5mm² cables, not also considering the distance between the distribution board (DB) and the heavy electrical appliance. This definitely causes the cable to heat up when loaded, and is a potential source for electrical fire. A competent person must be knowledgeable, in determining the adequate size of cable for the specific electrical appliance, using the necessary tables as provides in the “requirements for electrical installations” (Bs 7671). The selection of the adequate cable size will not only ensure safety, but will also reduce maintenance cost

4. Conclusion
The initial verification, periodic inspection and testing of any electrical installation is beneficial to both the inspector and the person ordering the inspection. In order to ascertain the current state of any electrical installation for the continuous safe use of the installation, both the owners of buildings and the tenants fall in the category of persons ordering an inspection. The periodic inspection and testing of the electrical installation definitely will minimize the frequently witnessed electrical fire in residential buildings in Bayelsa state, and therefore, will guarantee the safety of both the building and the occupants of the property.

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