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Analysing the Core Diameter and Insulation Thickness of Electrical Wires within Designated Zones in Nigeria

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Abstract

The study aimed to examine electrical cables obtained from leading modern markets in major Nigerian cities, such as Onitsha, Abuja, Kano, Lagos, and Port Harcourt. The main goal was to assess the cables' compliance with established standards, following the protocols set by the Standard Organization of Nigeria. The study adopted a quantitative research approach. Cables of different cross-sectional areas (1.5mm², 2.5mm², 4mm², and 6mm²) were gathered from major markets and evaluated against established standards. The findings showed that certain commonly used sizes (1.5mm² and 2.5mm²) failed to meet the core diameter requirements specified by the Nigerian Industrial Standard, whereas 4mm² and 6mm² cables generally complied with these standards. Notably, all sampled cables exceeded the expected insulation thickness. To address deficiencies in core diameter, manufacturers compensated by adding extra insulation to meet the total cable diameter standards. As a result, reduced core diameters contribute to cable overheating and the frequent occurrence of fire outbreaks in Nigeria. Recommendations include intensified efforts by regulatory agencies and cable producers to combat piracy and mitigate these fire hazards.

Keywords: *Copper cables, Overheating of electric wire, Core diameter, Fire outbreaks, House wiring*

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Background to the Study

Electrical cables are essential elements in power transmission systems, enabling the smooth transfer of electricity from one location to another with efficiency. Understanding the electrical characteristics of different cable brands is necessary for ensuring optimal performance and reliability in various electrical applications. In Nigeria, locally manufactured electrical cables are highly esteemed by consumers, with manufacturers consistently positioning themselves as reputable entities within the industry. The issue of overheating, especially attributed to counterfeit cables imported from China with potentially lower copper content in their core, has been raised (Iroegbu et al, 2014). Findings emphasize that a significant portion of substandard electrical materials in Nigeria originates from Asia, notably China and India, as highlighted by (Schneider Electric, 2015) research. It's noteworthy that while many of these materials are imported, there's also evidence suggesting local production of substandard electrical items within Nigeria. Additionally, there is a pressing need for regulatory bodies to strengthen their efforts against the use of substandard building materials in Nigeria, aiming to effectively mitigate potential risks. The extensive use of substandard construction materials has resulted in devastating consequences in the country, involving loss of thousands of lives and the destruction of properties, worth billions of Naira resulting from incidents like building collapses, electrocutions, and electrical fires. According to (Ugochukwu et al, 2014), the authors reported that substandard materials in building construction poses significant risks not only to the safety of individuals residing in these structures but also to the integrity of the properties themselves and the economic well-being of the affected people.

The key parameter used to assess the performance of cables is electrical resistance, which is a measure of the opposition to the flow of electric current within the cable (Dorf & Svoboda, 2010). In determining the overall performance of an electrical cable, the core diameter and insulation thickness are essential. Core diameter represents the size of the conductive material within the cable, affecting its ability to carry current without significant voltage drops or power losses. Additionally, insulation thickness acts as a protective barrier, preventing electrical leakage and ensuring the safety of electrical installations.

Amidst the plethora of cable brands available in the market, stakeholders face the challenge of selecting the most suitable cable brand that meets their specific project requirements while ensuring compliance with industry standards. These cables have been grouped into varying load-carrying capacity abased on specific wiring applications. Consequently, the utilization of either oversized or undersized cables can result in economic inefficiency. Undersized cables hinder the smooth flow of current, leading to obstruction of electron passage and subsequent heat generation. Insulation serves to prevent current leakage, electrocution and also helps protect the conductor from environmental factors such as chemicals, moisture, and extremes temperature.

Despite the indispensable role of electrical cables in delivering electricity to homes, businesses, and institutions, concerns persist regarding the quality and adherence to standards of household electrical cable brands in Nigeria. Substandard cables present significant safety hazards, such as electrical fires and equipment damage. However, there remains a dearth of empirical data of the core diameter and insulation thickness of various cable brands available in the Nigerian market. This knowledge gap impedes efforts to ensure electrical safety and reliability, thereby jeopardizing both public safety and the integrity of Nigeria's electrical infrastructure. Consequently, there is an urgent imperative to conduct a systematic empirical analysis to evaluate the variability in core diameter and insulation thickness among household electrical cable brands in Nigeria and to provide evidence-based recommendations for enhancing safety standards and regulatory practices. The aim of this study is to provide a comprehensive comparison of electrical resistance values among various cable brands for different cable sizes, while taking into consideration both the core diameter and insulation thickness. By analyzing and evaluating the resistance data alongside core diameter and insulation thickness, stakeholders can make informed decisions regarding cable selection based on specific project requirements and industry standards. The study focused on examining electrical cables sourced from prominent modern markets across major cities in Nigeria, including Onitsha, Abuja, Kano, Lagos, and Port Harcourt. The primary objective was to evaluate the cables' adherence to established standards, following the protocols outlined by the Standard Organization of Nigeria. The research method employed in this study follows a quantitative approach.

Methodology

The study focused on examining electrical cables sourced from prominent modern markets across major cities in Nigeria, including Onitsha, Abuja, Kano, Lagos, and Port Harcourt. These cables, originating from various brands and widely utilized, underwent thorough scrutiny to assess their core diameters and insulation thickness. The investigation encompassed a selection of commonly used cable sizes in household electrical wiring, such as $1.5mm^2$, $2.5mm^2$, $4mm^2$, and $6mm^2$, chosen due to their prevalence in residential electrical installations and relevance to typical household power requirements. These cables were sold by various traders, claiming to be products of both local and foreign manufacturers.

The primary objective was to evaluate the cables' adherence to established standards, following the protocols outlined by the Standard Organization of Nigeria. Each cable brand received a unique code corresponding to the store from which it was purchased. Core diameter and insulation thickness measurements were conducted using a digital vernier caliper. First, we gently removed the cable jacket to protect the insulation and measured the diameter of the insulated conductor ( ). Then, we measured the diameter of the conductor (Dc) after removing the insulation. The insulation thickness (*Di*) was calculated as the difference between these two measurements, as shown in equation 1.

$$Di = DT - Dc \quad (1)$$

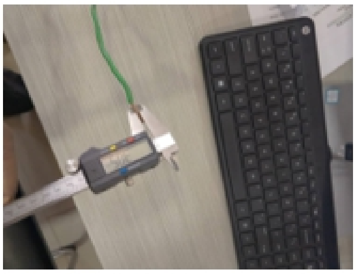

Figure 1: Determining the Diameter of a Wire

Research Method

The research method employed in this study follows a quantitative approach, as advocated by (Creswell, 2003) This approach involves the analysis of numerical data, facilitating the use of statistical methods for a more precise and accurate depiction of results. By focusing on quantitative research methods, the study aims to provide a robust analysis grounded in statistical evidence.

Experimentation Results

This study presents measurements core diameters and insulation thicknesses for 10 brands of electrical cables manufactured in Nigeria, as outlined in tables 1 and 2 and Figures 2 through 5. The data clearly indicates that the core diameters of certain cables with sizes 1.5mm², 2.5mm², 4mm², and 6mm² fall short of the established standards. However, all cables across these sizes conform to the insulation thickness standard specified in table 2. According to the graph in Figure 2 below, just 10% (Sample E) of the cable brands for the 1.5mm² size displayed core diameters of 1.38mm, aligning with the expected benchmark set by SON for the minimum core diameter. In contrast, the remaining 90% of the brands (Sample(s): A, B, C, D, F, G, H, I, and J) failed to meet this minimum standard.

Figure 3 illustrates that 70% of the cable brands did not meet the minimum stipulation of 1.78mm for the 2.5mm² sizes. Conversely, Sample A, D, and E were the brands that surpassed the minimum requirement. In Figure 4, it can be noted that 30% of the cable brands did not satisfy the minimum criterion of 2.25mm for the 4mm² sizes. Conversely, 70% of the brands conformed to this standard requirement. In Figure 5, findings indicated that 40% of the cable brands complied with the prescribed minimum core diameter of 3.03mm for the 6mm² cable sizes. Conversely, the remaining brands did not adhere to this minimum standard.

Table 2 illustrates that all the cables analyzed possessed sufficient insulation, surpassing the expected thickness. Consequently, some manufacturers utilize additional insulation material to offset deficiencies in conductor diameter, ensuring compliance with insulated wire requirements. This strategy complicates the identification of such practices through visual inspection alone. Incorporating extra insulation may enlarge cable dimensions, posing challenges in space-restricted installations and potentially escalating material costs. Although extra insulation aids in limiting heat transfer, it might hinder heat dissipation from the conductors, leading to concentrated heating within the cable and possibly resulting in insulation deterioration over time. Excessive insulation thickness, particularly in environments with high temperatures, could lead to insulation degradation or damage, jeopardizing electrical safety and dependability.

The prevalence of this practice is particularly evident in 1.5mm² and 2.5mm² cables due to their high demand for household wiring. Specifically, 1.5mm² cables are typically used for low-voltage lighting and bulbs while 2.5mm² cables are commonly employed for lighting installations like low-voltage air conditioners and kitchen appliances. Moreover, 4mm² cables are chosen to supply power to 220-volt air conditioners, small water heaters, ovens etc.

The extensive use of these cable sizes in Nigerian homes and workplaces significantly increases the risk of cable overheating during operation, which can lead to fire outbreaks. This risk is further compounded by the prevalent sourcing of most electrical cables directly from industrial markets.

As a result, any deficiency in these less commonly demanded cables becomes noticeable as they tend to remain in distributors' and retailers' warehouses for longer periods before being sold, unlike the more frequently used cable gauges. This observation corroborates with the findings of (Onafowokan, 2018), which highlighted the prevalence of substandard cables in electrical distribution lines. According to (Eze, 2017), the author reported that the Standards Organization of Nigeria recently seized warehouses holding electrical cables purportedly imported but repackaged as locally manufactured. This action clears our local cable producers of any involvement in such misconduct. However, it highlights the ongoing necessity for regulatory agencies to rigorously monitor their activities Furthermore, indigenous manufacturers should proactively engage in self-examination to identify and eliminate any unscrupulous practices within their operations.

Presentation of Data

Table 1: Core diameter of Solid Core Cables and Analysis of Core diameter of single core electrical cables

CABLE BRAND	CABLE BRAND										**Minimum core diameter (SON)**
	Sample A	Sample B	Sample C	Sample D	Sample E	Sample F	Sample G	Sample H	Sample I	Sample J	
1.5(mm^2)	1.3	1.34	1.3	1.36	1.38	1.3	1.35	1.33	1.34	1.33	**1.38**
2.5(mm^2)	1.89	1.7	1.69	1.8	1.8	1.71	1.7	1.7	1.68	1.42	**1.78**
4(mm^2)	2.21	2.44	2.28	2.25	2.25	2.31	2.18	2.46	2.56	2.19	**2.25**
6(mm^2)	2.93	2.94	2.68	3.23	3.23	3	3.36	2.74	3.18	3.01	**3.03**

Table 2: Insulation Thickness of Solid Core Cables and Analysis of Core diameter of single core

Cable Sizes (mm2)	CABLE BRAND										**Minimum core diameter (SON)**
	Sample A	Sample B	Sample C	Sample D	Sample E	Sample F	Sample G	Sample H	Sample I	Sample J	
1.5	1.8	1.51	1.7	1.29	1.74	1.73	1.55	1.61	1.62	1.48	0.7
2.5	1.8	1.8	1.49	1.5	1.5	1.83	1.5	1.5	1.63	2.54	0.8
4	1.6	1.93	1.44	1.5	1.73	1.49	1.69	1.86	1.66	1.57	0.8
6	1.39	2.2	1.38	2.25	1.84	1.84	1.77	1.52	2.05	1.32	0.8

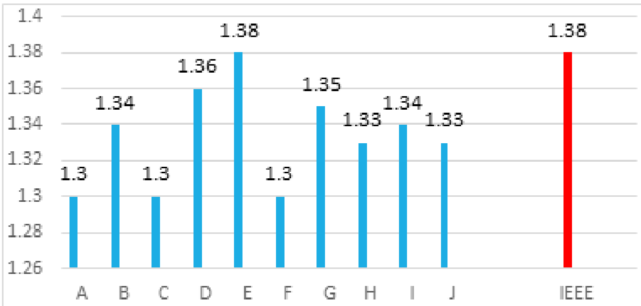

Figure 2: Core Diameter of $1.5mm^2$

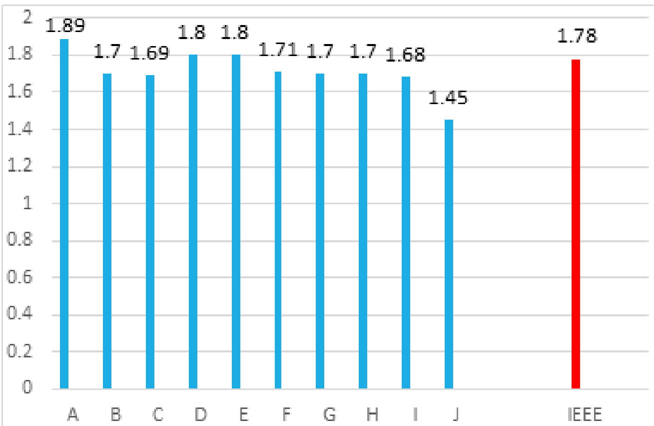

Figure 3: Core Diameter of $2.5mm^2$

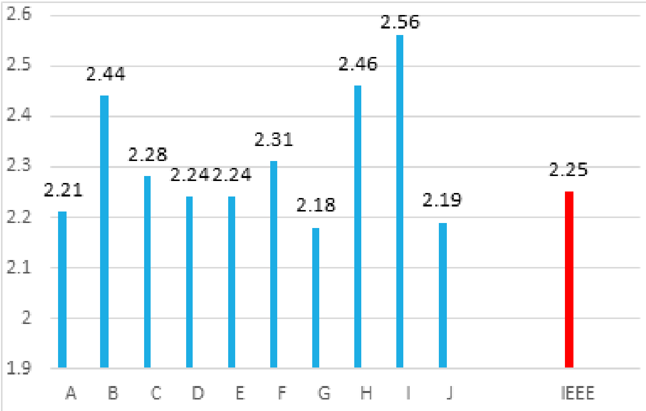

Figure 4: Core Diameter of 4mm^2

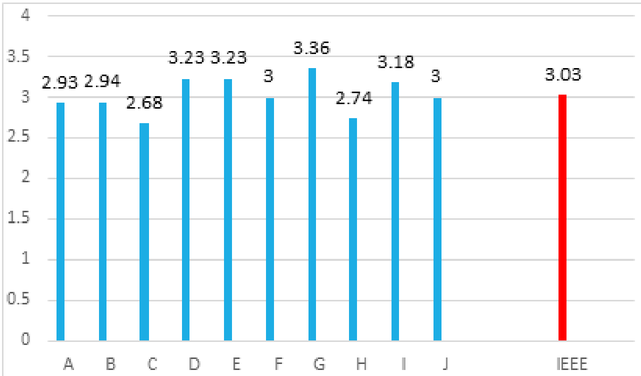

Figure 5: Core Diameter of 6mm^2

Conclusion

This study has revealed deficiencies in core diameter among commonly used household cables sourced from major industrial markets in Nigeria, indicating non-compliance with Nigerian Industrial Standards (NIS). These findings highlight the substandard quality of core diameter, which significantly contributes to overheating issues in electrical wires, leading to frequent electrical fires in residential and commercial buildings. Most manufacturers utilize additional insulation material to offset deficiencies in conductor diameter, ensuring compliance with insulated wire requirements. To address this issue, regulatory bodies such as the Standard Organization of Nigeria (SON) and cable manufacturers must enhance efforts to combat piracy in the industry. This would curb the proliferation of substandard products and mitigate the incidence of fire outbreaks and electrocution in Nigeria. Non-compliance with core diameter requirements outlined in NIS for electrical systems poses severe risks to electrical safety, increases fire hazards, invokes legal consequences, impacts insurance terms, and introduces health and environmental hazards. Therefore, strict adherence to these standards is imperative to ensure the reliability and safety of electrical installations and mitigate the risk of fire incidents. However, Regulatory agencies should enforcement measures and penalties for substandard cable production

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