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Empirical Analysis of Core Diameter and Insulation Thickness of House Wiring Cables in Nigeria

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Abstract
The diameter of metal conductor (core) and insulation thickness of copper cables produced by some Nigeria manufactures was assessed in this study as preliminary search for the basic the cause of incessant fire outbreaks traceable to overheating of electric wires in our residential and work places. Colman, cutix, and scan, wesco cables with cross sectional area ranging from $1mm^2$ to $16mm^2$ obtained from our industrial markets were sampled and compared with set standards. Results revealed that the core diameters of some cable sizes with high demand in house wiring ($1mm^2$, $2.5mm^2$ and $4mm^2$) were short of Nigerian Industrial Standard while other ($1.5\ mm^2$, $6mm^2$, $10mm^2$ and $16mm^2$) with less demand profile conformed. The $1mm^2$ cables of Wesco and Scan exhibited average core diameters of 1.13mm and 1.12mm which are below the expected minimum of 1.15mm while all fall short of the minimum core diameter of 1.82mm expected of $2.5mm^2$ cables. Scan cables also fall short of the minimum diameter expected of $4mm^2$ cable. In addition all the cables sampled were adequately insulated because their insulation thickness are far greater than the expected value. This showed that some of the manufactures uses the excess insulation to make up the short fall in the diameter of the metal conductor to scale through the expected total diameter of the cable, thereby making it difficult to notice their short practices by mere physical observation of the cable. Thus, the overheating of the cables during service and its consequential high rate of fire outbreak in this country is caused by the reduction in the core diameters of some electrical cables used in our house wiring. It is therefore recommended that Nigeria regulatory agencies and cable producers should step up fight against piracy in this sector to save the nation from this fire inducing scourge.

Keywords: Copper cables, Core diameter, Fire outbreaks, House wiring, Overheating, Electric wire

1. Introduction

Electrical cable is one of the made-in-Nigeria products which local consumers have confidence in and the manufacturers' continued to position themselves as competent players in the sector (Iroegbu-Chikezie, 2014). Although, the increasing rate of fire outbreaks traceable to overheating of electric wires in Nigerian residential and work places raises doubt on accuracy of both the producers' claim and buyers' thrust, Yusuf (2014) and Eze (2017), showed imported fake cables as the major cause of this scourge. According to Iroegbu-Chikezie (2014), Nigerian cable manufacturers attributed this scourge to reduction in the diameter of copper content

(core) of some imported fake cables from China which causes their overheating during service. Despite this defense, one still expects that the frequency of the scourge should have been on decline since the local cable producers enjoys high patronage. This is because the alleged use of undersized cables for house wiring and installations in this country were refuted by the stakeholders in the building sector while Adetoro (2012), showed that electrical cables produced in Nigeria conformed to set standards.

An electrical cable is an assembly of one or more electrical conductors used for carrying electric current and its basic components include metal conductor (wire), insulator and protective jacket (Nguyen, 2015). The wire is the only metallic part of an electric cable and the medium for current/electron flow from source to the appliances. Electric wires are rated into different cross sectional areas according to their load/current carrying capacity and specific wiring applications. Thus, the use of an oversized cable for an application amounts to economic waste while an undersized cable application causes its overheating (Minneapolis, 2014). This because an undersized cable offers inadequate space for easy flow of current been delivered, thereby obstructing electron passage which in turn generates heat. Insulation prevents current of a wire from coming into contact with other conductors/electrical leakage while the jacket constitues the outermost layer of a cable that protects the wire and its insulator from external physical and chemical deterioration (Minneapolis, 2014). Since overheating of electric wires and current leakage constitute basic initiators of spark which in turn induces fire outbreak, sampling of the core diameters and insulation thickness of made in Nigeria house wiring cables in our markets is paramount in the renewed search for the remote cause of increasing rate of electrical fire outbreaks in our homes and work places.

. Copper and polyvinyl chloride (PVC) constitute respective conductor and insulation materials mostly used for producing house wiring cables in Nigeria. Copper wires are common in Nigeria building sector because of it is cheap and has high load surge withstanding/corrosion resistance capabilities. It is common practice to use 1 and 1.5mm^2 copper cables for lighting while the thicker (2.5-16mm^2) ones are mainly for specific applications such as installation of kitchen appliances, electric heaters, oven, clothes dryers, air conditioners and sub panels (Minneapolis, 2014). According to Nigerian Industrial Standard (NIS) and ASTM B258 specifications; 1mm^2, 1.5mm^2. 2.5mm^2, 4mm^2, 6mm^2, 10mm^2 and 16mm^2 copper cables used must exhibit minimum core diameters of 1.15, 1.45, 1.82, 2.23, 2.90, 3.60 and 4.60mm respectively while 0.7mm 0.8mm and 1mm constitutes respective minimum insulation thickness for 1-1.5mm^2, 2.5-6mm^2 and 10-16mm^2 cables. Since breach of these set standards amounts to undersized cable application and its consequential electric spark, this work appraised the core diameters and insulation thickness of different sizes of locally produced copper cables sampled from Nigeria markets as basic step in identifying the remote cause of increasing rate of

electrical induced fire outbreaks in Nigeria.

2. Methodology

The electrical cables used for this investigation were bought from industrial markets in Aba, Abuja, Kano, Lagos and Port Harcourt of Nigeria. The core diameters and insulation thickness of ten samples of different sizes of House wiring copper cables displayed by different traders as products of some local manufacturer were measured and analyzed for conformity to set standards on using Institute of Electric and Electronics Engineers (IEEE 400) procedure. The cable brands include scan, cutix, wesco and coleman while $1mm^2$, $1.5mm^2$. $2.5mm^2$, $4mm^2$, $6mm^2$, $10mm^2$ and $16mm^2$ constitutes the cable sizes evaluated. The core diameter and insulation thickness of each cable was measured using vernier calliper and profile enlarger respectively. Each test involved peeling of the cable jacket without the straining its insulation material before measuring the diameter of its insulated conductor (D_T). Thereafter, diameter of the conductor (D_c) was measured after removing the insulation. The insulation thickness (D_i) of the wire was determined as the difference between two (Eqn. 1) and confirmed using profile enlarger readings which involves placing a 3.0mm slice of the peeled insulation material vertically on the tray of a profile enlarger lens and its calibrated lens adjusted till it aligns with the slice.

$$.D_i = D_T - D_c \quad (1)$$

3. Results and Discussion

The results of measured core diameters and insulation thickness of four brands of made in Nigeria electrical cables were analyzed with set standard as shown in Table 1 and Figs. 1-7 respectively. It is very obvious from this table that the core diameters of some $1mm^2$, $2.5mm^2$ and $4mm^2$ cables were short of the set standard while all the 1.5 mm^2, $6mm^2$, $10mm^2$ and $16mm^2$ cables conformed. The $1mm^2$ cables of Wesco and Scan exhibited average core diameters of 1.13mm and 1.12mm which are below the expected minimum of 1.15mm while all fall short of the minimum core diameter of 1.82mm expected of $2.5mm^2$ cables. Scan cables also fall short of the minimum diameter expected of a $4mm^2$ cable. Figs. 1-7 respectively shows that all the cables sampled were adequately insulated because their insulation thickness are far greater than the expected value. Hence, some of the manufactures uses the insulation material to make up the short fall in the diameter of the conductor to scale through the total diameter expected of insulated wire, thereby making it difficult to notice the short practice by mere physical observation of the cable. Hence, favourable records on Nigeria made electric cable by the regulatory agencies and some authors.

Table 1: Analysis of Core Diameters of Products of Some Cables Manufacturers in Nigeria

Cable Size (mm^2)	***Minimum* Core Diameter (mm)**	**Brand**	**Core Diameters of Cables Sampled (mm)**					
			Aba	**Abuja**	**Kano**	**Lagos**	**Port Harcourt**	**Average**
1	**1.15**	Wesco	1.14	1.15	1.13	1.13	1.10	**1.13**
		Cutix	1.30	1.15	1.15	1.20	1.20	**1.20**
		Scan	1.11	1.15	1.12	1.12	1.10	**1.12**
		Coleman	1.10	1.15	1.20	1.20	1.10	**1.15**
1.5	**1.45**	Wesco	1.60	1.60	1.55	1.60	1.60	**1.55**
		Cutix	1.50	1.50	1.48	1.50	1.52	**1.50**
		Scan	1.61	1.60	1.62	1.62	1.65	**1.62**
		Coleman	1.63	1.65	1.62	1.60	1.60	**1.62**
2.5	**1.82**	Wesco	1.77	1.78	1.80	1.80	1.75	**1.78**
		Cutix	1.80	1.80	1.80	1.80	1.80	**1.80**
		Scan	1.72	1.75	1.73	1.75	1.80	**1.75**
		Coleman	1.74	1.80	1.75	1.76	1.75	**1.76**
4	**2.23**	Wesco	2.25	2.10	2.50	2.20	2.20	**2.25**
		Cutix	2.40	2.30	2.20	2.30	2.30	**2.30**
		Scan	2.20	2.10	2.30	2.20	2.20	**2.20**
		Coleman	2.25	2.30	2.30	2.30	2.20	**2.27**
6	**2.90**	Wesco	3.10	3.10	3.15	3.10	3.15	**3.12**
		Cutix	3.15	3.15	3.00	3.20	3.15	**3.13**
		Scan	3.15	3.10	3.20	3.20	3.10	**3.15**
		Coleman	3.25	3.20	3.10	3.30	3.20	**3.21**
10	**3.60**	Wesco	4.05	4.10	3.95	4.00	4.15	**4.05**
		Cutix	4.03	4.05	4.00	4.01	4.01	**4.02**
		Scan	4.10	4.10	4.15	4.05	4.10	**4.10**
		Coleman	4.25	4.25	4.15	4.15	4.20	**4.20**
16	**4.60**	Wesco	5.40	5.00	4.90	5.00	5.20	**5.10**
		Cutix	5.20	4.80	5.00	5.10	4.90	**5.00**
		Scan	5.20	5.20	5.10	5.30	5.20	**5.20**
		Coleman	5.30	5.10	5.20	5.30	5.20	**5.22**

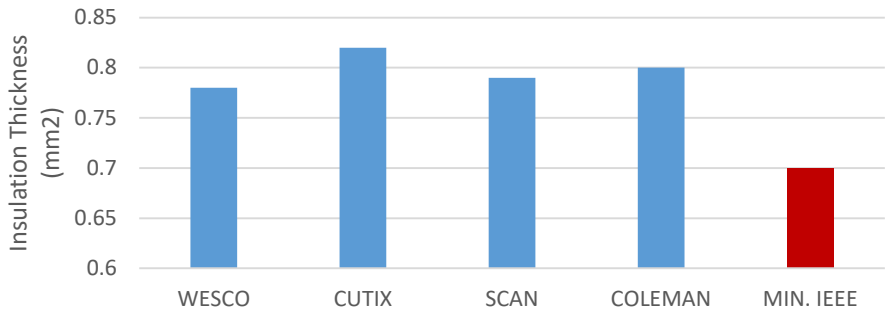

Fig. 1 Insulation thickness of 1mm^2 cables

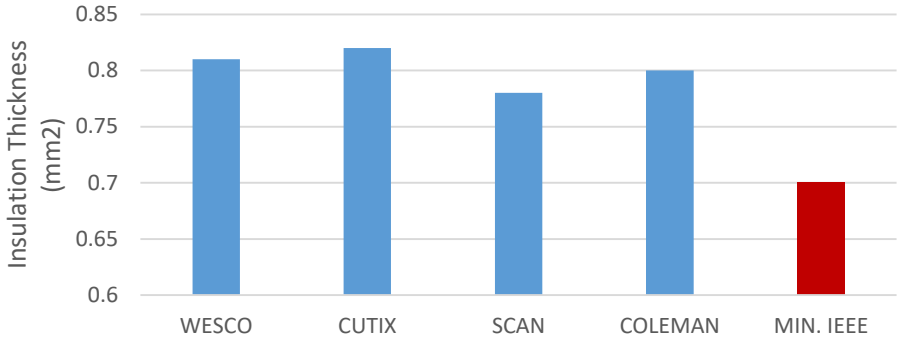

Fig. 2 Insulation thickness of 1.5mm^2 cables

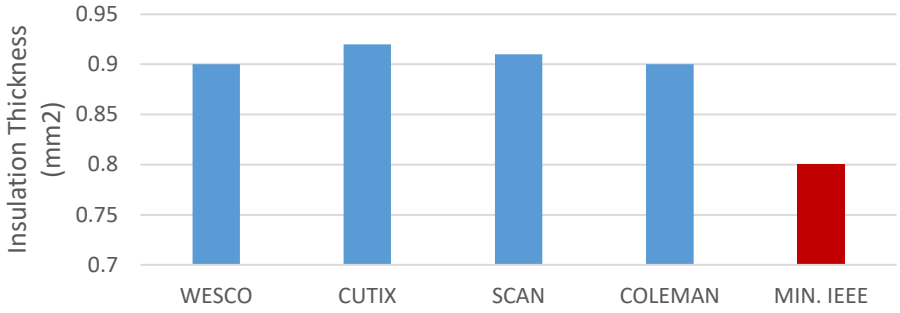

Fig. 3: Insulation thickness of 2.5mm^2 cables

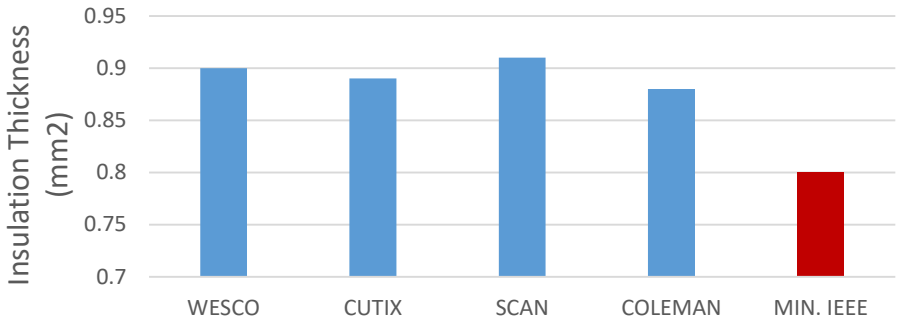

Fig. 4: Insulation thickness of 4mm^2 cables

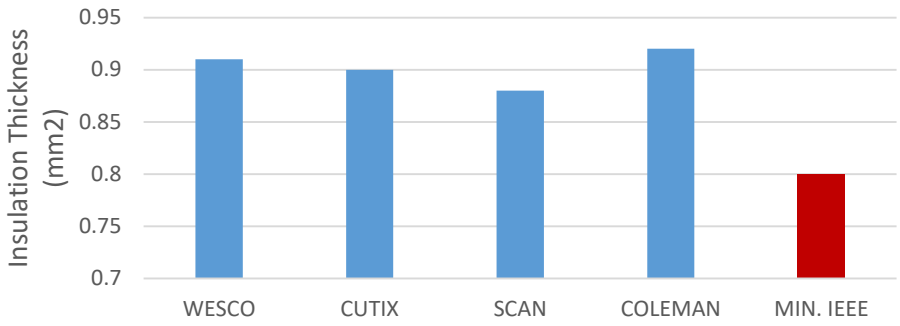

Fig. 5: Insulation thickness of 6mm^2 cables

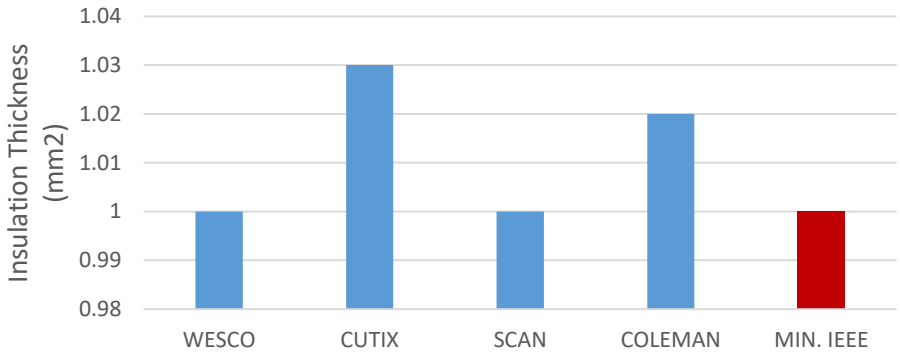

Fig. 6: Insulation thickness of 10mm^2 cables

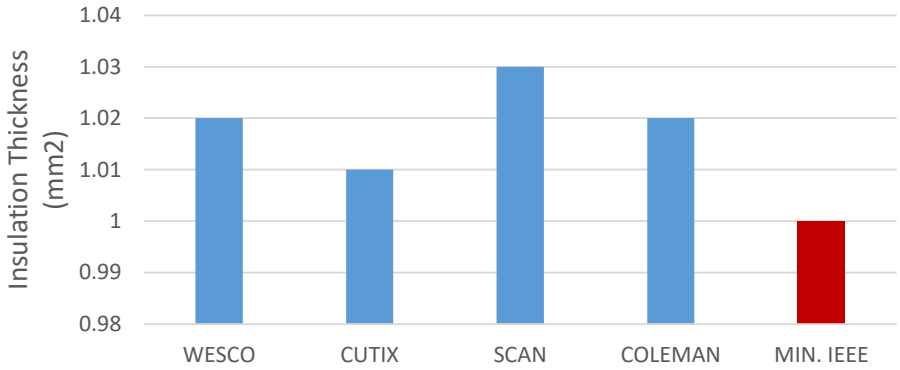

Fig. 7: Insulation thickness of 16mm^2 cables

The high profile of this short practice in 1mm^2, 2.5mm^2, and 4mm^{2}cables is because they are mostly required in large quantity in house wiring. The 1mm^2 cables are for low voltage lighting and lamp cords, 2.5mm^2 goes for lighting runs and installations such as low volt-air conditioners and kitchen appliances while 4mm^2 cable suites 220-volt air conditioners, ovens and small water heaters. Thus, the cause of overheating of the cables during service and its consequential fire outbreak in most Nigerian homes and work places since the majority of electrical cables used for building wiring are sourced directly from our industrial markets. The core diameter shortage was not

observed among the other sizes of the cables sampled because they are not needed in large quantity in house wring; 1.5mm^2 cable is mainly used as extension cord while others are main for for installation of large heaters, furnaces and sub/service panels. Therefore, any short fall in these low demanded cable will be exposed because they stay longer time in the distributors/retailers warehouse before sale when compared with the other three wire gauges. This observation is in accord with Onafowokan (2018), which showed that substandard cables are dominant in electrical distribution line. Although, the report of Eze (2017) on Standards Organisation of Nigeria recent apprehension of warehouses stocked with alleged imported electrical cables that were repackaged as made in Nigeria exonerates our local cable producers of this evil, there is need for close monitoring of their activities by the regulatory agencies. The local manufactures should also step up for self-examination to purge out miscreants among them.

Conclusion

This work revealed that some of mostly used house wiring cables sampled from industrial markets in Nigeria as products of some local producers are short of Nigerian Industrial Standard (NIS) and ASTM B258 specification for conductor diameter. This is the major cause of overheating of electric wires during service which in turn the cause of incessant electrical fire outbreaks our homes and work places. Thus, Nigeria regulatory agencies and cable producers should step up fight against piracy in this sector to save the nation from this fire inducing scourge

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