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DETERMINATION OF SAFE ACOUSTIC DISTANCES FOR INSTALLATION OF A 635 kVA SOUND PROOF POWER GENERATOR AT RESIDENTIAL AREAS

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ABSTRACT

Noise from a source like even a sound proof power generator adversely affects the quality of our environment. It is very pertinent to acoustically determine the safe distances for its installation. This work therefore presents the determination of safe acoustic distances for installation of a 635 kVA sound proof power generator at residential areas. Measurements of noise levels with respect to distance, x from the power generator were considered. The data obtained were analysed and residential noise models were developed. The results revealed that the maximum noise level of the generator (i.e. at x = 0 m) was (76.88±0.312) dBA. It was observed that the noise of the generator disturbs people beyond a distance of 70 m. This kind of generator should be installed from a distance of 80 m. This is because at 80m, the noise level of the generator is 52.7 dBA, while the WHO standard is 55 dBA for residential areas. The results obtained from the models developed in this work, $L_{Gmodelled}$ were compared with those from the physical measurements, $L_{Gmeasured}$ and there wasi nsignificant difference between them. These models are therefore recommended to be used as more reliable tools for environmental noise impact assessments.

KEYWORDS: *Acoustics, determination, modelling, power generator, residential areas*.

1. INTRODUCTION

Domestic noise pollution, is now considered as a threat to our environment [1], [2]. Noise pollution is one of the major environmental hazards that has direct effect on human performance [3].High noise levels of adequate exposure time can cause hearing damage. This is generally associated with people working in industrial plants or operating machinery. It can also take place at discotheques or near to aircraft on the ground if the duration is long enough. However, measurable hearing loss from various industrial sounds involves daily exposure for a number of years. On the other hand, domestic noise intrusions like traffic noise can obstruct speech communication, interfere with sleep and relaxation and disturb the capacity to perform difficult tasks [4]. The industrial noise is one of the most annoying sources of noise complaints [5]. The survival and healthy existence of man depend largely on the enabling environment where he resides [6].Noise pollution is one of the major environmental problems people are facing in urban areas all over the world [7]. Neighbourhood noise usually originates from building and installations associated with the food preparation business like cafeterias, restaurant, and discotheques; from recorded or live music; from playgrounds and car parks; from sporting events including motor sports; and from household animals for example barking dogs. The major sources of indoor noises include aeration systems, home appliances; office machines, and neighbours [8].Sound is the human sensation of pressure fluctuation in the air. Noise can seriously harm human health and interfere with people’s daily activities at school, work, home and during leisure time. Noise can be defined as unpleasant sounds which disrupt the human being physically, physiologically and cause environmental pollution by destroying environmental properties [9], [10].

Residential noise is considered by World Health Organisation (WHO) as community noise or environmental noise or domestic noise [11]. The most important sources of community noise comprise air, rail and road traffic, neighbourhood, municipal work, and the construction plant, among others. A study carried out by Cornell University indicated that children exposed to noise during classes experienced problem with various cognitive developmental delays in addition to words discrimination. Specifically, the writing learning mutilation called dysgraphic is usually related to stress on environment during classes [12], [13]. Noise has been connected to

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vital cardiovascular health risks. In 1999, the WHO drew a conclusion that the existing evidence shown predicted a weak relationship between hypertension and long term exposure to noise beyond 67 – 70 dBA [14]. More current studies have recommended that noise levels of 50 dB(A) at night may also increase the risks of myocardial infarction by constantly enhancing production of cortisol [15].

A research[16] was conducted in Itu Local Government Area of Akwa Ibom State and it was concluded that the sources of noise that the people in Itu Local Government Area are exposed to are numerous, while workshop/factory noise bother them most. In the United States of America, the Environmental Protection Agency (EPA) identified noise as a hindrance since in the 1970s [17]. The agency carried out a main study of noise at that time and has continued to update its findings. This means that the study of noise is a continuous phenomenon. Noise has risen to the point where it is nowadays the most important peril to the superiority of our existence[18]. This increase in noise can be attributed to the ever increasing number of people in the globe and the growing levels of economic affluence [19]. Impacts of elevated levels of sound also include high rate of vertigo fatigue, headaches and stomach ulcer [5]. Results of findings show that constant noise above 55 dBA causes serious annoyance and above 50 dBA moderate annoyance at home [20]. In a non-work place and for health and safety purposes, 55 dBA is set as a safety noise level for outside and 45 dBA inside. Hospital and school permissible levels of noise are 35 dBA [11]. Noise beyond harmless levels leads to numerous health impacts which include high blood pressure, annoyance, sleep loss, stress, hearing impairment, loss of productivity and the ability to concentrate, among others. The British Columbia Work's Compensation Board sets 85 dB as its highest tolerant level in the work place. Above this limit hearing protection should be used. It states that the threshold of pain is attained at 120 dB and it classifies 140 dB as excessive hazard level. WHO safety noise levels are similar while EPA of Nigeria tends to have even a stricter standard of 70 dB as a maximum safe level of noise in work place. They gave the safe level around home to be 50 – 55 dB [21]. This research on environmental noise pollutionis very necessary for more awareness creation on the adverse effects of noise on the environment. In this research, the determination of safe acoustic distances for installation of a 635 kVA sound proof power generator at residential areas shall be carried out

2. MATERIALS AND METHODS

2.1 Physical measurements

A 635 kVA sound proof power generator was identified and measurements of noise levels from it as they vary with distances were taken. The distance measurements were made using a measuring tape. The noise level measurements were made using the sound level meter model TES 1350A with ½ inch Electret condenser microphone. This model has both A and C weightings and 0.1 dB resolution with fast/slow response. It has low and high measuring ranges 35 to 100 dB and 65 to 160 dB respectively. Also, it was equipped with a built in calibration check (94.0 dB), tripod moving and analogue DC/AC conditional output of 10 mV/dB. It has a weight of 210 grams (including a 9 v battery) and completed with hard vinyl case. It also has electronic circuit and readout display. The microphone detects the small air pressure variations associated with sound and changes them into electrical signals. These signals are then processed by electronic circuitry of the instrument. The readout displays the sound levels in decibels. The sound level meter measures the sound pressure level at one instance in a particular location. The measurements were taken by setting the sound level meter to A-weighting network in all the sampling locations. The sound level meter was calibrated before and after each use. The manufacturer's manual gave the calibration procedure. During the noise level measurements, the sound level meter (microphone) was positioned at a distance of at least 10 m from the generator at a height of 1.2 m above the ground. Slow response was used for comparatively stable noise measurement.

2.2 Calculating The Generator Noise Levels (L_G)

The generator noise levels in dBA were calculated by using equation (i) [22], [4], [23], [18].

$$L_G = 10 \log_{10} (10^{0.1L_T} - 10^{0.1L_B}) \qquad \text{(i)}$$

Where, L_G = Generator noise levels in dBA
L_B = Background noise levels in dBA
L_T = Total noise levels in Dba

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2.3 Noise modelling

The data obtained were analyzed. The linear regression method was adopted and models were developed for only generator noise levels, L_G. The relevant displayed parameters used in the model development are the maximum noise level of the power generator, the attenuation coefficient and the coefficient of determination.

3. RESULTS AND DISCUSSION

3.1 Results

The results of this research are shown in Tables 1 – 2 and Figures 1 – 6.

Table 1: A 635 kVA Sound Proof Power Generator Noise Levels

Distance, x (m)	**Background Noise Level L_B (dBA)**	**Total Noise Level (L_{Total}) (dBA)**	**Generator Noise Level (L_G) (dBA)**
10	49.7	76.3	76.3
20	50.0	69.7	69.7
30	48.1	66.7	66.6
40	46.8	63.9	63.8
50	46.8	60.8	60.6
60	46.3	58.2	57.9
70	45.8	56.0	55.6
80	45.5	53.6	52.7
90	43.7	50.0	48.8
100	47.2	48.8	43.7
110	45.7	47.1	41.5
120	45.2	46.9	42.0

Table 2: Comparison of the 635 kVA Sound Proof Power Generator Measured Noise Levels, $L_{GMeasured}$ and Modelled Noise Levels, $L_{GModelled}$ (dBA)

Distance, x (m)	**$L_{GMeasured}$ (dBA)**	**$L_{GModelled}$ (dBA)**	**$L_{GDifference}$ (dBA)**
10	76.3	73.8	2.5
20	69.7	70.7	1.0
30	66.6	67.5	0.9
40	63.8	64.4	0.6
50	60.6	61.3	0.7
60	57.9	58.2	0.3
70	55.6	55.0	0.6
80	52.7	51.9	0.8
90	48.8	48.8	0.0
100	43.7	45.7	2.0
110	41.5	42.6	1.1
120	42.0	39.4	2.6

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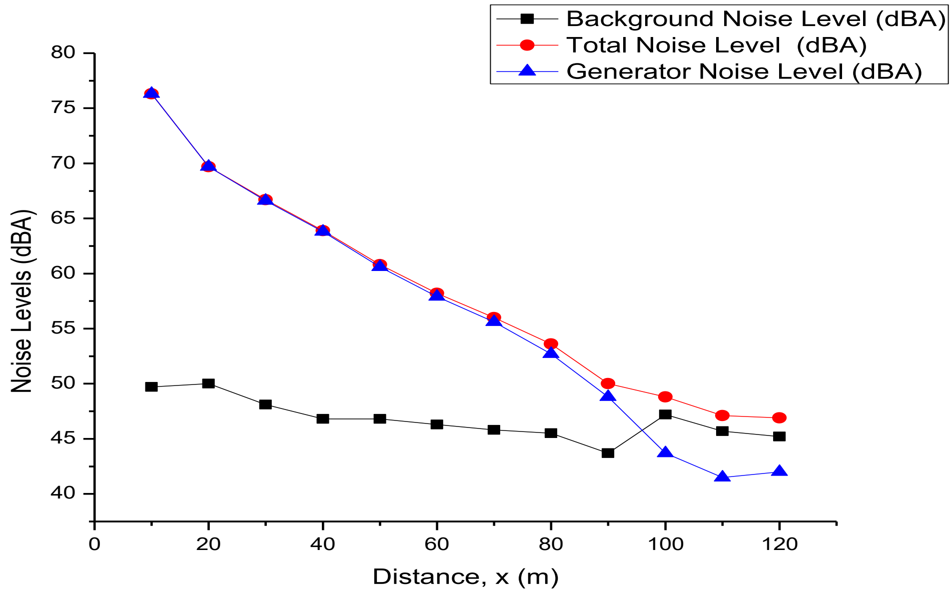

Figure 1: A 635 kVA Sound Proof Power Generator Noise Levels Against Distance

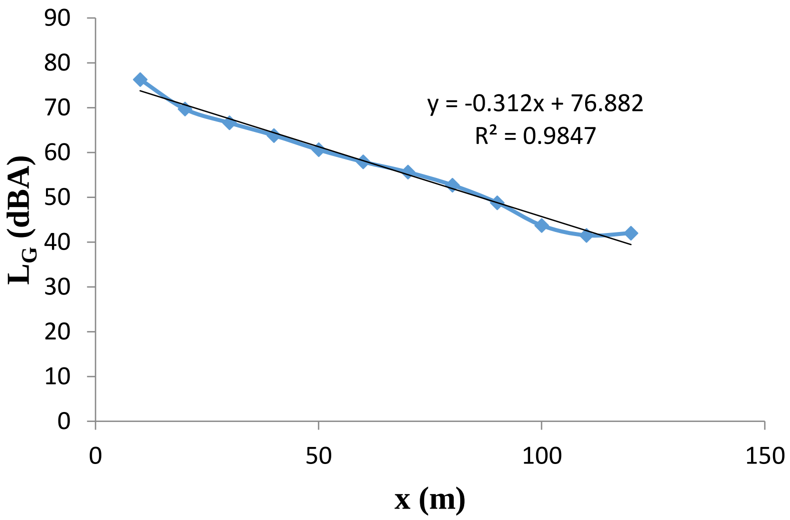

Figure 2: The Characteristics of the635 kVA Sound Proof Power Generator Noise Level

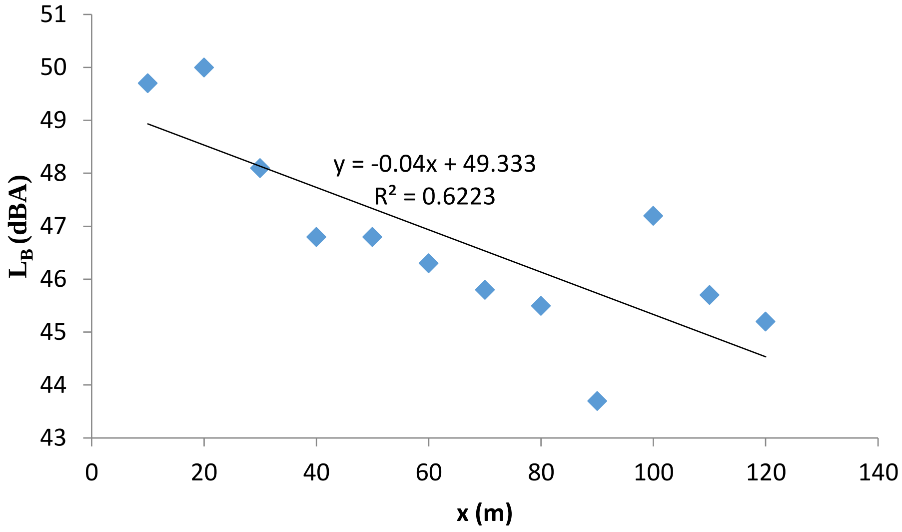

Figure 3: The Characteristics of the Study Area without the 635 kVA Sound Proof Power Generator

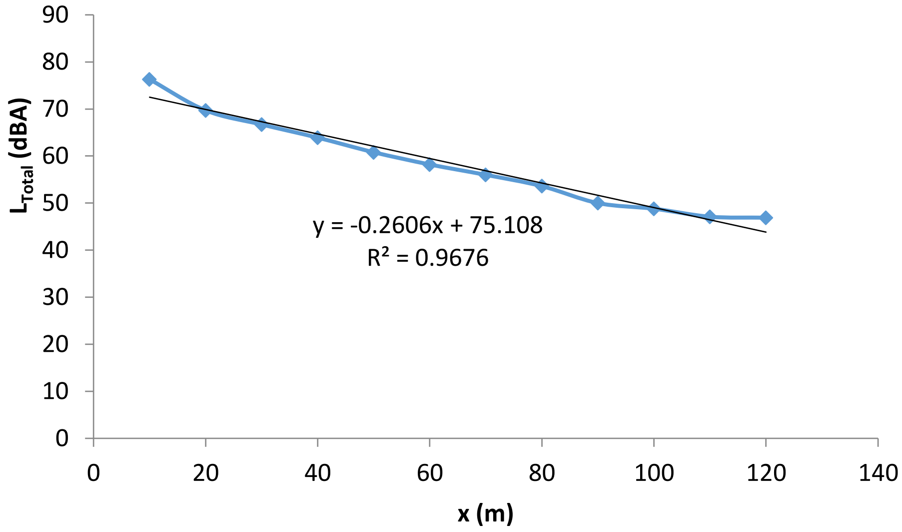

Figure 4: The Characteristics of the Study Area with the 635 kVA Sound Proof Power Generator

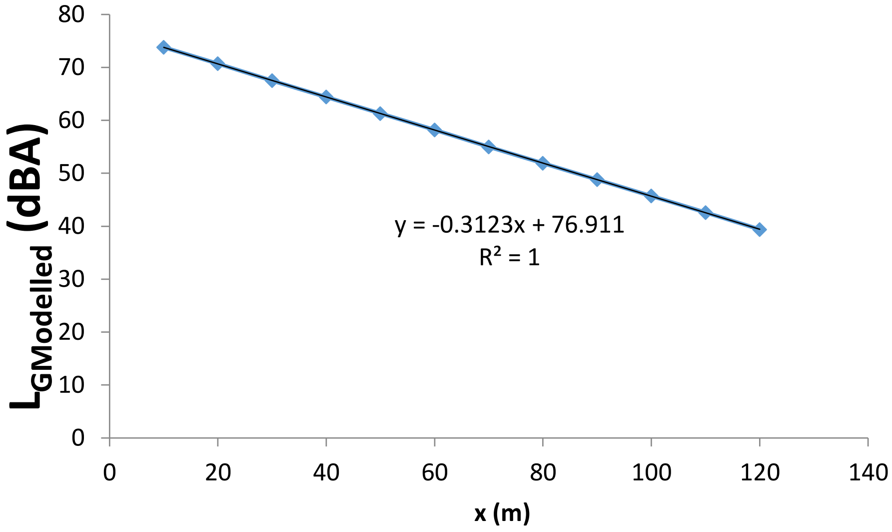

Figure 5: The Characteristics of the 635 kVA Sound Proof Power Generator Modelled Noise Level

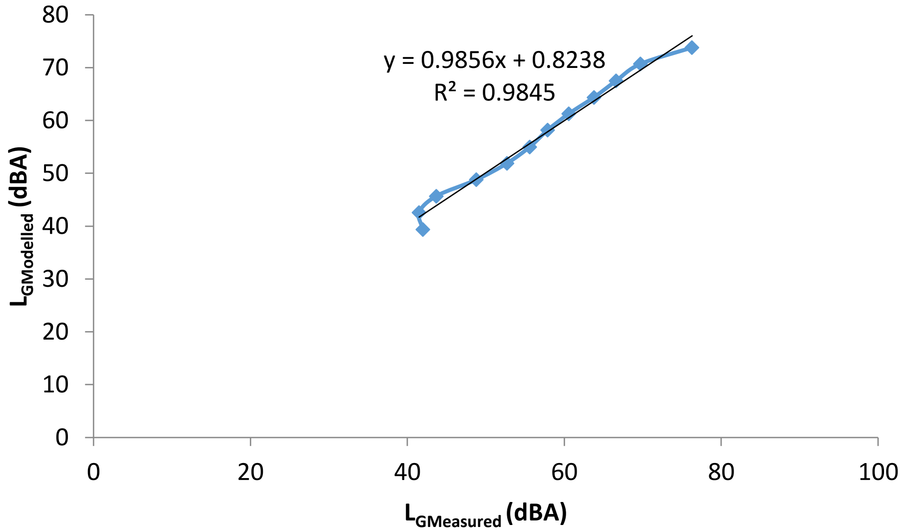

***Figure 6:** Comparison of modelled, $L_{G(modelled)}$ noise levels and measured, $L_{G(measured)}$ noise levels of the 635 kVA sound proof power generator*

3.2 Discussion

The results in Tables1 – 2 and Figures 1 – 6 revealed that when the 635 kVA sound proof power generator is switched off, the environment is conducive as the background noise level at any distance, x is less than the WHO safety noise level standard of 55 dBA for a non-work environments.

The generator noise affects the residents beyond a distance of 70 m. This is because at x = 70 m, L_G = 55.6 dBA instead of WHO standard of 55 dBA for a non-work environment. It is observed that the total noise levels and the generator noise levels are approximately the same up to a distance of about 80 m. This simply means that they have almost the same frequency up to the distance of about 80 m. The generator of this kind has to be installed beyond 80 m from residential areas. This is because at x = 80 m, L_G = 52.7 dBA which is below the WHO tolerance level of 55 dBA for residential areas.

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The results of the analysis of a 635 kVA sound proof power generator noise levels L_G show that the noise levels of the sound proof power generator and distance, *x* are strongly correlated with the coefficient of determination, $R^2 = 0.984$. The results of the analysis give a linear fitting model in dBA as presented in equation (ii).

$$L_G = 76.88 - 0.312x \quad \text{(ii)}$$

Considering the error term, ϵ_G equation (ii) becomes

$$L_G = 76.88 - 0.312x + \epsilon_G \quad \text{(iii)}$$

In equation (ii), at $x = 0$, the noise level of the sound proof power generator is:

$$L_G = 76.88 \text{ dBA.} \quad \text{(iv)}$$

This value (76.88 dBA) represents the intercept or the maximum noise level with a standard error of 0.904 dBA. The model has a slope of -0.312 $dBAm^{-1}$ with a standard error of 0.012 $dBAm^{-1}$. Comparing the modelled noise levels, $L_{G(modelled)}$ of the sound proof generator with its measured noise levels, $L_{G(measured)}$, (Table2 and Figure 2), it is indicated that there is no significant difference between them. Hence, equation (ii)or (iii) can be used as a model for evaluating, predicting and controlling environmental noise pollution from a noise source of this type, even without the equipment.

4. CONCLUSION

It is concluded from the findings that the maximum noise level of the 635 kVA sound proof power generator is (76.88± 0.37) dBA. The adverse effect of this kind of generator covers distances beyond 70 m. It is therefore determined that this kind of generator should be installed beyond a distance of 80 m from residential areas. Also, the result shows that the model developed in this work can be used in evaluating and predicting the distance at which adverse effects of noise from this generator can cover, and also aid in controlling environmental noise pollution even without the equipment. It requires less cost, less manpower and less time than the physical measurements. It can also be used by the manufacturer of the 635 kVA sound proof generator to reduce its maximum noise level. Hence, it is recommended to be used as a reliable tool for environmental noise impact assessment.

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