ENVIRONMENTAL NOISE ANALYSIS OF AGED CERAMIC INSULATOR UNDER INFLUENCE OF ELECTRICAL STRESS

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ABSTRACT

This thesis mainly presents a study about Corona Discharge that is commonly occurred at Ceramic Insulator surface. The purposed of this research is to study the effect of Corona to the environment in term of the severeness and impact to human and also wildlife using TERCO HV experiment setup and field investigation. These methods have been chosen due to its availability, cost effective and many other reasons. This research is done by analyzing the corona discharge by-product mainly audible noise during the corona event by using Sound Level Meter to obtain the desired data. After the experiment is taken place, the data found reveal the severity of the corona and flashover sound measurement which happen to formed broadband frequency range noise with a very low and high frequency threshold compared to human hearing. The decibel level of when corona occur slightly exceed the comfortable level during daytime which is 60 dB maximum and the value reach to the untolerable level when the flashover is taking place. Magnetic field with a high reading at a very close range is also detected but the value reduced exponentially with distance and leave a harmless exposure at distance more than 8 meter. From the result obtain, corona audible noise is not significantly affect normal people quality of living. However, this does not applied to people with sound sensitivity disorder and remote place which sound different can easily be detected. Low frequency that affect human health is also a thing to be concern with. The recent study does proved the low frequency negative effect to human body to be more than myth while the animal have a tendency to be disturb by high frequency in term of their communication and sensitive hearing. Safety precatious and consideration by authorities before installing high voltage structure can reduced the possibility of living beings are distracted and suffer from the problems discussed.

ABSTRAK

Tesis ini membentangkan kajian terutamanya tentang nyahcas korona yang selalu berlaku di permukaan penebat seramik. Tujuan kajian ini adalah untuk mengkaji kesan korona kepada persekitaran dari segi kesan buruk dan dan implikasi terhadap manusia dan haiwan liar menggunakan kelengkapan ujian TERCO HV dan kajian kawasan. Cara ini dipilih kerana kemudaan sedia ada, kos yg berpadanan dan lain-lain sebab lagi. Kajian ini dilakukan dengan menganalisis kejadian nyahcas korona menggunakan meter tahap bunyi untuk mendapatkan data yang diinginkan. Selepas ujikaji dilakukan, data yang diperoleh mendedahkan keburukan yang berlaku disebabkan korona dan letupan arka dimana ianya membentuk bunyi jalur lebar yang merangkumi frekuensi yang sangat rendah dan tinggi berbanding tahap pendengaran manusia. Apabila korona berlaku, tahap desibelnya adalah tinggi daripada tahap selesa iaitu 60 dB maksima dan menjadi terlampau apabila letupan arka berlaku. Bacaan tinggi medan magnet pada jarak dekat juga dikesan tetapi nilainya berkurang dengan mendadak dan meninggalkan kesan yang tidak berbahaya pada jarak lebih 8 meter. Daripada penemuan ini, korona didapati tidak memberi kesan ketara kepada kualiti hidup manusia biasa. Bagaimanapun, ia tidak termasuk mereka yang mempunyai masalah pendengaran yang sensitif dan tempat terpencil di mana perbezaan bunyi dapat dikesan dengan mudah. Frekuensi rendah yang memberi kesan terhadap tubuh perlu diambil perhatian. Kajian terkini membuktikan kesan negatifnya terhadap manusia manakala haiwan lebih cenderung terganggu oleh bunyian frekuensi rendah dari sudut perhubungan dan kepekaan pendengaran. Langkah berjaga-jaga dan bertimbang rasa oleh pihak berkuasa sebelum memasang struktur voltan tinggi dapat mengurangkan kemungkinan hidupan berasa terganggu dan tersiksa daripada masalah ini.

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LIST OF SYMBOLS AND ABBREVIATIONS

V_{arc}	-	Arc Voltage
V	-	Voltage
I	-	Momen of Iner
L	-	Length
m	-	Mass
Q	-	Rate of Flow
r	-	Radius
x	-	Shift
H	-	High
q	-	Angle
E	-	Corona Gradient
f	-	Frequency
δ	-	Relative density
dB	-	Decibel
UTHM	-	Universiti Tun Hussein Onn Malaysia
IEEE	-	The Institute of Electrical and Electronics Engineers

CHAPTER 1

INTRODUCTION

1.1 Overview

Insulator which has been in service for a long time often being expose to failure due to many factors such as contamination deposition, extreme weather condition, vandalism and corona. Corona and flashover that occur produce noise of a certain level that might disturb living being in a radius of the event. Noise pollution, as it affects environment, has been a recognized problem for decades, but the effect of noise on human being and wildlife has been considered a potential threat to their health and long-term survival. Research into the effects of noise on life-form, which has been growing rapidly since the 1970s, often presents conflicting results because of the variety of factors and variables that can effect or interfere with the determination of the actual effects that human-produced noise is having on any given creature [1]. Both human and animal have been studied, especially in regards to noise from man-made structure and machineries especially in area where those two population density is high. Most researchers agree that noise can affect both life-form physiology and behaviour, and if it becomes a chronic stress, noise can be injurious to an animal's energy budget, reproductive success and long-term survival while it possess a psychological and physical threat to human being. Armed with this understanding it should follow that humans would attempt to minimize the threat by reducing the amount of noise that are exposed to in natural areas [2].

1.2 Problem Statement

Although polymeric insulator usage is gradually replacing ceramic insulator, the number of ceramic insulator still in service is still far greater than polymeric insulator thus the environmental impact occur is also greater since inferiority of ceramic insulator compared to polymeric insulator in many aspect. One of the problems suffered by insulator is corona. Since ceramic insulator is less effective to repel against salt deposition and contamination on the insulator surface, the corona easily produced [3, 4]. Corona also produces by-products which one of them is audible noise. The nuisance caused by the noise produce by corona might not be loud enough to be categorized as heavy noise pollution but however in term of psycho acoustic point of view, it may cause insecurities and sense of danger to neighbouring residents [5]. Sleepless night and insomnia can occur to a person who is experiencing frequent exposure of the noise at night while it may not be much of a bother during daytime. [6] The power line that stretch along the human resident, forest and anywhere where there is life form may form a threat to the inhabitant nearby be it by noise made by the corona or the magnetic field radiate from the corona source.

1.3 Objective

The objective of the project is to investigate and provide analysis about the effect of the corona that occurs on the aged insulator surface that contributes to audible noise at residential area. Through this, couple of experimentation will be conducted on the ceramic insulator to measure the value of audible noise level under the influence of maximum 100kV HVAC electrical stressed with the simulated surrounding noise. Outdoor investigation will be made to determine the distance of the corona source from residential area. Questionnaires are distributed to collect information on the audible disturbance to the residents. Data collected will be analyzed with the statutory guideline limit of acceptance exposure or distortion level that applied internationally.

1.4 Scope of the Project

The scope of project will be as follows:

i. Literature review covering related object such as corona discharge, ceramic insulator and audible noise.
ii. Preparing appropriate experimental setup to generate and measure the corona on the insulator surface.
iii. Couples of experiment will be conducted in UTHM Laboratory using different value of HVAC voltages on the appropriate model that being set in the international standards.
iv. Work analysis of data founded and comparison will be made with the limit of acceptance exposure/distortion level that applied internationally.
v. Production level of audible noise will be measured from the corona production on the insulator surface using appropriate devices.

1.5 Expected Result

Environmental problem caused by electrical stressed to insulator is a common problem in high voltage transmission line. In this project, audible noise will be measure using appropriate method that is used internationally and will produce a standard result. The measured noise need to be as close as the noise in the actual environment thus simulated ambient noise will be simulated. Overall, this project will revolve around finding the data of the audible noise produces during corona phenomenon occurrence on the insulator to know what the intensity of produced noise is so that analysis can be made to determine whether the sound level is enough to significantly disturbed living being exposed to the sound source. The finding will be slightly different from actual phenomenon due to limited capability of HVAC equipment used in the experiment which cannot exceed 100kV maximum. Collected data will be analyzed and compared.

CHAPTER 2

LITERATURE REVIEW

2.1 INSULATOR

2.1.1 Overview

A true insulator is a material that does not respond to an electric field and completely resists the flow of electric charge. These materials are used in electrical equipment and structure as insulators or insulation [7]. All insulators have dual functions, mechanical and electrical, which commonly present conflicting demands to the design need. Their function is to support or separate electrical conductors without allowing current through themselves [8]. The term also refers to insulating supports that attach electric power transmission wires to utility poles or tower. Insulator for the purpose of this thesis, are device which are use on electric supply networks to support, separate or contain conductor at high voltage.

2.1.2 Type of Insulator

The insulators play one of the key roles in provision of safe transmission of electric energy and minimization of energy loss. By application the insulators of the following types as suggested by Holtzhausen (2008) is shown in figure 2-1 [9]. Insulator however may be built from different kind of material to meet the design requirement in term of application, climate, strength-to-weight ratio and many more.

The most common material that has been used in constructing the insulator is polymer and porcelain. The main advantages of the polymer insulator are improved corrosion resistance of outer polymer insulation under conditions of polluted air, reliability and endurance in the wide range of mechanical loads and temperature changes, light weight, significant savings achieve during assembly and replacement, vandal-proof design and so on [10]. In Malaysia, ceramic insulator is commonly used in many area compared to polymeric insulator. Polymeric insulator is newly introduce hence it is not widely used but it slowly replacing the ceramic type insulator.

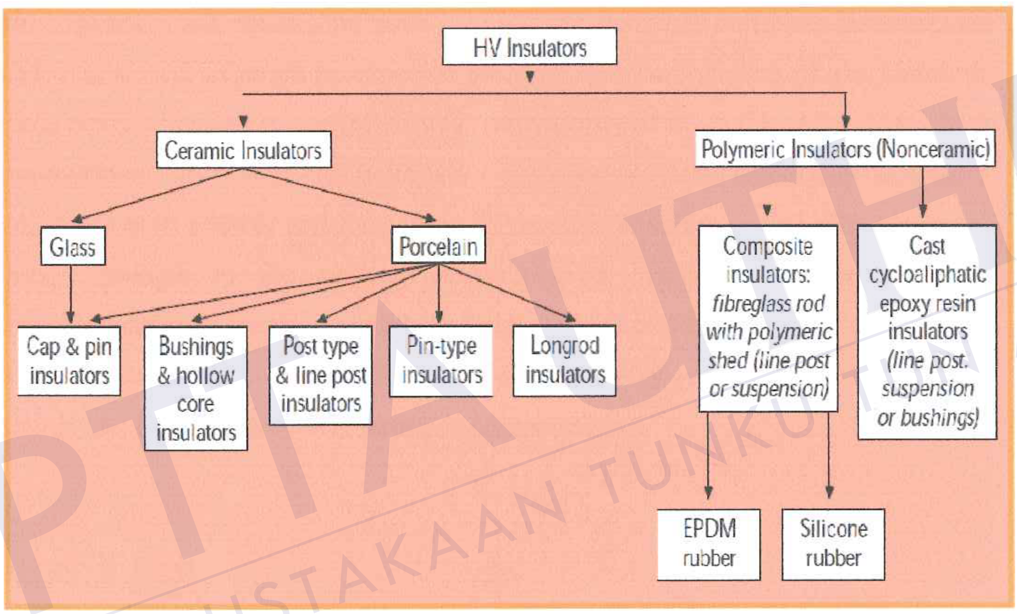
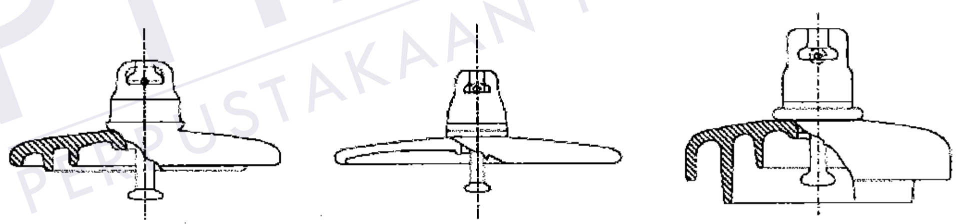


Figure 2.1: Classification of Power Line Insulator [10]

Given the material based the type of design, the protective mould material, voltage class and mechanical destructive power determines the type of the insulator. Figure 2.1 shows the classification and type of the insulator commonly used in power system. There is two of most commonly used material that is ceramic which comprise of glass and porcelain and polymeric or non ceramic type [11].

2.1.3 Ceramic Insulator

Ceramic insulators are made of ceramic materials which include porcelain and glass. Their initial use precedes the construction of power systems. They were first introduced as components in telegraph networks in the late 1800s [12]. There are a number of basic designs for ceramic insulators; examples were shown in Figures 2.2 (a), (b) and (c). Porcelain is used for the production of cap and pin suspension units, solid and hollow core posts, pin type, multi-cone and long rod insulators, and bushing housings. Glass, on the other hand, is used only for cap and pin suspension and multi-cone posts [13, 14, 15]. Porcelain and glass insulators are well established, as might be expected based on their long history of use. Currently these types of insulators comprise by far the majority of in-service units. Continuous improvements in design and manufacturing processes have resulted in insulators, which are both reliable and long lasting. Porcelain units are coated with a glaze to impart strength to the surface. Today's glass insulators are predominantly manufactured from thermally toughened glass, which prevents crack formation. Both of the materials have inert surfaces, which show very good resistance to surface arcing, and both are extremely strong in compression.



(a) (b) (c)

Figures 2.2: Typical constructions of ceramic type suspension insulators (a) Standard. (b) Open profile (self-cleaning). (c) Anti-fog and for d.c applications [14]

2.1.4 Testing and specifications

All insulators are tested according to standard procedures outlined in various national and international publications. Ceramic and glass insulators are mechanically and electrically proof tested prior to shipment. In the case of polymeric insulator, prior to leaving the factory each production piece is subject to mechanical but not to electrical proof testing. The primary reason for this difference is that ceramic and glass units are generally made of a number of smaller units in series [16]. Performing electrical tests on each unit would require significant time and investment in a sizeable high voltage test facility. In addition to mechanical and electrical proof tests, the raw materials used in the production of polymer insulators are tested as a control on the production process. With regards to qualification and application testing, the most widely used standards are those issued by IEC, ANSI, IEEE, CSA, and CEA [17]. Depending upon the type of insulator, the electrical tests include wet and dry power frequency flashover, lightning impulse flashover, steep front impulse flashover, power arc, and corona tests. Mechanical tests include tension, thermal mechanical cycling, torsion, cantilever, and electrical–mechanical testing. Contamination performance tests are also performed on these insulators [18].

2.1.5 Inspection and failure modes

Insulators are often periodically inspected to ensure their continued integrity. In-service monitoring of polymeric insulators presents a greater challenge. Methods such as IR thermography, radio noise detection, corona observation, and electric field monitoring have proven effective as diagnostic tools for assessing the in-service condition of polymeric insulators [19]. The insulator can be seriously damaged inside with no indication on its exterior. The mode of failure predominant with ceramic insulators involves mechanical or electrical failure due to breakage or surface or internal cracking. Up-to-date information on different approaches to the monitoring of polymeric insulators in-service is summarized in IEC publication (1993; 1997) [20, 21].

2.1.6 Flashover mechanism of polluted insulators

G. G. Karady et al. mentioned that [22, 23] if the insulators in service become covered with a layer of pollution there are two conditions applied. When the surface is dry, the contaminants are non-conducting. But when the insulator surface is wetted by light rain, fog, or mist, the pollution layer becomes conducting with the following sequence of events shown in figure 2.3.

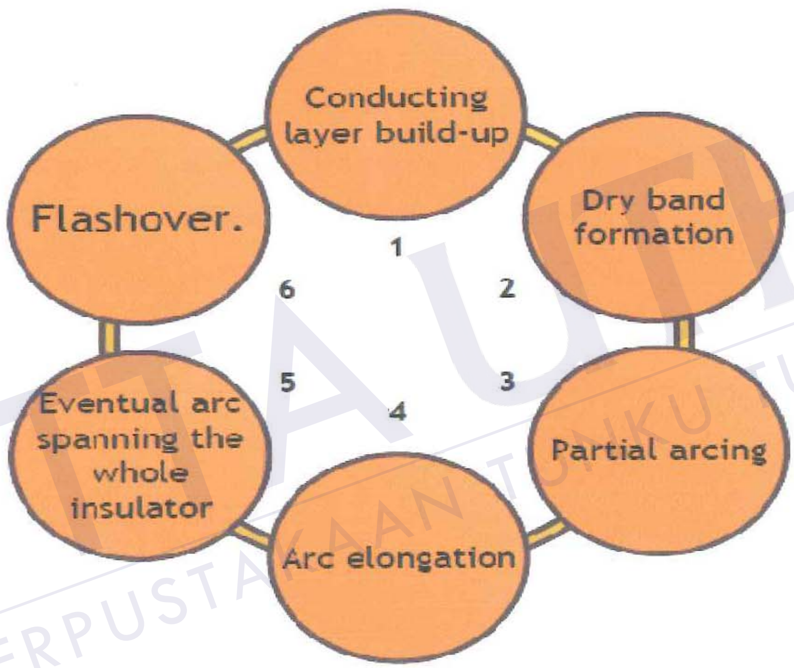


Figure 2.3: Flashover design sequence

The pollution layer in general is not uniform. When conduction starts, the currents are in the order of several milliamps, resulting in heating of the electrolyte solution on the insulator surface. The leakage current begins to dry the pollution layer and the resistivity of the layer rises in certain areas. This leads to dry band formation, usually in areas where the current density is highest. The dry band supports most of the applied voltage. The air gap flashes over, with the arc spanning the dry band gap which is in series with the wet portion of the insulator. The arc may extinguish at current zero and the insulator may return to working conditions. Dry band formation and rewetting may continue for many hours.

2.1.7 Model for flashover of polluted insulators [24]

Let us assume a uniform pollution layer with resistance as shown in Figure 2-6. When the arc is burning in series with the pollution layer, the voltage across the insulator with an arc partially bridging the insulator will be given by:

$$V = V_{arc}\,(I, x) + \,(L - X)r \qquad [25]\ (2.1)$$

Where the function V_{arc} relates the arc voltage to the current I and the arc length x. In general, for a given resistance r the curve relating V to x/L has the form shown in Figure 2.4.

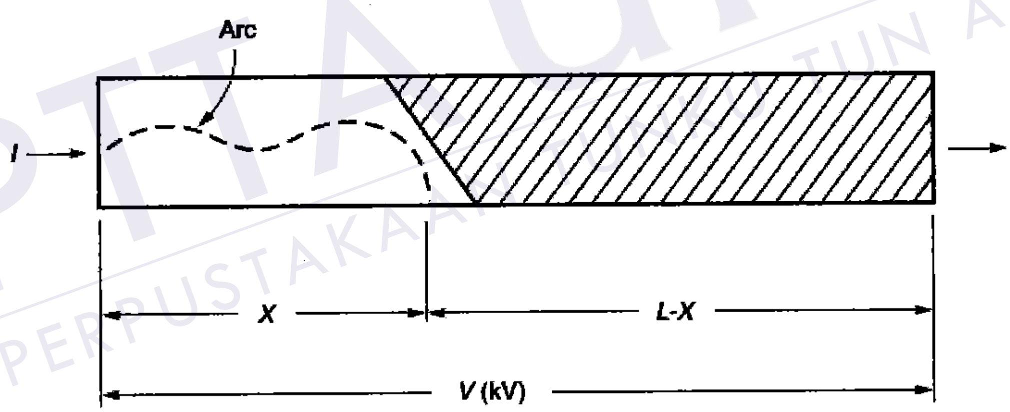


Figure 2.4: Model of a single arc developing on a polluted surface (Uniform pollution layer r, k_/mm)[26]

For an applied voltage, V_a, x/L may have values no greater than x/L_a.The curve has a maximum critical voltage V_c, and for voltages equal to or greater than V_c, x/L may have values up to unity. When the applied voltage V_a is less thanV_c, x/L cannot be increase to unity and flashover cannot occur. Numerous empirical relations in [25, 26, 27] have been proposed to solve equation (2.1). For example, for vertical 33 kV and above:

$$V_c = 0.067r^{1/3}L_a^{2/3}L_s^{1/3}\ kV\ (rms) \qquad [27](2.2)$$

Where, L_a is the minimum arc length (mm) to the bridge insulator and L_s is the leakage path in millimetre on the insulator surface.

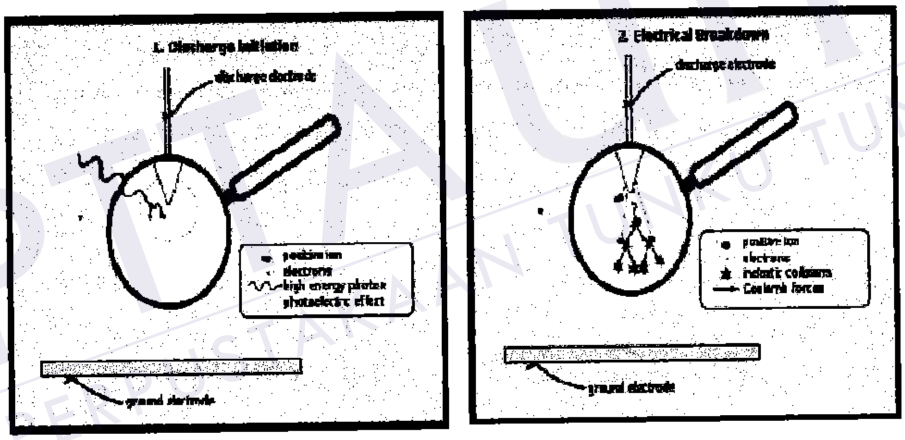
2.2 CORONA DICHARGE

2.2.1 Overview

A corona is a process by which a current, perhaps sustained, develops from an electrode with a high potential in a neutral fluid, usually air, by ionizing that fluid so as to create plasma around the electrode [28]. The ions generated eventually pass the charge to nearby areas of lower potential, or recombine to form neutral gas molecules. When the potential gradient is large enough at a point in the fluid, the fluid at that point ionizes and it becomes conductive. If a charged object has a sharp point, the air around that point will be at a much higher gradient than elsewhere. Air near the electrode can become ionized (partially conductive), while regions more distant do not. When the air near the point becomes conductive, it has the effect of increasing the apparent size of the conductor. Since the new conductive region is less sharp, the ionization may not extend past this local region. Outside this region of ionization and conductivity, the charged particles slowly find their way to an oppositely charged object and are neutralized. If the geometry and gradient are such that the ionized region continues to grow instead of stopping at a certain radius, a completely conductive path may be formed, resulting in a momentary spark, or a continuous arc [29]. Corona discharge usually involves two asymmetric electrodes; one highly curved (such as the tip of a needle, or a small diameter wire) and one of low curvature (such as a plate, or the ground). The high curvature ensures a high potential gradient around one electrode, for the generation of plasma.

2.2.2 Mechanism of Corona

Figure 2.5a shows that a neutral atom or molecule of the medium, in a region of strong electric field such as the high potential gradient near the curved electrode is ionized by an exogenous environmental event (for example, as the result of a photon interaction), to create a positive ion and a free electron. The electric field then operates on these charged particles, separating them, and preventing their recombination, and also accelerating them, imparting each of them with kinetic energy [30].



a) b)

Figure 2.5: Model of corona mechanism [32]

As a result of the energization of the electrons (which have a much higher charge/mass ratio and so are accelerated to a higher velocity), further electron/positive-ion pairs may be created by collision with neutral atoms. These then undergo the same separating process creating an electron avalanche. Both positive and negative coronas rely on electron avalanches. In processes which differ between positive and negative coronas, the energy of these plasma processes is converted into further initial electron dissociations to seed further avalanches [31] (see figure 2.5b). An ion species created in this series of avalanches (which differs between positive and negative coronas) is attracted to the un-curved electrode, completing the circuit, and sustaining the current flow which can be seen in figure 2.6 [32].

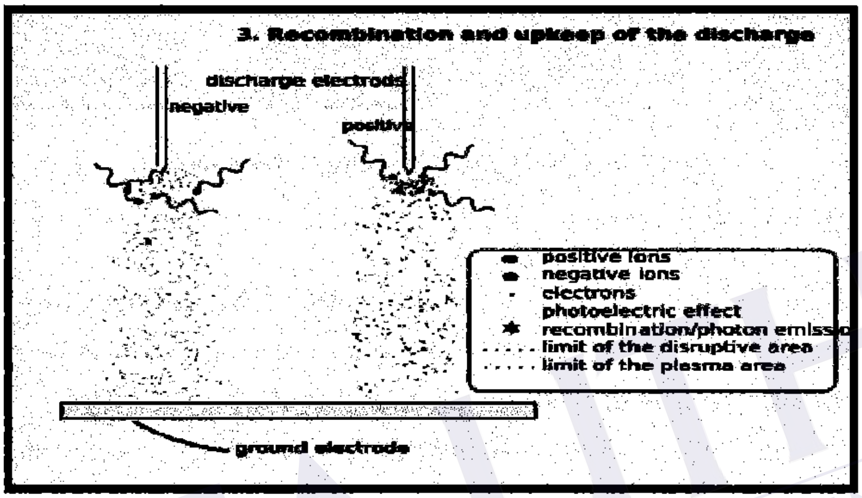


Figure 2.6: Recombination and upkeep of the discharge [32]

2.2.3 Corona Effect

Corona's can generate audible and radio-frequency noise, particularly near electric power transmission lines. They also represent a power loss, and their action on atmospheric particulates, along with associated ozone, can also be disadvantageous to human health where power lines run through built-up areas. Corona discharge is generally undesirable in electric power transmission, where it produce unwanted by-products shown in figure 2.7.

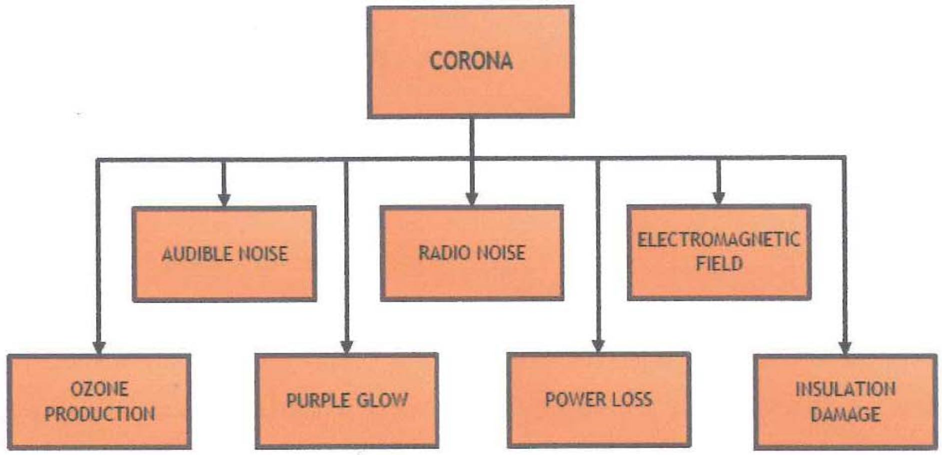


Figure 2.7: Corona by-product and side effect

Corona also occurs inside electrical components such as transformers, capacitors, electric motors and generators. Corona progressively damages the insulation inside these devices, leading to premature equipment failure. In the situations where high voltages are in use, but ozone production is to be minimized, corona is the least to be wanted [33]. However, corona can be suppressed by Corona Ring which is a device that serves to spread the electric field over larger area and decrease the field gradient below the corona threshold.

2.2.4 Corona Loss

When compared to the heating loss(I^2R), the average corona losses can be higher if the value of the transmission voltage is higher. In foul-weather, the losses can go up to 300kW/km. Since, rain however does not fall all through the year the corona loss in kW/km cannot be compared to heating loss directly. Cumulative annual average corona loss amounts only to 10% of heating loss, on the assumption of continuous full load carried. With load factors of 60% to 70%, the corona loss will be a slightly higher percentage. Nonetheless, during rainy months, the generating station has to supply the heavy corona loss and in some cases it has been the experience that generating stations have been unable to supply full rated load to the transmission line. Thus, corona loss is a very serious aspect to be considered in line design.

2.2.5 Corona-Loss Formulae

Corona-loss formulae were initiated by F.W. Peek Jr. in 1911 derived empirically from most difficult and painstaking experimental work. Since then many formulae have been derived by others both from experiments and theoretical analysis. They all yield the power loss as a function of (*a*) the corona-inception voltage, V_o (*b*) the actual voltage of conductor, V (*c*) the excess voltage ($V - V_o$) above V_o (*d*) conductor surface voltage gradient, E (*e*) corona-inception gradient, E_o (*f*) frequency, f (*g*) conductor size, *d*, and number of conductors in bundle, *N*, as well as line configuration; (*h*) atmospheric condition, chiefly rate of rainfall, r, and (*i*) conductor surface condition [34].

Peek's formula (1911):

$$P_C \propto (V - V_O)^2 \qquad [34]\ (2.3)$$

For a conductor of radius *r* at a height *H* above ground,

$$P_c = 5.16 \times 10^{-3} f \sqrt{r/2HV^2}\,(1 - \frac{V_o}{V})^2 \text{ , } kW/km \qquad [34](2.4)$$

Where V and Vo are in $kV\ rms$ and r and H are in meters. The corona-inception voltage and voltage gradients are, at an air density of d is given for equation:

$$V_O = \frac{2E_c\ r ln\frac{D_{ph}}{\sqrt{sr}}}{1+\frac{2r}{s}} \text{ , } kV_{peak} \qquad [34]\ (2.5)$$

$$E = \frac{v}{r} \ln\left(\frac{2H}{r}\right) \text{ and } E_o = 30\delta m \left(1 + \frac{0.3}{\sqrt{\delta r}}\right) \quad , kV_{peak} \qquad [34]\ (2.6)$$

The relative air density is a function of the pressure and temperature.

$$\delta = \frac{2.94p}{273+\theta} \qquad [34]\ (2.7)$$

δ where δ is the relative density (usually set as 1 for air) which relate the pressure ρ in kPa and the temperature θ in °C.

2.3 AUDIBLE NOISE

2.3.1 Overview

Audible noise produced by corona has become an important consideration in the design of high-voltage transmission lines. Although it does not appear that transmission lines are major contributors to the community noise problem, utilities now have to address the subject of corona-produced audible noise as an environmental impact problem. Transmission-line audible noise has several characteristics which differentiate it from more often encountered community noises, and which warrant a need for its level of severeness being measured.

2.3.2 Generation and Characteristic.

When corona is present, high voltage lines generate audible noise which is especially high during foul weather. The noise is broadband, which extends from very low frequency to about 20 kHz. Corona discharges generate positive and negative ions which are alternately attracted and repelled by the periodic reversal of polarity of the ac excitation. Their movement gives rise to sound-pressure waves at frequencies of twice the power frequency and its multiples, in addition to the broadband spectrum which is the result of random motions of the ions, as shown in Figure 2.8 [35]. The noise has a pure tone superimposed on the broadband noise. Due to differences in ionic motion between ac and dc excitations, dc lines exhibit only a broadband noise, and furthermore, unlike for ac lines, the noise generated from a dc line is nearly equal in both fair and foul weather conditions. Since audible noise is man-made, it is measured in the same manner as other types of man-made noise such as aircraft noise, automobile ignition noise, transformer hum and etc.

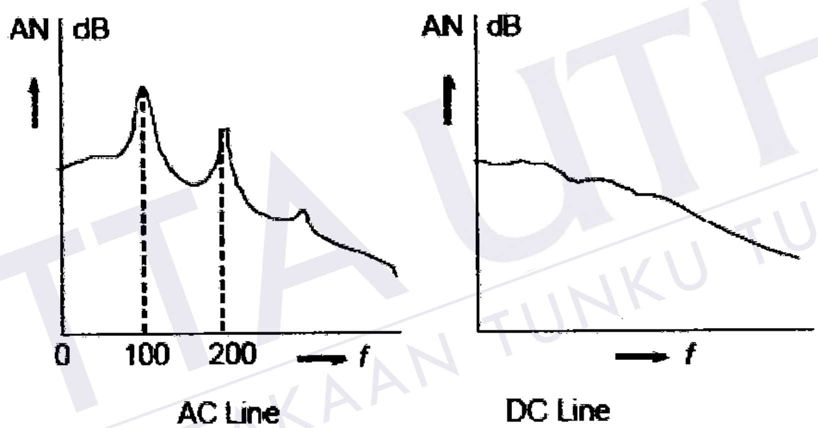


Figure 2.8: Audible Noise frequency spectra from ac and dc transmission lines.

Audible noise can become a serious problem from 'psycho-acoustics' point of view, leading to insanity due to loss of sleep at night to inhabitants residing close to an HV line. Regulatory bodies have not as yet fixed limits to audible noise from power transmission lines since such regulations do not exist for other man-made sources of noise. The problem is left as a social one which has to be settled by public opinion. The audible noise generated by a line is a function of the following factors shown in figure 2.9.

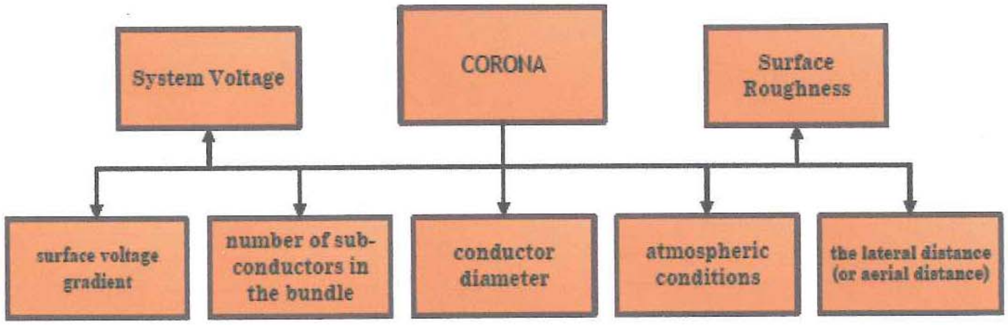


Figure 2.9: Audible Noise frequency spectra from ac and dc transmission lines.

2.3.3 Limit for Audible Noise

Since no legislation setting limits for audible noise for man-made sources exists, power companies and environmentalists have fixed limits from public-relations point of view which power companies have accepted from a moral point of view. In doing so, like other kinds of interference, human beings must be subjected to listening tests. Such objective tests are performed by every civic minded power utility organization. The limits are as follows [36]:

No complaints	:	Less than 52.5 dB
Few complaints	:	52.5 dB (A) to 59 dB
Many complaints	:	Greater than 59 dB

Noise level as mentioned in OSHA (Occupational Safety and Health) regulation state that there are duration limit someone can be expose to a certain level of noise (Figure 2.10). Depend on the intensity of the noise; the higher the intensities are the less time one should be exposed to the noise. Appendix 1 shows the table of exposure duration on noise level.

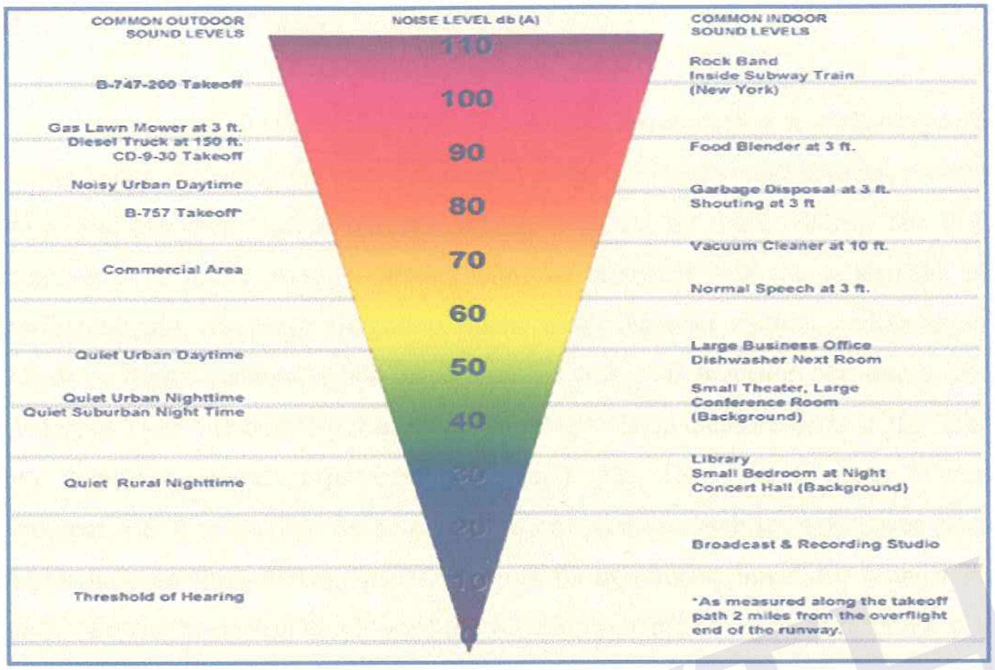


Figure 2.10: Comparison of Surrounding Noise Level

2.3.4 Audible Noise Measurement

Audible noise is caused by changes in air pressure or other transmission medium so that it is described by Sound Pressure Level (SPL). Alexander Graham Bell established the basic unit for SPL as $20 \times 10-6$ *Newton/m2* or 20 *micro Pascal* [$2 \times 10-5$ *micro bar*]. All decibel values are referred to this basic unit. In telephone work there is a flow of current in a set of head-phones or receiver. Here the basic units are 1 milliwatt across 600 ohms yielding a voltage of 775 mV and a current of 1.29 mA [37]. For any other SPL, the decibel value is given by equation:

$$SPL\ dB = 10Log_{10}\left(\frac{SPL}{20 \times 10^{-6}}\right) Pascals \qquad [37]\ (2.8)$$

This is also termed the Acoustic Power Level or simply the audible noise level. At present, there are so many methods available to measure or to monitored audible noise but the most commonly use method are:

A. Sound Level Meter

The sound level meter (SLM) is the basic instrument for investigating noise levels. It can be used to evaluate area noise levels, to identify noise sources, estimate employee exposures and aid in determining solutions for noise control. The SLM consists of a microphone, a preamplifier, an amplifier with an adjustable and calibrated gain, frequency weighting filters, meter response circuits, and an analog meter or digital readout. ANSI has classified levels of precision for sound level meters as Type 0 (laboratory standard), Type I (precision measurements in the field), and Type II (general purpose measurements) [38]. The Type II meter is most frequently used in the field for human exposure and noise evaluation purposes. Some SLMs have an "impulse" or "peak" response for monitoring impulsive sounds. The peak value is the maximum value of the waveform, while the impulse response is an integrated measurement.

B. Noise Dosimeters

A noise dosimeter is essentially an SLM that integrates noise levels over the sampling period and calculates the noise dose. It is the primary instrument used for compliance measurements. The noise dosimeter is worn by an individual during sampling to calculate personal noise dose, or it can be placed in a specific location to measure the sound level in that area. Specific instrument settings can be selected on a noise dosimeter, including exchange rate, frequency weighting, fast or slow response, criterion level, and threshold [39].

C. Octave Band Analyzer

Octave band analyzer is a type of SLM which can separate the monitored noise into specific frequency bands, which is necessary when analyzing noise sources to develop noise control solutions. This information is also useful in selecting hearing protectors by calculating the amount of attenuation for specific

frequency bands. Most octave band analyzers filter the sampled noise spectrum into 9 or 10 octave bands while some analyzers can measure noise in one-third octave bands for an even more detailed analysis

D. Sound Intensity Analyzer

Ordinary SLMs measure sound pressure level, which indicates the level of the sound, but not the direction from which the sound is coming. A sound intensity analyzer can measure intensity, which is a measure of both the magnitude and direction of the sound energy. With an intensity analyzer, noise sources can be specifically identified and ranked according to sound power [40]. This analysis can often be performed in environments where the noise is reverberant, since the intensity analyzer indicates the direction of the noise. A sound intensity analyzer is particularly useful for pinpointing noise sources and determining appropriate engineering controls.

2.4 ENVIRONMENTAL EFFECT

2.4.1 Overview

The corona phenomenon produces such unwanted effects that bother surrounding living organism and electronic devices be it sensitive or not in a certain radius distance where it happen to occur. The audible noise produce and e.m.f present as a threat to quality living of a living being in term of health, nuisance and device interference. In this sub-topic, the effect of corona audible noise and magnetic field produced is briefly discussed from previous research and studies.

2.4.2 Audible Noise

A. Effect to human being.

Audible noise produce from the corona might not be as loud as flashover occurrence but the level still need to be noted and not to be taken lightly as the duration of exposure by a certain degree of noise and some people which has intolerant toward sound has to be taken into account. There are well documented associations between noise exposure and changes in performance, sleep disturbance and emotional reactions such as annoyance. Moreover, annoyance is associated with environmental noise level, psychological and physical symptoms and psychiatric disorder. Although noise level explains a significant proportion of the variance in annoyance, the other major factor, confirmed in many studies, is subjective sensitivity to noise [41]. Noise sensitive people attend more to noises, discriminate more between noises, find noises more threatening and out of their control, and react to, and adapt to noises more slowly than less noise sensitive people.
There are examples of noise sensitivity related disease that happen to affect the patient's quality of living such as hyperacusis, misophonia and others [42].

- Hyperacusis - is a health condition which shows itself as over-sensitivity to certain frequency ranges of sound. A person with severe hyperacusis has trouble tolerating with sounds, some of which seem unpleasantly loud to that person but not to others standing right next to them [43]. This is not a matter of someone merely being too sensitive, but a situation where certain noises, not usually a problem for most, can drive a person suffering from Hyperacusis into a sound proof room. The symptoms are ear pain, annoyance, and general intolerance to any sounds that most people don't notice or consider unpleasant [44].

- Misophonia - literally hatred of sound is a form of decreased sound tolerance. It is characterized by negative experiences resulting only from specific sounds, whether loud or soft. Unlike hyperacusis, misophonia is specific for certain sounds. Little is known about the anatomical location of the physiological abnormality that causes such symptoms but it is most likely high central nervous system structures. People who have misophonia are most commonly annoyed, or even enraged, by such ordinary sounds as other people eating, breathing, sniffing, coughing or repetitive sounds [45]. People with misophonia may be diagnosed with mood or anxiety disorders as well as obsessive-compulsive disorder. Though a few sufferers are bothered by sounds they make themselves, most are not. The reactions are completely involuntary. People who have misophonia may also be annoyed by other people's repetitive movements, such as leg-tapping, nail-biting, the rising and falling of the belly, and typing. Sensitivity to these sounds tends to be exacerbated by anger, stress, hunger, sadness, or fatigue [46].

- Ligyrophobic - may be fearful of devices that can suddenly emit loud sounds such as heavy machinery, speaker or loud electrical appliances such as motor. They may avoid parades and carnivals due to the loud instruments such as drums [47]. Other Ligyrophobic also steer clear of any events in which fireworks are to be let off.

- Phonophobia - Is a fear of loud sounds. For example, listening to a sound that starts with a minute of silence and then suddenly goes loud would be extremely startling for most people, assuming they had no prior knowledge beforehand. Being startled is in itself a normal reaction, but the key difference is that people with actively fear such an occurrence [48].

B. Effect to wildlife.

Noise does not have to be loud to have negative effects. Very low frequency sounds including infrasound are also being investigated for their possible effects on both humans and wildlife. Renewable Energy World (2010) [49] stated that infrasound is inaudible to the human ear but this unheard sound can cause human annoyance, sensitivity, disturbance, and disorientation. For birds, bats, and other wildlife, the effects may be more profound. Noise from traffic, wind and operating turbine blades produce low frequency sounds less than 1-2 kHz which been research by Dooling (2002), Lohr et al. (2003) [50, 51] has been found to cause disturbance to these avian species due to the frequency range. Several other studies also find that noise did affect the wildlife.

- Swaddle and Page (2007) [52] tested the effects of environmental noise on pair preference selection of Zebra Finches. They noted a significant decrease in females' preference for their pair-bonded males under high environmental noise conditions.

- Bayne et al. (2008) [53] found that areas near noiseless energy facilities had a total passerine density 1.5 times greater than areas near noise-producing energy facilities.

- Schaub et al. (2008) [54] investigated the influence of background noise on the foraging efficiency and foraging success of the greater mouse-eared bat, a model selected because it represents an especially vulnerable group of gleaning bats that rely on their capability to listen for prey rustling sounds to locate food. Their study clearly found that traffic noise, and other sources of intense, broadband noise deterred bats from foraging in areas where these noise were present presumably because these sounds masked relevant sounds or echoes the bats use to locate food.

- Barber et al. (2010) [55] assessed the threats of chronic noise exposure, focusing on grouse communication calls, urban bird calls, and other songbird communications. They determined that while some birds were able to shift their vocalizations to reduce the masking effects of noise, when shifts did not occur or were insignificant, masking could prove detrimental to the health and survival of wildlife

There are few studies specifically focused on the noise effects from the transmission line on birds, bats and other wildlife. However, scientific evidence regarding the effects of other noise sources is widely documented. The results show, as documented in various examples above, that varying sources and levels noise can affect both the sending and receiving of important acoustic signalling and sounds. This also can cause behavioural modifications in certain species of birds and bats such as decreased foraging and mating success and overall avoidance of noisy areas

2.4.3 International Standard

International standards are important in the assessment of environmental noise either because they are used directly or because they provide inspiration or reference for national standards. This section highlights some of the more important standards. There are two main international bodies concerned with standardisation. The International Organization for Standardization (ISO) deals primarily with methodology to ensure that procedures are defined to enable comparison of results. The International Electrotechnical Commission (IEC) deals with instrumentation to ensure that instruments are compatible and can be interchanged without major loss of accuracy or data.

2.4.4 ISO 1996 -- Assessment of Environmental Noise

ISO 1996 "Acoustics -- Description and Measurement of Environmental Noise" is a central standard within environmental noise assessment, acting as a reference work on the subject. It is divided into 3 parts:

- ISO 1996 Part 1 1982: Basic quantities and procedures
- ISO 1996 Part 2 1987: Acquisition of data pertinent to land use
- ISO1996 Part 3 1987: Application to noise limits

It defines the basic terminology including the central Rating Level parameter and describes best practices for assessing environmental noise. ISO 1996 is currently under revision with focus on updating measurement techniques to modern

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