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"I hereby declare that I have read through this report entitle "Study On Tracking Performance For Pollution Insulators By Using Salt Fog Test" and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Industrial Power)"

Signature :…………………………………………..

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STUDY ON TRACKING PERFORMANCE FOR POLLUTION INSULATORS BY USING SALT FOG TEST

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A thesis submitted in fulfillment of the requirement for the Bachelor in Electrical Engineering (Industrial Power)

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STUDENT DECLARATION

I hereby declare that the content in this thesis entitle "Study On Tracking Performance For Pollution Insulators By Using Salt Fog Test" is the result of my own work except references and citations which I have clearly stated the sources of origin.

Signature :

Name : Muhammad Shaffiq Izwan Bin Abdul Aziz

Date :

To My Beloved Parent (Ibu & Ayah)

From Love With Love To Loved

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ABSTRACT

The pollution flashover performance of insulators is generally tested by the steam fog method. However, environmental temperature in tests differs greatly, so the dispensability of test results is high. Moreover, the influence of fog-water conductivity has been taken into recorded. Compared with the steam fog method, the cold-fog method simulating natural fog is more consistent with the actual operating conditions of transmission line insulators. This deals with the influence of salt deposit density (SDD) and fog-water conductivity on pollution flashover performance. The contaminant level is consideration of the ratio water with salt. The influence of the two factors is determined by analyzing the results of laboratory experiments where polluted insulators were tested by using the salt cold-fog method. The results show that the 50% AC pollution flashover voltage (U50) decreases as SDD and fog-water conductivity increase. The correction coefficient indicating the influence of fog-water conductivity on U50 can be expressed as an exponential function. *This is the technique for figuring out the condition of ageing occurs among the insulators on line or predicts their remaining life span has yet to be proposed. In addition, a study on diagnosis and monitoring of aged glass insulators is found lacking.* At the end, leakage current flow has been recorded. *The findings in this research suggest that under wet insulator surface condition of the transmission line glass insulator leakage current are good indicator of ageing. Furthermore this technique can be applied for online monitoring and diagnosing ageing transmission line glass insulator and it is very useful to the utility supplier.*

ABSTRAK

Pencemaran prestasi sah penebat umumnya diuji dengan kaedah kabus wap. Walau bagaimanapun, suhu alam sekitar dalam ujian sangat berbeza, jadi kebarangkalian terhadap keputusan ujian adalah tinggi. Selain itu, pengaruh kekonduksian kabus air telah diambil direkodkan. Berbanding dengan kaedah kabus wap, kaedah sejuk kabus simulasi kabus semula jadi adalah lebih persis dengan keadaan operasi sebenar penebat talian penghantaran. Ini berkaitan dengan pengaruh kepadatan deposit garam (KDG) dan kekonduksian kabus air kepada prestasi pencemaran arka. Tahap pencemaran adalah pertimbangan air nisbah dengan garam. Pengaruh kedua-dua faktor ditentukan dengan menganalisis keputusan uji kaji makmal di mana penebat tercemar telah diuji dengan menggunakan garam kaedah sejuk kabus. Hasil kajian menunjukkan bahawa 50% AC flashover pencemaran voltan (U50) berkurangan apabila KDG dan kabus air peningkatan kekonduksian. Pekali pembetulan menunjukkan pengaruh kekonduksian kabus air di (U50) boleh dinyatakan sebagai fungsi eksponen. Ini adalah teknik untuk memikirkan keadaan penuaan berlaku antara penebat pada baris atau meramalkan jangka hayat mereka masih belum dicadangkan. Di samping itu, kajian mengenai diagnosis dan pemantauan penebat kaca berumur adalah didapati kurang. Pada akhirnya, aliran arus bocor telah direkodkan. Penemuan dalam kajian ini menunjukkan bahawa di bawah keadaan permukaan penebat basah daripada talian penghantaran kebocoran kaca penebat semasa adalah penunjuk yang baik penuaan. Tambahan pula teknik ini boleh digunakan untuk memantau talian dan mendiagnosis penuaan talian penghantaran kaca penebat dan sangat berguna kepada pembekal untuk aktiviti penyelenggaraan.

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AC	-	Alternating Current
AEC	-	Artificial Environmental Chamber
C	-	Capacitor
cm	-	centimetre
CT	-	Current Transformer
DAQ	-	data acquisition device
DC	-	Direct Current
EPDM	-	Ethylene Propylene Diene Monomer
EPR	-	Ethylene Propylene Rubber
ESDD	-	Equivalent Salt Deposit Density
FOV	-	Flashover Voltage
FFT	-	Fast fourier transform
Hz	-	Hertz
IEC	-	International Electrotechnical Commision
kg	-	kilogram
kS/s	-	kilosamples per second
kV	-	kilovolts
LabVIEW	-	Laboratory Virtual Instrumentation Engineering Workbench
LC	-	Leakage Current

LV	-	Low Voltage
m^3	-	cubic metre
mA	-	miliampere
ml	-	mililitre
mm	-	milimetre
min	-	minute
NSDD	-	Non-soluble Salt Deposit Density
PC	-	Personal Computer
R	-	Resistor
Rad	-	Radian
RH	-	Relative Humidity
rms	-	root- mean- square
SIR	-	Silicone Rubber
THD	-	Total Harmonic Distortion
TNB	-	Tenaga Nasional Berhad
V_z	-	Zener voltage

CHAPTER 1

INTRODUCTION

1.1 Project Background

At present, by using salt fog method, the contamination of flashover performance of insulator can be tested. The test leads to a rather big difference between the temperature of the real environment and the high temperature of the test environment (more than 25°C). Moreover, the salt fog conductivity has influenced the test method. The real environment temperature is below 12°C (<12°C) when it is sprayed [1]. Fog-water conductivity is differs depending on the district, the season and environmental contamination. For example, fog-water conductivity is as high in seriously polluted districts, in suburbs, and in outer suburban districts [2]. Therefore compared with the traditional salt-fog method, the suitable method can be use for the research of the contamination flashover performance of insulators and fog-water conductivity is a fresh-fog method. It is more suitable for specific reasons.

Mainly, fog-water conductivity can be done into consideration of ratio water and salt. Because of that, the use of the cold-fog method can provide more reason references for the design and selection of the external insulators. After that, it is easier to make the temperature of the test similar to the temperature of the real environment. This influence makes the test of environment more consistent with real operating conditions. The contamination flashover of insulators is a complicated process with that process. The contamination of performance flashover voltage (PFV) can be influenced by numerous factors. The additional of salt deposit density (SDD) into the method has been referred in papers, and the results show that flashover performance is increases with the decreased the salt density [3]–[7]. It can be expressed by refer to the power function. The influence of non-soluble deposit density (NSDD) into the method also been studied [8]-[10]. For this additional, the result show that the flashover performance is increases with the decreased the non-soluble density. It is also can be expressed by the power function.

Scholars have discovered that the non-uniform contamination distribution between the top and bottom surfaces of insulators has great impact on the PFV. This finding has been studied further in papers [11][12]. The results show that the PFV increases with the increase of non-uniform contamination distribution degree. The influence of atmospheric pressure on PFV has been studied in papers, and the results indicate that PFV decreases with the decrease of atmospheric pressure, which can be expressed by a power function[13]–[18]. The research results of papers show that PFV decreases by 0.7–1.0% when the environmental temperature increases by 1°C within the range, from 5°C to 35°C [19][20]. The influence of contaminating ingredients on PFV has been analysed in papers, and the results of these studies indicate that under the same SDD, PFV varies with different contaminating ingredients [21]–[23]. The influence of acid rain on PFV has also been studied in papers [24][25], and the results show that PFV decreases with the increase of acidity. There are many other factors influencing PFV, such as the profile of the insulators, the materials, the arrangement of the insulators, string length and the environmental parameters [26]-[28]. It can be seen that several factors influencing PFV have been studied. However, the previous studies barely touched on the flashover performance of polluted insulators in cold fog and the influence of fog-water conductivity on the flashover performance of polluted insulators.

This paper attempts to address the said issue. The influence of SDD and fog-water conductivity on the AC contamination flashover performance of typical porcelain, glass and composite insulators under cold foggy conditions will be studied in this paper. The contamination flashover performance will be analysed under different fog-water conductivity conditions. The correction coefficient indicating the influence of fog-water conductivity on U50 will be proposed. The steam-fog method and the cold-fog method will be analysed and compared. This paper is expected to provide a basis for the selection and design of the external insulation of transmission lines.

1.2 Project Motivation

Many studies have been done to examine the effect of ceramic insulator design under various conditions of wetting. For example, in desert conditions, open profile or aerodynamic designs have been found to perform well when compared to designs having ribs [1]. On the other hand in salt fog conditions, a bell shape design or designs having deep ribs on the underside of the insulator, example of fog type insulators, perform better in coastal areas than open designs. The shed spacing to diameter ratio, shed inclination angle, and protected creepage distance are the various design parameters that have been studied and shown to be important in insulator performance [2,3].

The measurement of flashover voltage and the distribution of pollution density have been used to study the various aspects of insulator design in ceramic insulators [2]. With non-ceramic insulators, less attention has been given to weather shed design. Most of the research has concentrated on the material composition rather than on the design of the weather sheds. As a result, it is not yet entirely clear if insulator design affects the long-time performance of polymer insulators. Research conducted (by Ontario Hydrc) in clean fog concluded that insulator design has a negligible effect on insulator flashover [4]. However, it is believed that when insulators are contaminated and cleaned under natural conditions, their performance will be dependent on weather shed design. On the other hand, the research done at NGK indicated that alternating shed designs showed better contamination performance than straight sheds [5]. Znaidi studied the effect of weather shed design on accumulation of contamination for both ceramic and non-ceramic insulators in actual field and laboratory conditions [6].

Non-ceramic insulators with open profiles (low slope) accumulated more pollution on the topside than on the bottom side. Also insulators with small shed diameters have been found to keep more pollution on their surfaces than insulators with longer shed diameters. The self-cleaning factor was effectively improved for insulators with large shed spacing but their cores were generally more polluted. Finally, insulators with alternate shed diameter showed better performance for both desert and coastal conditions than with straight shed design [6]. Gorur *et al.* [7] studied the effect of polymer insulator profile on the erosion and tracking performance in salt-fog. It was found that insulators with protected profiles maintained their initial surface hydrophobic for a much longer time than other designs. Also, the leakage current was much less for the protected profiles than for un-protected profiles.

Chemey and Stonkus studied the effect of the form factor (L/A where L is the leakage distance and A is the surface area) on the performance of polymer insulators [8].

The leakage current decreased with an increase in the form factor. Measurement of flashover voltage [4], distribution of pollution density [5,6], and leakage current [7,8] have been used to study the effect of insulator design in polymer insulators. Leakage current, during various types of tests, has been measured and analyzed by various researchers. It has been observed that by studying the various components of the leakage current more information on specific characteristics can be obtained. Suds studied the leakage current harmonic components for ceramic insulators in clean-fog. [9]. He noticed that the likelihood of flashover became higher when the peak leakage current and the magnitude of odd-order harmonic components exceeded a particular level. Karady *et al.* [10] also studied the correlation of the harmonic content of the leakage current to flashover in clean fog. The FFT analysis of the leakage current showed that the harmonic content increased suddenly before flashover. Fernando and Gubanski conducted a detailed leakage current analysis on non-ceramic insulators in clean fog [11-14]. The measured leakage currents were found deformed from sinusoidal shape. However, the measured levels were much lower than the level of leakage current that precede flashover. These deformed waveforms contained a significant third and fifth harmonic components and their content increased with the applied voltage.

1.3 Problem Statement

A lot of research has been done on the electrical properties of high voltage insulation materials. Usually, there are two types of test can be conducted, the standard test used for product test and non-standard test for research work. On previous studies, the test has been conveyed to determine the dielectric strength of different type of polymer materials where, the breakdown tests are conducted for the analysis of the dielectric strength, performance of polymeric insulation material properties. Nowadays, this high voltage testing is going to be used to determine the voltage breakdown of the material using different shapes of electrode and analyze the characteristic of electrical breakdown. Since this experiment generates high voltages, compulsory handling steps and safety precaution need to be taken when handling the equipment. The safety precautions cover the laboratory safety, equipment, safety and user safety. Therefore, the standard test procedure accordingly to international standard is vital to be complied and must follow to get reliable results. And it's also referring to the British Standard Institution. Selection guide for polymeric materials for outdoor use under HV stress. PD IEC/TR 62039.2007 [6]. The minimum dielectric strength to be fulfilled for outdoor high voltage polymeric insulation shall not be less than 10kV/mm. In order to do testing on the dielectric strength of the polymer insulation, the international standard BS EN 60243-1:1998 is used. [7].

1.4 Objective of Study

The main objective of this project is:

1) To investigate the void around the insulator
2) To investigate the leakage current around the insulator
3) To analyze the condition of insulator when adjusted conductivity and maintain the HV or maintain the conductivity and adjusted HV.

1.5 Scope of Study

The experiment has focused on the testing for flashover occurs among insulator when salt fog has been given. The specification of testing has followed the specification from ISO 9227 and ASTM B117. The insulator use is glass type LXY-160 and the contaminant is set by light, medium and heavy weight. The insulator has tested inside the chamber where the chamber is setup by referring standardize from ASTM B117.

CHAPTER 2

LITERATURE REVIEW

2.1 Review of Previous Related Works

From the previous related research about salt fog test stated about the parameter and characteristic of salt fog test example of research of Farouk A. M. Rizk in April 1985 with research title Influence of AC Source Parameters on Flashover Characteristics of Polluted Insulators. This paper stated about systematic experimental investigation into the influence of AC test source parameters on the leakage current pulses, voltage fluctuations and flashover voltages of polluted insulators. The test techniques include both salt-and clean-fog methods, while the test insulators comprise long-rod and cap and pin strings of different lengths as well as support columns. Whenever possible the tests results are compared with the predictions of computer modeling of the phenomena involved.

Second of related research from Prof. Muhammad Amin and Dr. Mohammad Akhbar in 2006 with title Effect of UV Radiation, Temperature And Salt Fog On Polymeric Insulators. This research explained about the aging and estimate of useful life of polymer insulators installed in field is a major concern nowadays. In order, to find the extent of aging and useful life of polymer insulators, different laboratory methods are employed. This paper also analyzes the degradation caused by UV radiation, temperature, salt fog, electric stress and humidity; by exposing the HTV silicone rubber insulators to these parameters in laboratory. After these experiments, the samples were analyzed with material testing techniques and were visually observed to locate any noticeable change. Other than that, this paper also stated the polymeric insulators are gaining acceptability all over the world rapidly because of their advantages over ceramics. This paper is an effort towards introduction of polymeric insulators in Pakistan. In it, the behavior of polymeric insulators under the effect of UV radiation, temperature, electric stress and humidity with specific reference to Pakistani environment was observed and analyzed.

The last related works taken from A. H. El-Hag in 2001 with title research a Design Parameters of Weather sheds That Affect The Ageing of Polymer Insulators In Salt-Fog. This research mention the results of a study in which the third harmonic ti-equency component of leakage current is used to study various design parameters of weather sheds that affect the ageing of polymer insulators in salt-fog. Salt-fog was applied to model insulators for 120 hours at two different conductivity levels, i.e. 1000 pS/cm and 2000 pS/cm as an aging test. The effect of the number of sheds and shed inclination angle on the aging performance of polymer insulators was studied. Model insulators having 2-Sheds showed better performance than 4-Sheds. Also, the shed inclination angle improved the performance of the insulators in salt-fog.

2.2 Testing equipment

The apparatus for testing consists of a closed testing chamber, where a salted is atom which is by means of a nozzle. This produces a corrosive environment of dense saline fog in the chamber so that parts exposed in it are subjected to severely corrosive conditions. Typical volumes of these chambers are because of the smallest volume accepted by International Standards (IEEE Standard) on Salt Spray Tests. Other than qualification of this chamber come from ASTM-B-117, ISO 9227 and now discontinued DIN 50021. It has been found very difficult to attain constancy of corrosively in different exposure regions within the test chambers, for sizes below 400 liters. Chambers are available from sizes as small as 4.3 cubic feet (120 L) up to 2,058 cubic feet (58,300 L). Most common machines range from 15 to 160 cubic feet (420–4,530 L).

Test has been performed with standardize of 5% solution of NaCl (Natrium Cloride) are known as NSS (neutral salt spray). Results are represented generally as testing hours in NSS without appearance of corrosion products (e.g. 720 h in NSS according to ISO 9227). Other solutions are acetic acid (ASS test) and acetic acid with copper chloride (CASS test), each one chosen for the evaluation of decorative coatings, such as electroplated copper-nickel-chromium, electroplated copper-nickel or anodized aluminum.

Some sources do not recommend to use ASS or CASS test cabinets interchangeably for NSS tests, as it is claimed that a thorough cleaning of the cabinet after ASS or CASS test is very difficult. ASTM does not address this issue, but ISO 9227 does not recommend it and if it is to be done, advocates a thorough cleaning.

Figure 2.1 : Example of salt fog tested chamber[29]

2.3 Standardization

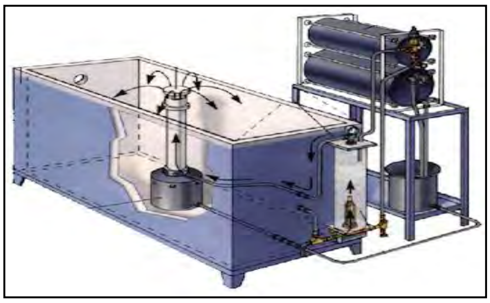

Figure 2.2 : Standardization of salt fog test chamber

The standard of chamber construction, testing procedure and testing parameters are standardized under national and international standards, such as ISO 9227 and ASTM B 117. These standards are describe the necessary information to carry out this test, example of testing parameters such as temperature, air pressure of the sprayed solution, preparation of the spraying solution, concentration, pH, and other else. Daily checking of testing parameters is necessary to show compliance with the standards, so records shall be maintained according the standard requirement. The standard requirement is produce by ISO 9227 and ASTM B 117 and it is widely used as reference standards.

Figure 2.3 : Corrosion in metal after Salt Fog Tested

Testing cabinets are manufactured according to the specified requirements here. However, these testing standards neither provide information of testing periods for the coatings to be evaluated, nor the appearance of corrosion products in form of salts. Requirements shall be agreed between customer and manufacturer. In the automotive industry requirements are specified under material specifications. Different coatings have different behavior in salt spray test and consequently, test duration will differ from one type of coating to another. For example, a typical electroplated zinc and yellow passivated steel part lasts 96 hours in salt spray test without white rust. Electroplated zinc-nickel steel parts can last more than 720 hours in NSS test without red rust (or 48 hours in CASS test without red rust) Requirements are established in test duration (hours) and coatings shall comply with minimum testing periods.

Artificial seawater which is used for Salt Spray Testing can be found at ASTM International. The standard for Artificial Seawater is ASTM D1141-98 which is the standard practice for the preparation of substitute ocean water.

2.4 Specifications

Salt spray tested chamber is referring the standard from ISO 9227 and ASTM B 117 for the specification in term of performance and parameter used. The some specification state in that standard are:

1. Temperature range Adjustable from ambient to +50°C/+122°F
2. Salt spray fall-out rates Adjustable from 0.5 to 2.5 ml per 80 cm2 per hour
3. Wetting mode (Premium chambers only) Adjustable from ambient to +50°C/+122°F
4. Drying mode (Premium chambers only) Adjustable from ambient to +50°C/+122°F
5. Cyclic corrosion test chamber performance
6. Wetting mode Temperature range Adjustable from ambient to +60°C/+140°F Humidity range Fixed at 95% - 100%
7. Salt spray mode Temperature range Adjustable from ambient to +50°C/+122°F Salt spray fall-out rates Adjustable from 0.5 to 2.5 ml per 80 cm2 per hour
8. Drying mode Temperature range Adjustable from ambient to +70°C/+158°F