" I hereby declare that I have read through this report entitle "High Voltage Impulse Voltage Test on a High Voltage Insulation Glove" and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Industrial Power)"

Signature : _____

Supervisor's Name: Mr. Azhan bin Abdul Rahman

Date : _____

HIGH VOLTAGE IMPULSE VOLTAGE TESTING ON A HIGH VOLTAGE INSULATION GLOVE

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A report submitted in partial fulfillment of the requirements for the degree
Of Bachelor in Electrical Engineering
(Industrial Power)

Faculty of Electrical Engineering
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2010

I declare that this report entitle "High Voltage Impulse Voltage Test on High Voltage Insulation Glove" is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : _____

Name : Mohd Haikal bin Mohd Sobri

Date : May 11th 2010

To my mother and my father

ACKNOWLEDGEMENTS

In the name of Allah, the Beneficent, the Merciful

Praise be to Allah, for his bless and kindness for giving me strength upon the completion of this report. Thank you so much to my supervisor, Mr. Azhan bin Ab. Rahman for his help and guidance to complete this progress report. He has helped me a lot in order to make me understand more about this project, and for being so supportive to me. Then, thanks to my panels, Mr. Khairul Anwar bin Ibrahim and Mrs. Anis Niza binti Raman for their comments and idea to improve my final year project and I would like to thanks Mr. Mohd Yusri for helping me doing testing. I would also like to thanks all my beloved family members for being so helpful and supportive in any moral aspect or economic condition. And, last but not least I would like to thanks my entire friend, for your opinion, for your idea, for your help and tolerance and I really have appreciated your co-operation upon completing my final year progress project report.

Thank you.

ABSTRACT

Electrical transmission and distribution systems will face the transient overvoltage, the amplitude that may exceed the peak value of a normal system voltage by a large amount. This transient overvoltage will occur due to two reasons that are by lightning strikes or by switching. Overvoltage that occurs due to lightning are called an external overvoltage and independent of system voltages. Switching overvoltage is an internal overvoltage that occurs due to the switching operations such as circuit breaker switching and always related to the system operating voltage. The purpose of this project is to perform a specific study on a high voltage impulse test in terms of: high voltage impulse test definition, types of impulse testing, configuration, characteristics of impulse test, wave shapes and high voltage impulse testing standard. An impulse test will then be performed on a selected consumer product in order to study the effect of the test, first by a simple simulation by using MULTISIM software, and then by a practical lab test. The practical lab test is done to determine the insulation strength on a various condition of the insulation surface.

ABSTRAK

Sistem penghantaran dan juga sistem pembekalan elektrik akan mengahadapi masalah lebihan voltan sementara yang mungkin melebihi sistem normal voltan dengan satu nilai yang besar. Lebihan voltan sementara ini akan terjadi disebabkan oleh dua sebab iaitu melalui kilat dan juga proses peralihan. Lebihan voltan yang berlaku disebabkan kilat adalah dikenali sebagai lebihan voltan luaran dan ianya bebas dari voltan sistem itu sendiri . Lebihan voltan disebabkan peralihan dikenali sebagai lebihan voltan dalaman dimana ia berlaku disebabkan operasi peralihan seperti operasi peralihan pemutus litar dan kejadian in selalunya berkait dengan voltan operasi sistem itu sendiri. Tujuan projek ini dijalankan ialah untuk mengadakan kajian yang terperinci di dalam bidang ujian impuls voltan tinggi seperti: definisi ujian impuls voltan tinggi, jenis-jenis ujian impuls, konfigurasi, ciri-ciri ujian impuls, bentuk gelombang impuls dan juga piawaian ujian impuls voltan tinggi. Ujian impuls ini kemudian akan dijalankan ke atas barangan pengguna yang terpilih untuk mengkaji kesan impuls voltan tinggi keatas barangan pengguna, melalui simulasi menggunakan perisian MULTISIM, dan melalui ujian amali di makmal voltan tinggi. Ujian amali dimakmal dijalankan untuk menentukan kekuatan penebat pada pelbagai keadaan pada permukaan penebat.

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CHAPTER 1

INTRODUCTION

1.1 Background

High voltage testing is a test that consists of the application of a voltage higher than the rated voltage for a specified time for the purpose of determining the adequacy against breakdown of insulating materials and spacing under normal condition. Test is done for proofing test of a new apparatus, maintenance of older equipment and as evaluating method to develop insulation systems. Stresses of the insulation will withstand under a various operating conditions should be determined and the response of insulation should also be determined in order to design and testing a high voltage insulations.

Basically, impulse test is just about:

i. Impulse test is used to evaluate any device insulation against lightning impulse.
ii. Impulse test can be implemented by using a special procedure such as a routine test.
iii. Impulse test consists of impulse voltage and impulse current test.
iv. Impulse test are usually done on a high voltage device such as a transformer, cable, surge arrester, insulator and many more.
v. Impulse voltage can be represented by a unidirectional waveform that rise rapidly to its peak value and slowly fall back to zero voltage.

vi. Impulse voltage test are consists of an Impulse Voltage Generator, voltage divider, shunts, control system and a measuring instrument with a calibration equipments

1.2 Problem Statement

To know the effect of high voltage impulse voltage when it is applied to the high voltage insulation glove on a various conditions

1.3 Objectives

The objectives of this project are:

i. To perform a high voltage impulse voltage test on the high voltage insulation gloves.
ii. To familiarize with high voltage lab testing and procedures.
iii. To know high voltage lab equipment.

1.4 Scope of the research.

This project has been confined to four relatively simple aspects which they are:

i. Learning and exploring in a way to produce the impulse voltage and to run an impulse voltage testing on the insulation glove with the four different condition which are normal condition, oily condition, wet condition and dirty condition.
ii. Perform an impulse voltage valued less than 100kV.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In electric power transmission engineering, high voltage is usually considered any voltage over approximately 35,000 volts. This is a sorting based on the design of apparatus and insulation. The International Electro technical Commission and its national counterparts (IET, IEEE, VDE, etc.) classify circuits with more than 1000 V for alternating current and at least 1500 V for direct current, and distinguish it from low voltage (50–1000 V AC or 120–1500 V DC) and extra low voltage (<50 V AC or <120 V DC) circuits. There were two conditions that cause impulse voltage to appear which is by switching surge and lightning. Both conditions will be discussed further in this section afterwards. [1, 5]

2.2 Switching Surge

Switching impulse voltage is produced due to switching operation such as circuit breaker operation on and off condition or faults that occur inside the system. Switching impulse is usually the dominant factor that affects the insulation design in high voltage power systems. The testing for switching surge are carried out in a dry condition while outdoor equipments is tested under positive switching impulses only

2.3 Lightning

Lightning phenomenon will possess a source of overvoltage. Lightning would cause overvoltage that may lead to the line insulation breakdown in the transmission lines. To understand lightning and its effect on the electrical systems, we have to examine on how charges are formed inside the cloud, the mechanism breakdown of the long air gap and how does the lightning obstruct the electrical system.[3] Lightning is the most spectacular and frightening dangers to the high voltage system. Larger particles inside an active thunder cloud usually posses a negative charge while smaller particles carries positive charge. Therefore, the base of a thunder cloud generally carries a negative charge while upper part carries positive charge with the whole being electrically neutral. [4]

There are many theories available to explain about charges forming activity inside the thundercloud and the theory that proposed by C.T.R Wilson and G.C Simpson received much attention. Both of them declare that the action of ascending currents of air on the falling raindrops took part on cloud charging and they did not agree on the part played by the various known atmospheric processes and conditions. Figure 2.1 shows the lightning mechanism on how the lightning occurs starting with the stepped leader and ends with the return and ground current.

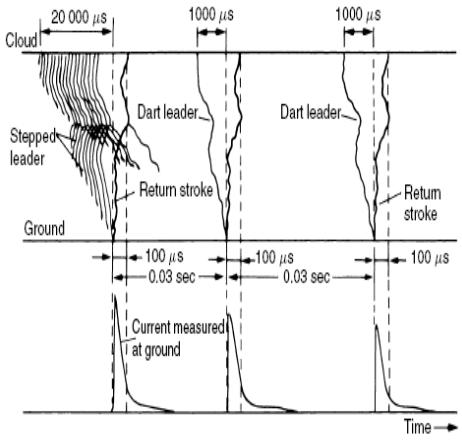

Figure 2.1: Lightning mechanism and ground current

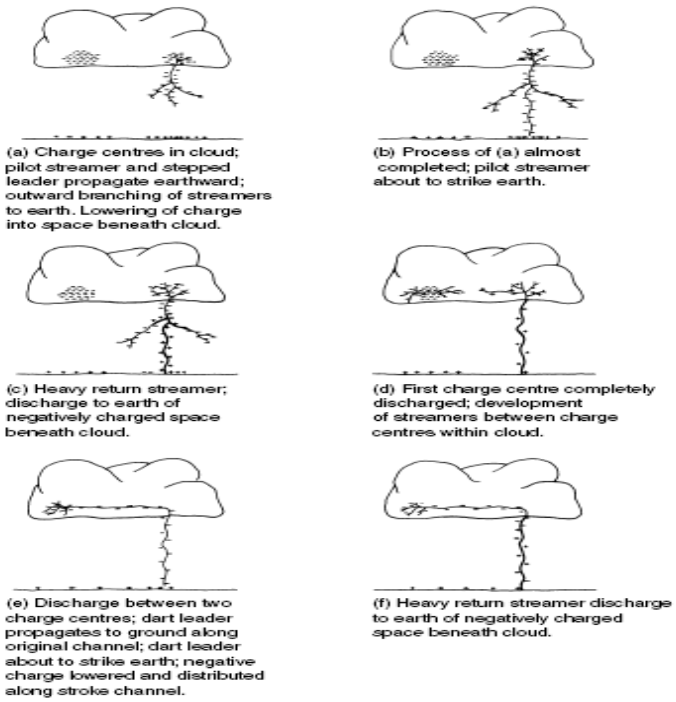

Figure 2.2: Various stage of lightning stroke between cloud and ground

Figure 2.2 above shows in detail on how the actual lightning's process happen. Started with the forming charge in the cloud and the stroke then fully discharged to the ground.

2.3.1 Lightning Effect on human life

Lightning cause an approximately 100 to 600 casualties every year in US and cause about 1000 to 1500 fatal injuries each year. The rate of death cause by lightning take the first place considered to the other natural phenomenon. The most severe cases is a direct strike, person or by the holding object such as golf club, tripod or umbrella is being hit directly by a 1MV or higher voltage. Aside flash occur when lightning hit other object and it jumps to the victim. Ground current could also injure people nearby while lightning strikes the ground nearby. Rarely, many people has been killed indoor while using a telephone or taking a shower.

When lightning strikes on human or on holding objects, the trauma effect that may occurs are:

i. Cardiovascular and respiratory effect is the primary death causing when victim is struck by the lightning. Victim may experience the cardiopulmonary arrest or diastole symptom may occur. Paralysis on respiratory system would also occur and the person may die on hypoxia.

ii. Central and peripheral nervous system that injured may cause transient confusion, paralysis and amnesia. Being hit directly may cause the brain bleeding and paraplegia can be a secondary effect to brain or spinal cord injury. There may also be neuropsychiatric complications such as depression, anxiety, memory deficits and post traumatic stress disorder.

iii. Dermatology effects are possible due to the effect of lightning. Most of the lightning victims have first or second degree burns. But the third or full thickness burn may also occur associated with metal objects.

iv. Ophthalmic and otology effects may also occur when victim get struck by lightning and most of them experience corneal injury. Victims may face the cataract problem on a few days after they get struck or maybe a few years afterwards. Another eye injury includes the retinal bleeding, retinal detachment and optic nerve degeneration. There may also be a transient autonomic nerve disturbances which can result in dilated and contracted pupils even without head injury.

v. Musculoskeletal effects occurs when the victim are struck whether by a direct hit or by being thrown during the blast. Contusion and fractures may occur along with muscle and ligament tears.

2.4 Types of high voltage

There are three types of high voltage which are high voltage alternating current (HVAC), high voltage direct current (HVDC) and high voltage impulse voltage. All these types of high voltage have their own usage and applications and generation of all types of the high voltage requires different type of generating circuit. The actual circuit used to produce high voltage is shown in figure 2.3 below.

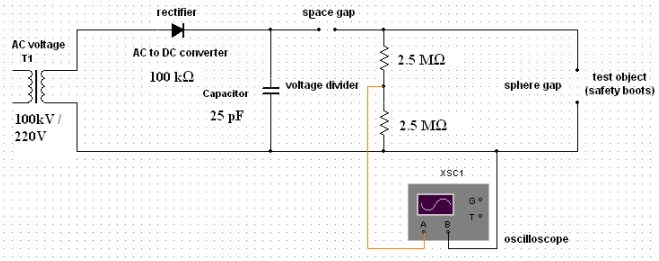

Figure 2.3 High Voltage Circuit

2.5 High voltage testing and generations

High voltage testing is a testing that uses a higher voltage than the rated voltage for a specified time for the idea of determining the capability of insulating materials and spacing under normal conditions against the breakdown. Tests are done for proofing test of a new apparatus, maintenance on older equipment and as evaluating method to develop an insulation system.

Generation of test voltages

a) A special transformer and surge generators have been developed to produce 60Hz power frequency voltages of 2.5MW, lightning and switch surges of over 5.0MW and DC voltage excessing 2.0MW.

b) Current level is not important in high voltage test as long as enough energy is available to energize tested system at the desired voltage level for required time length.

c) For impulse testing, special waveform must be generated to the approximately surge impulse voltage that are likely to stress high voltage equipment.

2.5.1 DC testing

- DC testing has been used to test new components of a distribution system, such as new cable that joined together to old cable, switchgear, motors, transformers and terminations.
- Even the components are new, entire system including supply cable should be tested using a DC testing method.
- DC voltage can be used to further degrade a high-resistance fault so that the fault location can be used to pinpoint the area. A capacitance discharge (thumping) is used to locate the failure points of cables.
- Thumping voltage value can lead to the insulations cable damage. [4]

2.5.1.1 DC Generation

Normally, for generations of over 100kV DC voltages, electronic valve rectifiers are used and the current output is about 100mA. The rectifier valves require special cathode and filaments construction since a high electrostatic field for about several kV/cm exists between the anode and the cathode in the non-conduction period. The supply (AC) to the rectifier tubes can be a power frequency or an audio frequency from an oscillator.

High DC voltage can be produced either by using a:

i. Half wave rectifier circuits; or
ii. Full wave rectifier circuits; or
iii. Voltage doublers type rectifiers.

The rectifier should be an electron tube or a solid state device. A single electron tube is able to produce 20kV peak inverse voltage, and also can be used for a higher voltage by arranging in series. To produce higher voltage, special care should be taken to uniform the distribution (transient voltage distribution are becoming non-uniform if arranging in series). [2]

2.5.1.2 Half wave rectifier

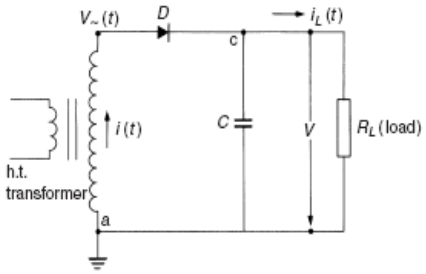

Figure 2.4: Half wave rectifier

As shown in figure 2.4 above, the half wave rectifier that used to produced high voltage direct current are arranged as above diagram. Power diode will rectify the alternating voltage to produce the direct current high voltage.

Half wave rectifier circuit operation:

- Capacitor will be charged to Vmax (maximum secondary voltage or the high voltage transformer) in the conducting half cycle.
- In other half cycle, capacitor will be discharged into the load.
- Value of the capacitor is chosen by the time constant CRL is at least 10 times of the AC supply period. [2]

2.5.1.3 Full wave rectifier

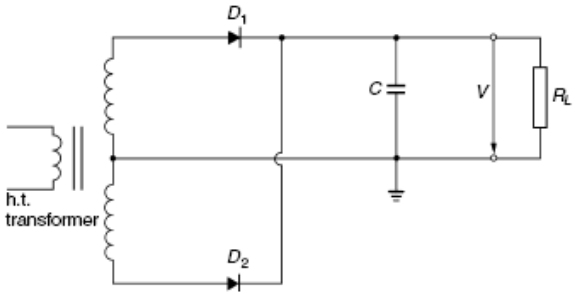

Figure 2.5: Full wave rectifier

Full wave rectifier circuit operation:

- Rectifier A will conduct and charges the capacitor during the positive half cycle and rectifier B will conduct and charges the capacitor during the negative half cycle.
- The high voltage source transformer requires a secondary centre tapped with a 2V rating.
- For the above 50kV rating applicants, a special construction of the rectifier valves are used (the cathode and anode contain a protective shield/ grid along around the filaments and cathode, with the anode is usually the circular plane).
- Nowadays, semiconductor rectifier stacks are commonly used for producing DC voltages in high voltage laboratories and testing installation.
- More commonly used diodes for high voltage rectifiers are silicon diodes with peak inverse voltage of 1kV to 2 kV compared to the semiconductor diodes that have a small conduction I_n the backward direction.
- Both full and half wave rectifiers' produces DC voltage less than AC maximum voltage, and ripple/ voltage fluctuation will also occur in the circuit. [2]