

**BREAKDOWN CHARACTERISTIC FOR VARIOUS
TYPE OF RUBBER**

MOHAMMAD FAIZUL BIN SAHBUDIN

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MOHAMMAD FAIZUL BIN SAHBUDIN

This report is submitted in partial fulfillment of requirements for
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“I hereby declared that this report is a result of my own work except for the excerpts that have been cited clearly in the references.”

Signature :
Name : MOHAMMAD FAIZUL BIN SAHBUDIN
Date : 7 MAY 2009

“I hereby declared that I have read through this report and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Industrial Power)”

Signature :

Supervisor's Name : JURIFA BTE MAT LAZI

Date :

For my beloved parents

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ABSTRACT

Rubber as solid insulating materials is used in many electrical applications. In all such applications, the electrical insulation ability of the rubber is of primary importance. Hence, the purpose of this project is to study the breakdown characteristic for various types of rubber. The types of rubber that had been selected for this project are natural rubber (NR), styrene butadiene rubber (SBR) and butyl rubber (IIR). In this project, the high voltage testing was conducted based on IEEE standard. By using Hafely construction KIT, AC and DC voltage breakdown tests and AC, DC and Impulse withstand voltage tests were conducted. The testing procedure focuses on 1 stage of high voltage configuration which the voltage can be generated up to 100kV. The experimental result will be analyzed to calculate the dielectric strength of the selected rubber in order to know the performance of the rubber as an insulating material. From the experimental results, it has indicated that NR has lower breakdown voltage strength compared to SBR and IIR. It also discovered that treeing phenomenon occurred on SBR and IIR under DC voltage breakdown tests.

ABSTRAK

Getah merupakan penebat pepejal yang digunakan dalam banyak aplikasi elektrik. Dalam kebanyakan aplikasi, kebolehan getah sebagai penebat elektrik amatlah penting. Oleh itu, tujuan projek ini adalah untuk mengkaji ciri-ciri voltan kejatuhan bagi pelbagai jenis getah. Jenis-jenis getah yang dipilih untuk projek ini adalah getah asli (NR), getah *styrene butadiene* (SBR) dan getah *butyl* (IIR). Dalam projek ini, ujian voltan tinggi dilakukan menurut standard IEEE. Dengan menggunakan pembinaan Hafely KIT, ujian voltan kejatuhan arus ulang-alik dan arus terus dan ujian ketahanan voltan arus ulang-alik, arus terus dan dedenyut dilaksanakan. Prosedur ujian ini memfokuskan penggunaan konfigurasi voltan tinggi 1 peringkat yang mana dapat menjana sehingga 100 kV. Hasil ujian yang dibuat akan dianalisis bagi kekuatan dielektrik bagi jenis-jenis getah yang dipilih bagi menentukan kesesuaian getah sebagai bahan penebat. Daripada keputusan ujian, diketahui NR memiliki kekuatan dielektrik yang rendah berbanding SBR dan IIR. Fenomena *treeing* juga didapati berlaku pada SBR dan IIR apabila ujian voltan kejatuhan arus terus dilaksanakan.

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LIST OF ABBREVIATIONS

DC	-	Direct Current
AC	-	Alternating Current
NR	-	Natural rubber
SBR	-	Styrene-Butadiene Rubber
IIR	-	Butyl Rubber

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CHAPTER 1

INTRODUCTION

1.1 Project Background

Work on distribution power systems is often performed under energized conditions to maintain the continuity of service to customers. Personal safety of workers is the primary concern in such distribution live-line maintenance operations. Protecting high voltage live-line workers from electrical shocks is partly achieved through the use of protective gear and special safe work procedures.

The protective gear includes flexible items such as natural or synthetic rubber gloves, sleeves and blankets. These items, serve as the *first line* of protection, since they are used to provide an insulating barrier between the worker and the energized parts. Therefore, proper understanding of breakdown characteristic of various type of rubber is essential for both design purposes and safe application.

To ensure that personnel using these materials have an adequate level of protection, numerous tests must be carried out to determine safe operating limits, reliability, and breakdown characteristics. To be of greatest value, the tests should be conducted under the most severe conditions likely to be encountered in practice. In this respect, the minimum values or puncture breakdown voltage and withstand voltages will have the greatest practical significance.

1.2 Problem Statement

Solid insulating materials are widely used in electrical power components. The most prominent materials are polyvinylchloride (PVC), polyethylene (PE) or cross linked polyethylene (XLPE). Rubber is known to exhibits unique physical and chemical properties. As a solid, rubber do possessed high mechanical strength due to their elasticity. With a vulcanization process, the properties of rubber can be improved. So it is important that a breakdown characteristic study should be carried on rubber to determine their dielectric strength and verify their selectivity as an insulating material.

1.3 Project Objectives

There are three aspects that need to be accomplished in order to make this project successful which are:

- i. To conduct high voltage testing on selected types of rubber;
- ii. To analyze and discuss the results obtained from testing which have been conducted.
- iii. To provide information on breakdown characteristic of different types of rubber.

1.4 Scope of Project

This project has been confined to three aspects which are:

- i. Types of rubber use are natural rubber (NR), Styrene-Butadiene Rubber (SBR), Butyl Rubber (IIR)
- ii. Types of high voltage testing to be conduct are DC, AC and Impulse voltage.
- iii. The high voltage testing is to be conduct according to IEEE Standard Technique for High-Voltage Testing (IEEE Std 4-1995).

1.5 Project Methodology

In order to complete this project, a necessary project planning should be arranged. As for this project, several steps have been outline in order to achieve the project objectives and scope. Basically, project methodology defines the planning process flow and principles that is essential guide to produce well plan project. Besides, selected approach or methodology will describe the activities that might be done in every stage.

The flow chart that describes the methodology for this project is shown in the Figure 1.1.

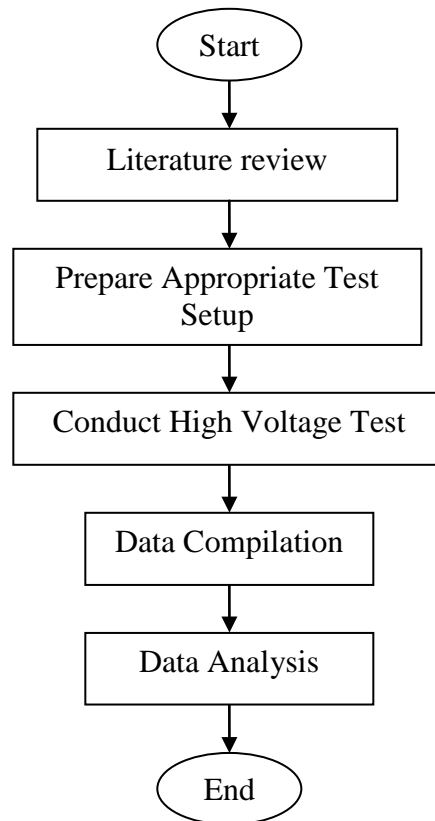


Figure 1.1: Flow chart of the project methodology

(a) Literature review

The literature review is conducted by doing some research and findings of information that related to the project through out resources such as internet, books, IEEE articles, journals and etc. This early stage is vital so that high understanding towards the project can be achieved.

(b) Prepare appropriate test setup

In this stage, the experimental setup when conducting the high voltage testing according to the type of high voltage (DC, AC and Impulse) will be highlighted. All the safety precautions that need to be taken also will be study.

(c) Conduct high voltage test

The DC, AC and Impulse high voltage testing will be conducted with the test object chosen. By doing this test, the breakdown voltage for the test objects will be determined.

(d) Data compilation

All the testing results will be recorded for further analysis.

(e) Data Analysis on the results obtained from lab session

In this part, the analysis on the lab testing results with the test object will be carried out. All the data and results obtained from the lab testing will be recorded and will be plotted in the graph. Finally, necessary analysis will be carried out the results obtained such as comparison of the breakdown voltage obtained on different types of high voltages and different types of material.

1.6 Thesis Outline

Chapter 1 briefly summarizes the project background and the problem statements as well as elaborates the objective and scope of the project. The project methodology

which is the most important part that describes the flow of the project is also discussed in detail in this chapter.

In Chapter 2, the literature review includes few methods can be used to generate DC, AC and Impulse high voltage. The brief elaboration on the test materials also included.

Chapter 3 will discussed the experimental setup using the HAEFLEY High Voltage Kits and safety precaution while doing the testing.

Chapter 4 will discussed testing procedure on the selected test materials which is subjected to the IEEE std 4-1995 Standard Techniques for High Voltage Testing.

In Chapter 5, details of the results of the project will be discussed. All the data and waveforms obtained will be presented in this chapter. Necessary comparison and analysis is carried out in this chapter.

Finally, Chapter 6 discusses the conclusion that can be drawn towards this project and necessary recommendations will be stated.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Before conducting high voltage testing on selected rubber materials in laboratory, it is important to review information related to the project. The information is based on books, journals, internet, previous research and discussion with supervisor. The focus of finding information includes proper high voltage testing procedure, related research on the same study and the test material properties.

2.2 High Voltage Testing Procedure

Basically to measure high voltage and basic testing techniques should be referred to IEEE or IEC standard. So far, they are generally applicable to all types of apparatus for alternating voltages, direct voltages, lightning impulse voltages, switching impulse voltages and impulse current [1]. This revision implements many new procedures to improve accuracy, provide greater flexibility and address practical problems associated with high voltage measurements.

In the high voltage testing, the amplitudes and types of the test voltages always higher than the normal or rated voltages of the apparatus under test. The selection of high voltage testing equipment had been prescribed by the national or international standards.

The experimental setup and testing procedure will be discussed further in Chapter 3 and Chapter 4.

2.3 Typical Characteristic of Dielectric Breakdown in Polymer

Since rubber is categorized as a polymeric material, it is important to study their typical dielectric breakdown characteristic in general. This study will help gain understanding toward their breakdown process.

2.3.1 Dielectric Breakdown Strength

The measured values of the breakdown voltage V_B of solid dielectrics are greatly influenced by the experimental conditions. For instance, when voltage is applied to the solid specimen kept in a surrounding medium of liquid or gas, a partial discharge in the surrounding medium often occurs mainly at the edge of the electrode before a complete breakdown of the solid dielectric. This phenomenon influences V_B of solids and decreases it. This is called the edge effect. In order to eliminate this effect, special forms of specimens and electrodes should be developed [2-5]. If electric strengths $F_B = V_B$ /sample thickness of some typical polymers are measured carefully with dc voltage to eliminate the edge effect [2-7], the following characteristic results were confirmed.

- a) The electric strengths of polymers are generally in the range of (1 to 9 MV/cm at 20°C) and these values are higher than those of ionic crystals (0.5 to 1 MV/cm at 20°C).
- b) In general, the maximum values of the electric strengths of polymers are obtained in the low temperature region. These values for polar polymers are more than 10 MV/cm and are higher than those of non polar polymers.
- c) The highest electric strength ever obtained for polymers is 15 MV/cm at -190°C for polyvinyl alcohol, having a polar group (-OH) in its side chain.

2.3.2 Temperature Dependence

Physical properties of polymers change with temperature, so the temperature dependence of their dielectric breakdown is of prime importance in analyzing their