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

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Supervisor’s Name	:	EN. FARHAN BIN HANAFFI
Date	:	10TH MAY 2010

HIGH VOLTAGE AND IMPULSE TEST ON INDUSTRIAL PIPELINE

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A report submitted in partial fulfillment of the requirement 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 and Impulse Test on Industrial Pipeline” 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	:	FARAH ZUNURAIN BINTI AB LATIF
Date	:	10TH MAY 2010

Special dedicated to

My beloved parents and siblings, who have encouraged, guided and supported me throughout my study life.

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ABSTRACT

It is generally known that power system outages caused by lightning flashover present a serious engineering problem. In many cases, lightning may caused damaged electrical equipment. From that, it will be lost millions of Ringgit Malaysia each year. Most of the industries looking for ways to protect equipment at the power plant site from damage by natural causes such as lightning. It will be the necessary precautions to keep the lightning channel far away from the immediate neighbourhood of flammable and explosive materials. Protection of electric equipment against this power of nature is one objective of high voltage engineering and testing. The aim of this experiments to analyze the safety gap that will be tested by prototype of pipeline using between stainless steel pipe and stainless steel plate. The influence of the spark gap discharge on the statistics of the air breakdown processes have been investigated in a wide range of gap lengths from 1.0 cm to 3.0 cm under AC, DC and Impulse conditions. The experimental results have been analyzed with the theoretical predictions and the satisfactory agreements which can be starts to be useful from an engineering point of view.

ABSTRAK

Seperti yang diketahui secara umum, kebocoran sistem kuasa yang disebabkan oleh kilat lampau memberi masalah kejuruteraan yang amat serius pada masa kini. Dalam kes seperti ini, kilat lampau boleh menyebabkan kerosakan pada peralatan elektrik. Oleh itu,, ia akan mengakibatkan kehilangan dan kerugian berjuta-juta Ringgit Malaysia dalam setahun. Kebanyakan daripada industri mencari cara-cara untuk melindungi peralatan pada tapak loji kuasa daripada kerosakan yang disebabkan oleh kilat. Ia akan menjadi langkah berjaga-jaga untuk menyimpan saluran kilat jauh daripada kawasan bahan-bahan yang mudah terbakar dan mudah meletup. Objektif kejuruteraan voltan tinggi dan pengujian adalah untuk melindungi peralatan elektrik pada sifat kuasa ini. Tujuan eksperimen ini adalah untuk menganalisa keselamatan jurang yang diuji pada prototaip saluran paip dengan menggunakan antara paip keluli dan plat keluli. Pengaruh pelepasan jurang spark pada proses-proses perangkaan kerosakan udara telah diuji dalam satu julat luas jurang daripada 1.0 cm sehingga 3.0 cm di bawah keadaan pengujian AC, DC dan Impulse. Hasil daripada pengujian itu telah dianalisis dengan ramalan-ramalan teori dan perjanjian dimana boleh menjadi berguna dari sudut kejuruteraan.

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CHAPTER 1

INTRODUCTION

1.1 Project Overview

High voltage and impulse test on industrial pipeline is the project that involves in Final Year Project on. The industrial pipeline is the largest process plant and most sophisticated structures that be protected by lightning. In other hand, industrial pipeline are closely related to the lifelines of complete regions and sometimes entire countries. Special measures must be taken to insure the reliability, the quality and the efficiency of this peculiar industry. The repair costs for replacing damaged are much higher than those of installing devices.

In this project will be described to analyze the breakdown voltage of the spark gap discharge that has been tested by prototype of pipeline using between stainless steel pipe and stainless steel plate. This project had been completely by tested with high voltage testing which is AC, DC and Impulse voltage.

The knowledge of the discharge developments which precede a prospective flashover in air is the basis for the identification of the withstand characteristics of air insulation. Therefore, such knowledge can also be the basis for the design of external insulation of high voltage apparatus by dimensioning its pipe termination and clearances.

Figure 1.1 shows the prototype of pipeline which is the equipment has been used for the testing. The equipment that used for testing constitute stainless steel pipe type 304, length one meter, outer diameter is four inches, thickness 3.05mm, and also IIR Rubber for insulator. Stainless steel plate also been used which is length one meter and be grounded. For the insulator used PVC at the bottom of the stainless steel plate. The experimental work has been testing to carried out with based on difference of distance between stainless steel pipe and plate namely 1.0cm, 1.5cm, 2.0cm, 2.5cm, 3.0cm and analyze the breakdown voltage of spark gap discharge in that gap ranging. In this experimental work, air breakdown as a media of insulation has been used.

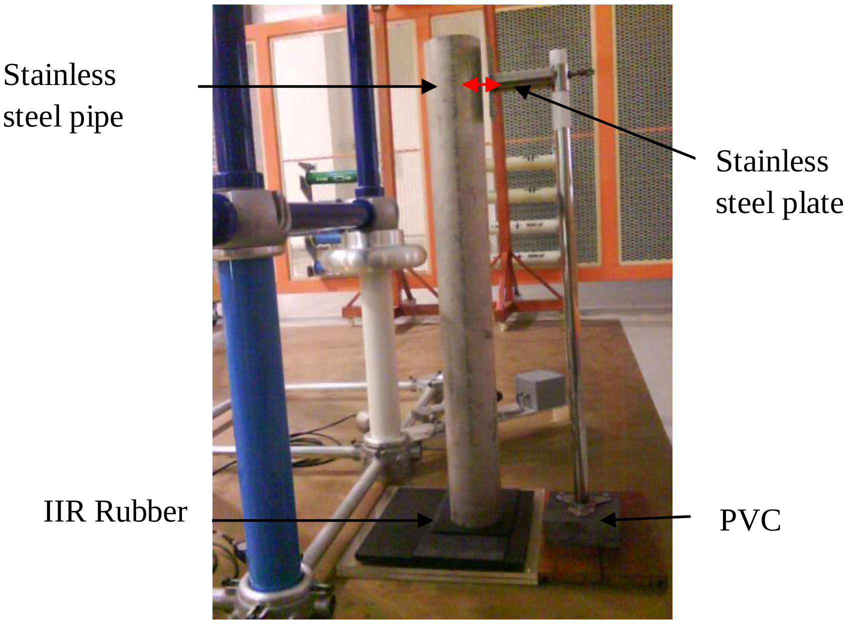

Figure 1.1: Equipment of the experimental work

1.2 Problem Statement

Historically, lightning has been known to split trees and blow holes in the ground. Besides, it also wipes out all types of computers, electronic devices and destroys electric utility equipment causing major blackouts. Lightning can cause structural damage to building and communication systems. It also destroys electrical utility equipments causing major blackouts and damage pipe on industrial pipeline that can cause fires. From the observation, the damage of equipment caused not come from supply but it also can from lightning flashover. Direct lightning strikes are really a threat for industrial pipeline. Besides, lightning flashover does not have exactly safety statement on industrial pipeline. Lightning will be strike and flow to the ground and also to the equipment that has low earthing resistance. It will affect the behavior of pipeline and other equipment.

1.3 Objectives of the Project

There are four objectives for fulfill in this project:

i. To study about lightning flashover effect in pipeline industrial. The industrial pipeline is the process plants belong to the largest and most sophisticated structures to be protected against lightning.
ii. To study about air breakdown which is media of insulation had been used.
iii. To investigate breakdown voltage of the spark gap discharge.
iv. To design a prototype of pipeline where used a stainless steel pipe and stainless steel plate for the experiment.

1.4 Scopes of the Project

To achieve the objective of the project, this is scopes of the project as a guideline:

i. Study about high voltage and impulse experiment for the flashover phenomena based on the theoretical which has related to the air breakdown.
ii. Analyze the air breakdown which is that media of insulation to be used.
iii. Using the stainless steel pipe and stainless steel plate that be used in chemical industrial because protected it from corrosion and stress.
iv. Analyze safety gap discharge with gap ranging 1.0 cm, 1.5 cm, 2.0 cm, 2.5 cm and 3.0 cm.
v. Use AC, DC and Impulse voltage for the testing.

1.5 Project Outline

The Final Year Report is organized into seven chapters and one appendix. Each chapter begins with an introduction describing the topics students will encounter and close with summary. Chapter 1 is an introduction that consists of a brief overview of the project and problem statement for why should did the project that entitled High Voltage and

Impulse Test in Industrial Pipeline. Included is objectives for fulfill in this project and scopes of the project as a guideline to achieve the objectives of the project.

Chapter 2 reviews about high voltage testing which is generation and measurement of AC, DC and Impulse voltage. From this chapter shown how to generate and measure high voltage testing. Chapter 3 discusses about conduction and breakdown in air. The principal media of insulation has been used in this project is air. In this chapter also covers about flashover on industrial pipeline. The case study about lightning flashover incident that occur at Johor Port, Pasir Gudang also includes in this chapter.

Chapter 4 covers methodology for development of the project and explains all five phases that contain in flow of the project in order to all works movement according to the plan. Test circuit and arrangement also contains in this chapter which is explaining the flow of the procedure the experimental work subjected to AC, DC and Impulse voltage testing.

Chapter 5 presents the result of the breakdown voltage that obtained from the experimental work. The result had been fill in the table which is can show the result more clearly. There are had eight result of the breakdown voltage in gap ranging from 1.0cm, to 3.0 cm which is for AC testing at the top and middle of the pipe. For DC testing had been testing at two conditions which are DC positive and DC negative and also for Impulse testing in two conditions positive and negative. Before that, for the impulse testing, the breakdown voltage at the sphere gap had measured first in two conditions positive and negative.

Chapter 6 discusses about the analysis and discussion of the result. The result will be showed with graph to analysis or compared with the previous journal. At the Chapter 7 covers about conclusion of this Final Year Project report that the objectives of this project had been achieved and the recommendation can be made to upgrade for future works.

Appendix A shows the wave of the breakdown voltage that obtained from the oscilloscope and measuring equipment.

CHAPTER 2

HIGH VOLTAGE TESTING

2.1 Introduction

High voltage testing is according to ANSI/IEEE Standard 100-1984 which is test that consists of the application the voltage higher than the rated voltage for the purpose to determine the adequacy against breakdown of insulating materials and spacings under normal conditions [1].

In other words, high voltage testing is any test done where the electric field gradient (stress) is sufficient to test and evaluate the properties of the insulation system in the performance of the device [1].

In the fields of electrical engineering and applied physics, high voltages of all types, namely AC, DC and Impulse are required for several applications. The generation of high voltages in a high voltage laboratory is required for the purpose of testing various types of power system equipment.

2.2 Generation of High AC Voltage

High alternating voltage AC are required for experiments and AC tests as well as a supply for most of the circuits to generate high direct (DC) or impulse voltage. The circuit of AC was shown at Figure 2.1. Test transformers generally used for this purpose have considerably lower power rating and frequently much larger transformation ratios than power transformers. The primary winding is usually supplied by regulating transformers fed from the main supply. Most testing with high AC voltage requires precise knowledge of the value of the voltage. This demand can normally only be fulfilled by measurement of the voltage on the high voltage side.

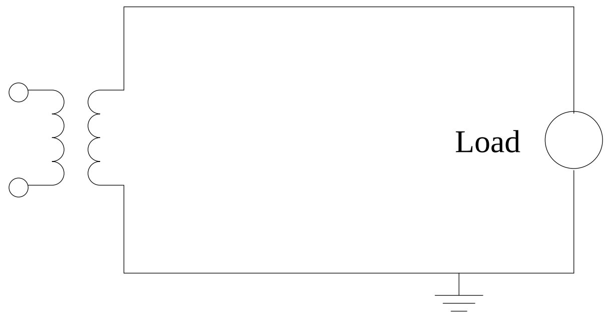

Figure 2.1: AC circuit

When test voltage requirements are less than 300kV, a single transformer can be used for test purposes. The impedance of the transformer should be generally less than 5% and must be capable of giving the short circuit current for one minute or more depending on the design [2].

The most common method of high AC voltage generation is using step-up test transformers. The test transformers mainly used to provide high AC voltages for various AC tests such as withstand flashover as well as partial discharge tests.

2.3 Measurement of AC High Voltage

Measurement with capacitive dividers is methods available for measuring high AC voltages. The incorporation of an oscilloscope in some of the measurement techniques makes it possible to view the waveshapes.

The errors due to the harmonics voltages can be eliminated by the use of capacitive voltage dividers with an electrostatic voltmeter or a high impedance meter such as an oscilloscope. If the meter is connected through a long cable, its capacitance has to be taken into account in calibration. Figure 2.2 shows the measurement using capacitive divider and the applied voltage V_1 is given by

$$V_1 = V_2 \left[\frac{C_1 + C_2 + C_m}{C_1}\right] \quad (2.1)$$

Where C_m is the capacitance of the meter and the connecting cable and the leads and V_2 is the meter reading.

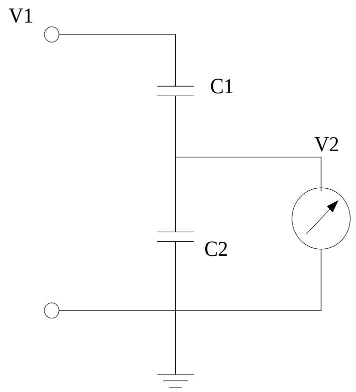

Figure 2.2: Measurement using capacitive divider

2.4 Generation of High DC Voltage

Generation of high DC voltages is required in research work in the areas of pure and applied physics, insulation tests [2]. Because of the diversity in the application of DC high voltages, ranging from basic physics experiments to industrial applications, the requirements on the output voltage will vary accordingly. A detailed understanding of various types of generating circuits based on the AC to DC conversion is emphasized. The rectification of alternating currents is the most efficient means of obtaining high voltage DC supplies.

The DC test voltage is defined as the arithmetic mean value between the highest and lowest level within a period:

$$U_{DC} = \frac{1}{T}\int_0^T u\,(t)dt \quad (2.2)$$

Periodic fluctuations of the direct voltage between the peak value Umax and the minimum value are given in terms of ripple amplitude:

$$\partial U = \frac{1}{2}(U_{max} - U_{min}) \quad (2.3)$$

The ripple is influenced by the load current, frequency and the smoothing capacitance.

For the DC configuration is realized with a half-wave rectifier circuit. Figure 2.3 shows half-wave rectifier. In the half wave rectifier, the capacitor is charged to V_{max}, the minimum AC voltage of the secondary of the high voltage transformer in the conducting half cycle. In the other half cycle, the capacitor is discharged into the load. The rectifier valve must have a peak inverse rating of at least $2V_{max}$ [2].

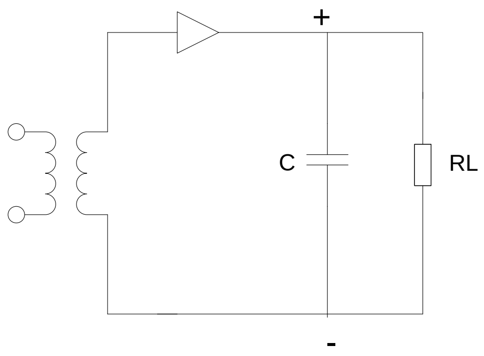

Figure 2.3: Half wave rectifier

For high voltage test circuits, a sudden voltage breakdown at the load (R_L nearing to 0) must always be taken into account. The rectifiers should be able to carry either the excessive currents, which can be limited by fast, electronically controlled switching devices at the transformer input or can be protected by an additional resistance inserted in the high voltage circuit.

2.5 Measurement of DC High Voltage

Measurement of high DC voltages in low voltage measurement generally accomplished by extension of meter range with a large series resistance. The net current in the meter is usually limited from one to ten microamperes for full-scale deflection. A resistance voltage divider with an electrostatic or high impedance voltmeter shows in

Figure 2.4. The influence of temperature and voltage on the elements is eliminated in the voltage divider arrangement. The high voltage magnitude is given by expression:

$$V_{hv} = \frac{R_1 + R_2}{R_1} V_2 \qquad (2.4)$$

Where V_2 is the DC voltage across the low voltage arm R_2.

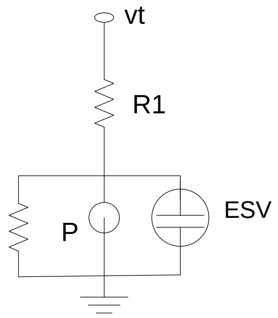

Figure 2.4: Resistance potential divider

2.6 Generation of High Impulse Voltage

Impulse voltages are required in high voltage tests to simulate the stresses due to external and internal overvoltages and also for fundamental investigations of the breakdown mechanism. It is usually generated by discharging high-voltage capacitors through switching onto a network of resistors and capacitors whereby multiplier circuits are often used [3].

In high voltage technology, a single unipolar voltage pulse is termed an impulse voltage. For testing purposes, double exponential impulse voltages have been standardized without appreciable oscillation these rapidly reach a maximum, the peak value U_{peak} and finally drop less abruptly to zero. If an intentional or unintentional breakdown occurs in the high voltage circuit during the impulse, leading to a sudden collapse of the voltage and this is called a chopped impulse voltage. The chopping can occur on the front at the peak or in the tail section of the impulse.

For overvoltages following lightning strokes, the time required to reach the peak value is in the order of 1µs are named atmospheric or external overvoltages. Voltage generated in a laboratory to simulate these is called lightning impulse voltage (LI) [3]. The peak value of impulse voltages can be determined with the aid of measuring gaps or better be measured by electronic circuits combined with voltage dividers. The most important measuring device for impulse voltage is the cathode ray oscilloscope which allows the complete time characteristics of the voltage to be determined by means of voltage dividers.

For impulse testing, special wave forms must be generated to approximate the expected impulse (surge) voltages that are likely to stress high voltage equipment. Figure 2.5 shows the wave shapes for lightning impulse voltage which is determined by certain time parameters for the front and tail. Since the true shape of the front of lightning impulse voltages is often difficult to measure, the straight line O_1S_1 through the point A and B is introduced as an auxiliary construction on the front, to characterize the latter. Then, the time T_s to front, as well as the time T_r to haif value being the time from O_1 to the point C are also determined [IEC Publ. 60-1 (1989)]. Lightning impulse voltages of shape 1.2/50 are generally used which means an impulse voltage with T_s = 1.2µs ± 30% and T_r = 50µs ± 20%.

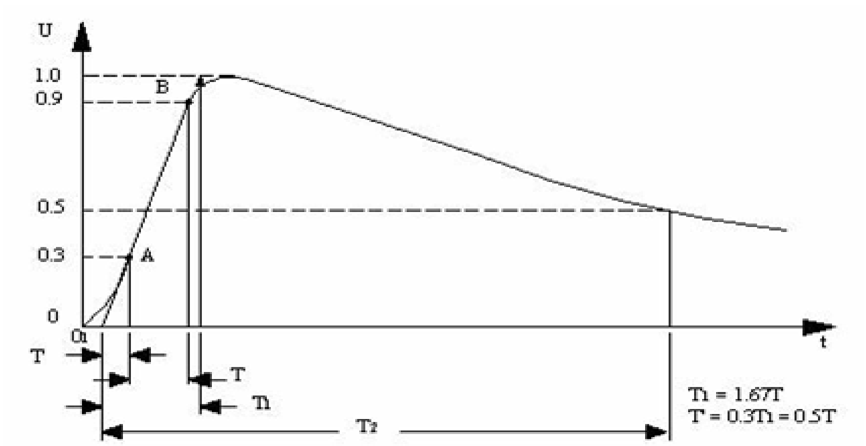

Figure 2.5: Wave shape for lightning impulse voltage

Figure 2.6 shows the single stage impulse generator which is the simple discharge circuit where the initial charge on C_1 of V_o is discharged into the test circuit by the breakdown of an air gap G. R_1 and R_2 are the front and tail wave shaping resistors and C_2 is the object under test [1].