" I hereby declare that I have read through this report entitle Experimental Study On Grounding Rod Installation Using Galvanized Iron and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Industrial Power)"

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EXPERIMENTAL STUDY ON GROUNDING ROD INSTALLATION USING GALVANIZED IRON

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A report submitted in partial fulfillment of the requirement for the degree of Bachelor of Industrial Power (BEKP)

Faculty of Electrical Engineering

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2015

I declare that this report entitle Experimental Study On Grounding Rod Installation Using Galvanized Iron 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.

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To my beloved wife and kids

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ABSTRACT

On the electrical installation, grounding is considered part of the installation. In other words, if the grounding was not included in the electrical installation, the installation will be considered as a failure and will not be allowed to be used. Normally, grounding system either for final circuit or lightning protection, copper will be used as the grounding material. In this project, the objective is to propose galvanized iron rod as a new grounding rod to replace copper. However, the galvanized iron rod buried into the ground is buried accordingly to a specific pattern. The pattern proposed for the galvanized iron rod was considering lot of factor such as no of loops, current carrying capacities and ground space. During the project conducted, the experiment has to face the typical weather of Malaysia with heavy rain and hot sunny day. Due to environment changes, the proposed grounding rod has experienced data fluctuation. Several methods were used in the analysis of the project and thus the data elaborated. Finally, the conclusion towards the galvanized iron rod as a new grounding method is made.

ABSTRAK

Di dalam sesebuah pendawaian elektrik, sistem pembumian dianggap sebagai salah satu cabang pendawaian elektrik. Sekiranya sesuatu sistem pembumian tersebut tidak memenuhi syarat yang ditetapkan, pendawaian elektrik tersebut dikira gagal dan keseluruhan pemasangan tersebut tidak boleh digunakan. Pada kebiasaanya, sistem pembumian samada untuk litar akhir mahupun sistem perlindungan kilat akan menggunakan tembaga sebagai sistem pembumiaan. Di dalam projek ini, besi tergalvani digunakan sebagai salah satu sistem pembumiaan. Walau bagaimanapun, besi tergalvani yang ditanam kedalam tanah adalah mengikut corak khas yang telah ditentukan. Corak khas ytang ditentukan tersebut telah mengambil kira pelbagai faktor seperti bilangan gelung, kemampuan membawa arus dan keluasan tempat pembumiaan. Sepanjang projek dijalankan, eksperimen ke atas sistem pembumiaan tersebut telah berdepan dengan cuaca Malaysia yang tidak menentu seperti hujan lebat dan panas terik. Berikutan perubahan cuaca tersebut, sistem pembumian tersebut telah menghasilkan data yang tidak seimbang. Beberapa kaedah telah digunakan didalam menganalisa data yang diperolehi dan data-data tersebut telah rungkaikan. Akhirnya, kesimpulan telah dibuat terhadap sistem pembumiaan yang menggunakan besi tergalvani.

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CHAPTER 1

INTRODUCTION

1.1 Project Background

Electrical installation can be known in plenty of type. However, the most common and used electrical installation is single phase installation that carry 230V with tolerance of ±10% and three phase installation that consumes 400V with the same tolerance. The range of installation with 230/400V is basically known as low voltage (LV) installation. In real scenario, there was several more type of installation and transmission applied in Malaysia [1]. Table 1.1 shows the type of transmission and installation in Malaysia.

Table 1.1 : Table of type of transmission and installation in Malaysia

Type of	Rated Voltage
Extra Low Voltage (ELV)	< 230V
Low Voltage (LV)	Up to 100V
Medium Voltage (MV)	6.6KV to 66KV
High Voltage (HV)	132KV up to 275KV
Extra High Voltage (EHV)	500KV up to 1000KV
Ultra High Voltage (UHV)	1000KV and above

In all installation, a proper protection device and apparatus was determined to protect and to make sure the installation is safe to be used. Besides, the protection device is also to prevent injuries and losses towards the personal and properties. Grounding is also part of the protection in the electrical installation.

A proper grounding installation is needed to make sure any over current or short circuit that may occur in the installation has been grounded safely. According to the Energy Commission of Malaysia (ST), the safe value or the ideal value of earth electrode resistance in every residential electrical installation must be less than 10Ω [2]. The lowest value of the earth electrode resistance will be much better where the grounding is able to spread the over current or the short circuit current throughout the ground smoothly. In electrical supply system, grounding system defines the electrical potential of the conductors relative to that of the Earth's conductive surface. The choice of grounding system has implications for the safety and electromagnetic compatibility of the power supply.

In Malaysia, all the grounding system must be tested and certified before it is been used. In Malaysia, the authority body that responsible to certify the grounding material is Standards and Industrial Research Institute of Malaysia (SIRIM). The whole system including the rod, tape, clamp and other material related will be tested accordingly to the IEC 60363 standard. The system that fulfill the requirement of the IEC standard will then been approved by Standards and Industrial Research Institute of Malaysia (SIRIM) to be used in the installation.

A functional earth connection serves a purpose other than providing protection against electrical shock. In contrast to a protective earth connection, a functional earth connection may carry a current during the normal operation of a device. Functional earth connections may be required by devices such as surge suppression and electromagnetic-compatibility filters, some types of antennas and various measurement instruments. Generally the protective earth is also used as a functional earth, though this requires care in some situations.

The contact between the installation and the ground is basically by using a solid rod buried onto the ground. The solid rod used to be buried onto the ground basically are copper, aluminum, mild steel or galvanized iron depending on the soil sensitivity and the electrical installation and as long as below 10Ω. The best and the most chosen rod to be buried onto the ground is copper, because of the highest capability on conducting the current among the rest. By its capability, copper current carrying capacity is high in order to transmit the overcurrent from the installation to the ground hence protecting the installation from facing damages or loses. In some scenario, although the best rod has been used, the resistance value was found still above the recommended value. This might been cause by the soil humidity and the soil sensitivity. In order to cater the situation, lots of solution can be implemente such as adding some natrium chloride to the ground or installing more than one rod in parallel connection to make sure the grounding comply with the requirement needed.

A good grounding system is very important. Besides saving life, a good grounding system shows the maturity of the project and the reliability of the engineer in designing the system. However, in today scenario, grounding has been seen as a part of the installation and can be designed at the end of the process. In other word, grounding system has been paid less attention compared to other system such as lighting, switchboard and generators.

1.2 Project Motivation

The motivation of the project is to propose the current used rod for the grounding system to a new grounding rod. The common used grounding rod in the system is copper and the project proposed the galvanized iron as a new grounding rod. However, due to current carrying capacity of the galvanized iron which is lower than the copper, the project proposed to identify the best grounding patterns of galvanized iron grounding rod in order to meet the best value nearly, equally or less from the copper grounding rod. The use of galvanized iron in replacing the copper as the grounding rod is due to the increase cases of loses copper rod install as a grounding rod in the project. Besides, the price of the copper rod that keeps on increase from time to time has make the different of five times copper prices compares to the galvanized iron. With the best patterns of galvanized iron and the best value of earth electrode resistance to be met, the project is believe to minimize the situation of copper rod stealing and the project is also believe can reduce the cost of grounding system installation.

1.3 Problem Statement

It cannot be denied that in the grounding process, copper is a big name in the grounding scenario due to its low resistance characteristic that will allow a maximum leakage or over current to flow through it and straight to the ground. By referring to this advantage, lots of engineer, designer and consultant prefer to have copper as their final decision to fulfill the grounding system. Starting from lightning arrester located on the top of the building, copper tape as a connection path until the copper rod that was buried on the ground, copper will be widely used in the system. This clearly proven that copper was a metal that is believed to have good current carrying capacities that will provide a good grounding system in a building.

However, in today economics scenario with a hike of a fossil fuel prices, copper price is look to be not so friendly to the industry. With that, instead of installing a pure copper to the system, the manufacturer has come out with a new solution that only apply a copper bonded coating to the metal by the purposes of reducing the cost. With that, a copper rod performance will not be the same as before since the only thing that can be consider copper is a thin layer of coating on metal. The efficiency of the copper has degraded in terms of current carrying capacity and this will also cause the resistivity of the copper to increase.

Another issue that always been faced involving a copper material in the construction scenario is upon after installation. By a studies done, slightly forty percent (40%) of copper material that usually involving copper rods and copper tape were being stolen after the installation [3]. The problem usually occurs during the defect liability period (DLP) where the building is still under warranty of the developer and contractor. When this scenario happened, the responsibility to replace the stolen parts usually goes to the developer or contractor and this will caused losses to the project. The reason of the copper is always been stolen is because the price of the copper that can be considered valuable compare to other material such as steel and metal.

With that, the project conducted was basically to replace and to reduce the usage of copper material in a construction to help reducing the non-return cost due to efficiency and criminality. The usage of galvanized iron with a special coated chemical to prevent rusty is used as a grounding rod with a specific pattern to be buried into the ground as to fulfill the grounding requirement.

1.4 Project Objective

The project consists of three main objectives to be achieved. The objectives are;

i. To compare the effect of different installation material between copper and galvanized iron (GI).
ii. To investigate the effect of different installation technique (pattern) on galvanized iron (GI) rod.
iii. To determine the best installation technique (pattern) of galvanized iron (GI) that gave the lowest resistivity value.

1.5 Project Scope

i. The project conducted is to identify the installation technique (pattern) that gave the lowest resistivity value by using galvanized iron (GI) rod as a grounding conductor
ii. The project will only focus on 3 different installation technique (pattern) to be buried into the ground by using galvanized iron (GI) rod (1.5 meter long each) as a grounding conductor
iii. The project will also bury six copper rods (1.5 meter long each) as a grounding conductor and the copper rod will be connected in series connection as a bench mark. The result between copper and galvanized iron thus will be compare.
iv. The project will be conducted on thirty days.

v. The project will collect thirty (30) readings (data) for every installation technique of galvanized iron (GI) rod and will also collect thirty (30) reading (data) from copper rod installation.

vi. The result on the testing will be measure by using Megger Digital Earth Tester

vii. All the reading (data) will be recorded and analyze by using a software.

1.6 Report Outline

Chapter 1 in this report briefly explained on the background and overview on the electrical network system in Malaysia. Besides, the introduction also touched on the grounding method and requirement to be fulfilled when the installation was conducted. In this chapter also, the problem statement and the project motivation that drive the project to be conducted was revealed. Objective and the project scope also were being determined in this chapter to become as guidance and it is also to set a fixed parameter once the project have started. It is also to make the project to be easier to understand and to be more friendly towards the supervisor, panel and others researcher in future.

Literature review or previous project research was been defined in Chapter 2. The purpose of the literature review is to identify and to be really understood on the project that will be conducted. However in the previous project research, the main criteria that was been paid attention is about the factor and the reason that can influence the grounding system. Instead of finding the root cause to enhance and to improve the current grounding system, it is also to verify either there is any project in previous that have been conducted before is similar or same towards the project that will be conducted by our side. From the literature review, it develops the knowledge on grounding system and it is also as a guidance to prevent and to defend from the factor that may cause the project to face a failure. There are approximately more than five (5) previous projects that have been studied in the literature review.

Chapter 3 in the report is explaining on the methodology of the project. In this chapter it's defined on the material used, tools and equipment, installation and data collection process. In this chapter also, the methodology procedure that will be used as a first level document was been identified. Instead of that, the experiment procedure also is been identified to show and to guide along the experiment was been conducted. All the procedure is being transposed in a simple flow chart system to make it friendlier to be understood. Methodology of the project basically is the important part in each project as it is used as reference step in conducting the project hence it is compulsory to follow all the methodology that have been identified to make sure the successful of the project.

Result and data gained in the project conducted is shown in Chapter 4. In this chapter, the data of the grounding will be tabled and analyzed to compare the effectiveness between the grounding methods. All thirty collected data for the whole thirty day is been presented in chart and analysis of the data is been shown and prove to identified the most compatible grounding method to be used.

The final chapter in this report is Chapter five where in this chapter all the conclusion of the project will be conclude. In this chapter, the result of the project is been discussed and the best pattern of galvanized iron rod grounding is been identified. The different value of the resistance in each patterns and grounding system is justified. Suggestion was been made and a recommendation on a future planning work is been identified to make an improvement towards the grounding system.

CHAPTER 2

LITERATURE REVIEW

2.1 Basic Principles

In electrical term, grounding refers to the reference point in an electrical circuit from which voltages are measured, a common return path for electric current, or a direct physical connection to the Earth. Electrical circuits may be connected to ground for several reasons. In mains powered equipment, exposed metal parts are connected to ground to prevent user contact with dangerous voltage if electrical insulation fails. Connections to ground limit the build-up of static electricity when handling flammable products or electrostatic-sensitive devices. For measurement purposes, the Earth serves as a reasonably constant potential reference against which other potentials can be measured. An electrical ground system should have an appropriate current-carrying capability to serve as an adequate zero-voltage reference level.

In the normal grounding system, all system and equipment of grounding shall comply with Electricity Regulations 1994 and relevant parts of IEC 60364. All protective conductors should be of high conductivity copper conductor either stranded or solid, continuous throughout the whole lengths and without joints, except by means of approved mechanical clamps to maintain and to make sure on the continuity. Before connecting the protective conductor, the metal works, the conductors and the metal work with the paint of contact, including the clamps, should be thoroughly cleaned of surface corrosion or paint and tinned to ensure that good electrical contact is made. Every circuit either in a switchboard, distribution board, control board and tap-off units, all lighting points, lighting switches, fan points, fan switches, three pin switched or un-switched socket-outlets or power point should be provided with circuit protective conductors and thus connected to the grounding terminal. All exposed conductive parts and extraneous conductive parts shall be effectively bonded to earth.

Usually, before installing the rod to the ground, a simple test will be conducted to measure the resistivity of the soil. By using a special meter, a value of ground resistance can be known just by injecting the probe to the ground. This process will make the grounding system become easier as the possible grounding value of the soil can be determined earlier before burying the rod. In normal scenario, the grounding rod will has to be buried first onto the ground thus the measurement of the soil later is been measured. Normally, if the result of the measurement gained is exceeding 10Ω, another rod will be buried onto the ground and parallel connection will be done towards the first rod and the second rod. If still the results gained after the second rods is been buried is still exceeding 10Ω, a third rod will be install and the same process will follow. If the value is still remains, the whole rod will be pulled out from the ground and a new spot for the purpose of grounding will be determined. A good grounding system will able to transmit and to carries any overcurrent that may occur in an installation straight to the ground in a short time period. With that, the overcurrent will be grounded and the grounding system will not allow the overcurrent to make a return to the installation that may harm the electrical apparatus and human [1].

2.2 Related Previous Works

2.2.1 Research on alternatives to copper grounding in sites requiring cathodic protection[4]

Research by Earl L. Kirkpatrick from Institute of National Association of Corrosion Engineers New York on September 1986 investigate the disagreement between the cathodic protection engineers and the power or grounding engineers on electrical isolation and common bonding of metallic structure to massive copper grounding grids or networks. According to cathodic protection engineers, it is believe that the copper grounding method causes severe corrosion problems for connected ferrous structure. Copper is cathodic to other materials of construction and by eliminating of copper grounding it can extend the life of the other commonly grounded underground structures. The problem occurs due to the corrosion engineer's lack of effective communication with other engineering disciplines thus the galvanic corrosion and cathodic protection (CP) have not been, effectively explained to engineers in the power industry. It is found that when protecting a short, isolated, well-coated and small diameter pipeline that has been effective electrically insulating fitting at the end, the structure become larger and more complex, current requirements increase.

The conflict of the research shows copper steel couples greatly accelerates the corrosion rate of the commonly bonded steel elements when CP is not applied. This scenario frequently happen before the piping plants operates, particularly when CP was not implemented in the early stages of the project. Corrosion control design requirement are adversely impacted by the excessive current requirements necessary to effectively polarize a copper cathode.

As for the conclusion, an alternative for grounding method was introduced. A suggestion on using of stainless steel ground rod, sacrificial anodes in cast, rod or ribbon shape, rebar or iron rod in concrete, galvanized steel ground rod and cables, as ewll as the use of cathodically protected less noble metals such as iron and steel. Another method of grounding was also been introduced such as;

i) Compressor station

- A design of zinc electrode grounding system with neoprene insulated connecting cable for pipeline compressor *ii)* *Utility pier foundations*

- Pier diameters ranged from 2.5 to 7.5 ft and 10 to 85 ft in length. Clearly by using the pier, there is a little grounding benefit from providing the copper grounding under the poured pier. Figure 2.1 show the construction of utility pole pier footong diagram.

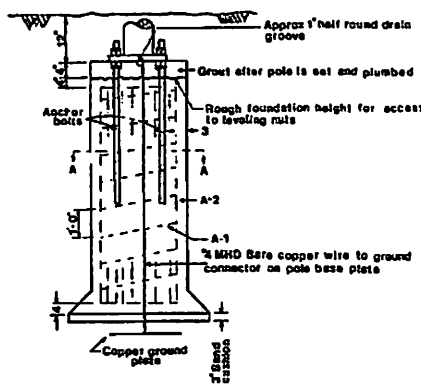

Figure 2.1 : Utility pole pier footing [4]

iii) *Foundation grade beam*

- Steel below grade that is completely encapsulated in chloride free concrete may be expected to perform satisfactorily for long period of time.

iv) *Substation grounding grid*

- Galvanized steel ground rods supplemented by CP have long been employed by the Rural Electrification Administration (RIA) and others. More recently, entire grounding grids have been fabricated from galvanized steel rods and cable.