REFOCUSING OF ELECTRICAL SAFETY PRACTICES IN MALAYSIA, CONSIDERING UNCONTROLLED AND CONTROLLED PARAMETERS

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To my beloved husband, mother and family

for their encouragement, blessing and inspiration…

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ABSTRACT

This project examines the issue of electrical safety and the regulatory inspection system currently practiced in Malaysia. There are controlled parameters should be considered in this electrical safety such as people, equipment and managing system itself. This project is concerned on three types of industry which are large (Panasonic, Pasir Gudang), medium (TNB, Johor Bahru) and small (Kedai Letrik Mohamad Lotfi, Kuala Pilah). Electrical safety is more than just the Arc Flash Hazard. Therefore, electrical safety needs to be a holistic approach that includes all aspects of electrical safety. This study attempts to identify the loopholes in electrical safety by surveying and visit those industries and then to focus attention on the items that need to be addressed to create on holistic approach to electrical safety. For uncontrolled parameter such as lightning we need to considered also in this project. Unfortunately the study of this lightning phenomenon is very difficult due to the fact that it doesn’t occur so frequently and cannot be controlled. Therefore, for the uncontrolled parameters the simulation with ATP-EMTP will be used to show how the effects of current/lightning to human being by using AC and impulse sources. This project concludes with analysis by accident reporting and identified the new technology methods to prevent them from injury.

ABSTRAK

Projek ini adalah untuk mengkaji isu-isu mengenai keselamatan elektrik dan sistem peraturan yang diamalkan di Malaysia. Terdapat parameter-parameter yang boleh dikawal dalam mengkaji keselamatan elektrik ini seperti pekerja, peralatan dan sistem pengurusan di industri itu sendiri. Kajian projek ini melibatkan tiga kategori industri iaitu industri besar (Panasonic, Pasir Gudang), industri sederhana (TNB Johor Bahru) dan industri kecil (Kedai Letrik Mohamad Lotfi, Kuala Pilah). Keselamatan elektrik bukan sekadar bahaya percikan arka. Oleh yang demikian, keselamatan elektrik perlu pendekatan yang lebih holistik yang merangkumi semua aspek keselamatan elektrik. Projek ini juga dapat mengenalpasti kelemahan dalam keselamatan elektrik yang diamalkan dengan menggunakan kaedah lawatan ke industri-industri yang terlibat dalam kajian ini dan perlu diberikan penekanan yang mendalam serta pendekatan yang sebaik mungkin bagi menangani kemalangan daripada berlaku. Bagi parameter yang tidak dapat dikawal seperti kilat, ianya juga perlu dikaji. Walau bagaimanapun, fenomena ini amat sukar untuk dikaji. Oleh yang demikian, simulasi komputer dengan menggunakan perisisan ATP-EMTP telah digunakan bagi tujuan ini untuk menunjukkan bagaimana kesan arus/kilat terhadap manusia melalui sumber bekalan arus ulangalik dan dedenyut. Projek ini diakhiri dengan analisis yang didapati dari laporan kemalangan serta menyarankan teknologi baru bagi melindungi pekerja-pekerja di industri dari terjebak dengan sebarang kemalangan elektrik.

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LIST OF SYMBOLS

SYMBOL	**DESCRIPTION**
Hz	Unit for frequency (hertz)
I_{AC}	Injected current with AC source
I_{imp}	Injected current with impulse source
I_{1F}	Current flow with one finger touching
I_{2F}	Current flow with two fingers touching
I_{3F}	Current flow with three fingers touching
I_{4F}	Current flow with four fingers touching
I_{5F}	Current flow with five fingers touching
m	1×10^{-3} (milli)
R_{1F}	Resistance for one finger touching
R_{2F}	Resistance for two fingers touching
R_{3F}	Resistance for three fingers touching
R_{4F}	Resistance for four fingers touching
R_{5F}	Resistance for five fingers touching
R_L	Leg resistance

GREEK SYMBOL	**DESCRIPTION**
μ	1×10^{-6} (micro)
Ω	Unit for resistance (ohm)

LIST OF ABBREVIATIONS

AP	Authorized Person
ATP – EMTP	Alternative Transient Program – Electromagnetic Transients Program
CIDB	Construction Industry Development Board
CP	Competent Person
CPR	Cardiopulmonary Resuscitation
DOE	Department of Engineering
DSM	Department of Standards Malaysia
EPPE	Electrical Personal Protective Equipment
ESD	Electrostatic Discharge
HV	High Voltage
IEC	International Electro-Technical Committee
ISO	International Standard Organization
LV	Low Voltage
NEC	National Electrical Code
NFPA	National Fire Protection Association
NIOSH	National Institute of Occupational Safety and Health
OSH	Occupation Safety and Health
OSHA	Occupational Safety and Health Administration
PAVCJM	Panasonic Audio Video Networks Johor Malaysia
PPE	Personal Protective Equipment
PTW	Permit to Work
SIRIM	Standard Industrial Research Institute Malaysia
TNB	Tenaga Nasional Berhad

CHAPTER 1

INTRODUCTION

1.1 Introduction

From the earliest introduction of electricity to the States of Malaya, electrical safety has been a concern for the regulator and increasingly for the public (Ir. H. P. Looi, 2003). As is the practice in most countries, regulatory measures to ensure electrical safety is embedded in the historical development of the electrical industry and plays a major role in the regulation of electrical safety. Principles of safety in electrical systems encompass two major issues:

a) Protection of persons; and

b) Protection of property (principally fire hazard).

Accordingly regulations in Malaysia take cognizant of the above by:

a) prescribing safe practice;

b) instituting a system of inspection and accident reporting; and

c) maintaining prescribed list of electrical equipment, contractors and installations.

This traditional approach where the regulator plays a dominant role in ensuring safety with rigid application of regulatory standards and procedures and punitive measures is increasingly being challenged. Current principles of 'Occupational Safety and Health' (OSH) where the public and purveyor of electrical systems and equipment are also being made responsible for electrical safety are being 'worked' into new model for electrical safety and regulation.

An electrical safety program is a plan designed so that neither workplace conditions, nor the action of people, expose personnel unnecessarily to electrical hazards. Employers should develop and implement an electrical safety program to give overall safety directions for facility activities related to electrical work. Effective electrical safety programs are a major key in preventing electrical incidents (Kim Eastwood, Danny Liggett, and Erling Hesla, 2002).

An electrical safety program are integrated with an overall safety and occupational health program. Good reasons for practicing electrical safety are:

1) Personal reasons – desire to return home healthy to family at the end of workday.
2) Business reasons – safety makes good business sense.
3) Regulatory and legal reasons – violations can result in fines and/or imprisonment.

There are five key objectives of an electrical safety program:

1) to instruct personnel concerning rules, responsibilities and procedures for working safely in an electrical environment;

2) to demonstrate the employer's intention to fully comply with all applicable laws;

3) to document general requirements and guidelines for providing workplace facilities that are free from unauthorized exposure to electrical hazards;

4) to document general requirements and guidelines that direct the activities of personnel who could be exposed to electrical hazards;

5) to encourage, and make it easier for, each employee to be responsible for his/her own electrical safety self-discipline.

The scope of the electrical safety program should address the needs of all employees, as well as contractors and visitors, at a facility. All parties shall be orientated with the program, and be very familiar with the parts that pertain to his/her own particular job assignments. The written program should include policy, requirements, responsibilities, and general guidelines. Specific, detailed procedures can be written in subdocuments and referred to in the program.

A complete electrical safety program should contain the following elements:

1) management commitment;
2) organizational support;
3) electrical safety policy;
   a) electrically safe facilities;
   b) documented safe electrical work practices;
4) training and qualification of all personnel;
5) use of protective equipment, testers, tools, and protective methods;
6) use of electrical equipment;
7) documentation;
8) oversight and auditing;
9) technical support;
10) emergency preparedness.

1.2 Objective

The objectives of this project are:

i) To focus of electrical safety on current practices in industries and refocus by defining on improvement by analyzing fault related issues and management dynamics.

ii) To model human being when they are touch in current/lightning by using ATP-EMTP software.

iii) To produce a electrical safety training aid to facilitate in training of personnel to be more awareness about safety.

1.3 Scope of Project

The scope of work for this project includes:

i) Study the currently practices of electrical safety for three types of industries which are large (Panasonic), medium (TNB) and small (Kedai Letrik Mohamad Lotfi).
ii) Analyzed data from the industries.
iii) Determined the advantages and the weakness of the practices.
iv) Compare the practices with the standard and regulation.
v) Simulation study by using human body model when they are touch in current/lightning with ATP-EMTP software.
vi) Produce a training aid to facilitate in training of personnel to be more awareness about safety.

1.4 Research Methodology

The research work is undertaken in the following stages:

i) Survey the practices in the industries by:
   a) Interview the person or officer in charged of the electrical safety.
   b) Questionnaire for the officers and workers.

ii) Site visit to focus of the electrical safety and what is currently being practices in the industries.

iii) Looking at the accident reported.

iv) Simulation study to show the effect to the human being.

1.5 Literature Review

This project is new. Therefore not much reference in Malaysia is related to this project. However there is some literature review is carried out on the current practice in maintenance and safety inspection to help me in completing this thesis.

1.5.1 Occupation Safety and Health (OSH)

The establishment and maintenance of a system of inspection and maintenance of safety standards for the electricity industry is a complex issue involving regulatory instruments, voluntary efforts and common practice. Traditionally, (before the term OSH became fashionable) public safety was maintained by strict application of punitive measures enforced by the law. This approach was one-sided and it was not found to be not effective. OSH recognizes that punitive actions and prescriptive regulations alone are not the answer to public safety and health,

a) The responsibilities for OSH lie also on the private sector and industry instead of just the regulator;

b) OSH legislation and regulations are therefore less prescriptive but more performance oriented;

c) The active involvement of industry and the private sector in OSH is encouraged both on voluntary and punitive programmed. The privatization of inspection officers (as oppose to the employment of fully government inspectors) can perhaps be listed as part of this procedure.

1.5.2 Active Measures

In Malaysia maintenance and safety inspection for the electrical industry include a mixture of punitive legislative measures and encouragement of voluntary efforts from industry. In line with the latest OSH trend, the involvement of private industry is expected to play an increasingly important part in OSH for the electrical industry. In Malaysia, maintenance and safety inspection can be categorized under the following broad categories:

a) **Maintenance Inspection** under "The Electricity Act" is mandatory for certain categories of industries where regular visits are made by independent licensed inspectors. Accident reporting as a mandatory statutory requirement under the responsibility of the inspector.

b) **Operation.** The safe operation of electrical installation are also covered under “The Electricity Act” which provides for the mandatory employment of competent persons qualified under the relevant grade of restriction. Accident reporting as a mandatory statutory requirement is also a function of the competent person responsible for maintaining the installation.

c) **Installation of new electrical installation** are covered by multiple laws which promote installation safety and standards:

i) “The Street, Drainage and Building Act” – all new structures or installation require submission of plans by competent persons, cross reference to the Engineers Act is also made. Under this Act registered engineers are also responsible for the maintenance of minimum safety standards (and in the near future energy efficient standards);

ii) “The Engineers Act” – registered engineers are name as qualified person eligible to submit plans;

iii) “The Electricity Act” – only registered wiring and/or electrical contractors are eligible to work on wiring/electrical installation;

iv) “The Electricity Act” – only qualified commissioning engineer and/or chargeman or wireman are eligible to test and endorse commissioning reports at their relevant competency level.

d) **Product Certification** supports the approval process listed above. Relevant agencies and laws are as follows:

i) The Electrical Department (Jabatan Elektrik) of the Energy Commission maintains a list of prescribed and approved items;

ii) In support of the prescribed list, SIRIM certifies electrical integrity and safety standards for approval. External or other foreign testing laboratories are also recognized by the Electrical Department;

iii) Apart from prescribed items, other items not on the prescribed list are subjected to certification standards demanded as a matter of procedure (especially in the construction industry);

iv) “The Standards of Malaysia Act” by its enactment confers certain legal status to standards adopted and published as Malaysian Standards. ISO/IEC standards by proxy therefore has legal status over other standards (if MS are not available).

1.5.3 Industry Participation

In line with current trends, the participation of the private sector in OSH legislation and procedures are increasingly becoming important. Concurrent with and reinforcing this trend include new paradigms shifts such energy efficiency, sustainable development and liberalization of the public sector. Some efforts in this include:

a) Standards Development

Despite and in spite of SIRIM and the DSM standard development and writing is a private sector driven initiative with DSM and SIRIM purely taking on the role of facilitator and record keeping.

b) Energy Efficiency

New legislative efforts in promoting energy efficiency are partly being driven by the private sector with the recognition that prescriptive and punitive regulations are not effective. Active consultation between industry and the regulators is an ongoing process.

c) Paradigm Shift in OSH for the Electrical Sector

Public consultation on a multitude of issues relating to OSH for the electrical sector is an ongoing process with perhaps a revision to “The Electricity Act’ and associated regulations, and the drafting of grid codes (for regulating the generation sector). This trend in public consultation has in recent times gained such momentum that government planners and legislator even co-opting the private sector participation in a multitude of issues including globalization, construction industry issues and sustainable development.

1.5.4 Industry Statistics

A quick preview of the electrical industry in Malaysia is shown in the following charts 1.1 to 1.2 (Ir. H. P. Looi, 2003) that shows statistics on accident reporting. The charts would seem to infer statistical rate (against total number of electrical consumers) as follows:

a) Electrical accident reports of about 1 to 100,000 per year; and

b) Rate of fire accident conclusively attributed to electrical fault of about 1 to 500,000 per year.

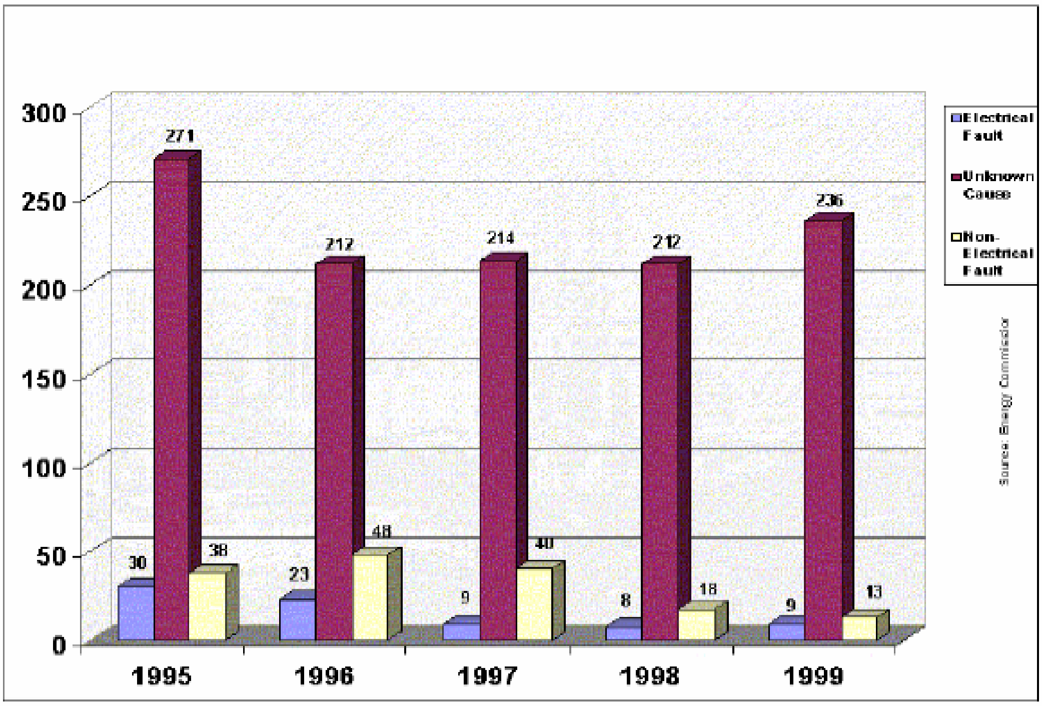


Chart 1.1: Number of Fire Accident Reported.

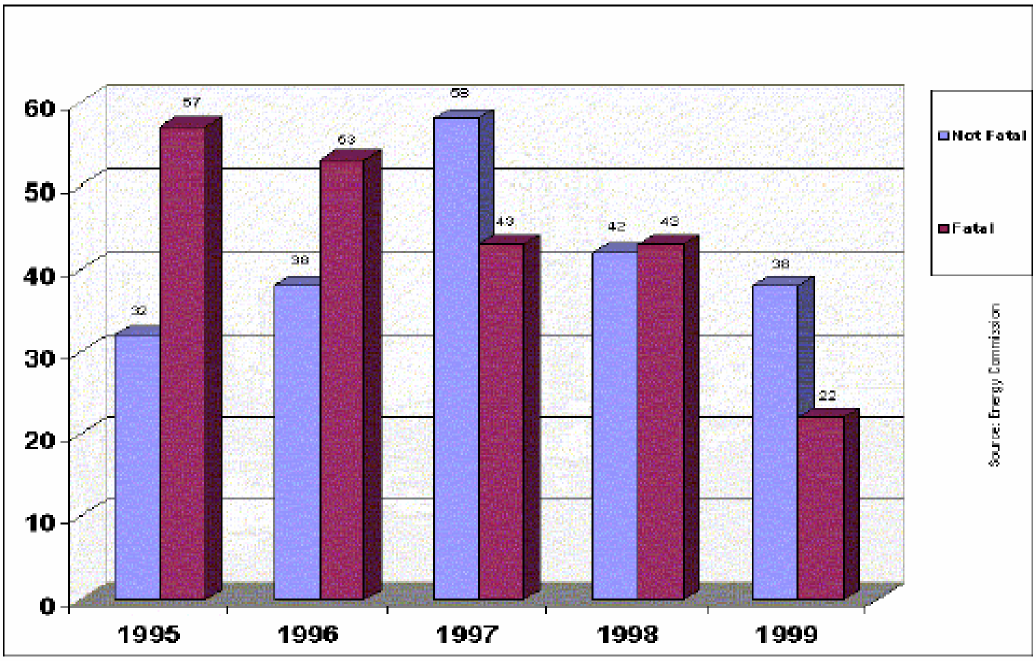


Chart 1.2: Number of Electrical Accidents Reported.

1.6 Structure and Layout of Thesis

This thesis is organized into five chapters. Chapter 1 gives the introduction to the project, stating its objective, scope of work, research methodology and overview. Chapter 2 mentioned the electrical safety must be addressed in a holistic manner to see the significant step change in improvement.

Chapter 3 discusses the result obtained from the surveying in the large, medium and small industry and continues with an analysis. Whilst in Chapter 4 the simulation is done by modeling the human being and to show the effect when they are touch in current/lightning. This is to facilitate in training of personnel to be more awareness about safety by using ATP-EMTP software. The thesis ends with Chapter 5, where the summary of this project is described. Recommendations for future work are also presented in this final chapter. Case study and training aid are also included in the appendix for employers and employees to be awareness about electrical safety.

CHAPTER 2

ELECTRICAL SAFETY

2.1 Introduction

Electricity is used to light our homes, drive our manufacturing facilities, provides us with entertainment and allows us to do more with the time given us. The use of electricity is dangerous and we have come to learn just how dangerous it is.

There are other aspects of electrical safety that are not being addressed. This can be seen not only in the way companies and people approach electrical safety but also in how national consensus standards are addressing electrical safety. Electrical safety must be addressed in a holistic manner (Danny Liggett, 2004).

Electrical safety has to be more than putting in personal protective equipment. If it is limited to just that then the electrical safety effort will not see the significant step change in improvement.

Electrical safety is a process of minimizing or eliminating the risk of incident or injury from electrical hazards. In order to do this electrical safety must have an approach that encompasses all of the factors that influences the outcome.

In Stephen Covey's book "The 7 Habits of Highly Effective People", (Steven Covey, 1989) he utilized a concept of three overlapping circles to show the need for three factors and the need for all three of them to overlap. This concept can be applied to the electrical safety.

Electrical safety can be breaking down into three categories which are **People**, **Equipment** and **Managing Systems** as shown in Figure 2.1. Each circle overlaps the others. The importance of the overlap is critical. The larger the overlap the greater effect each separate area has over the other areas and the overall impact will be more significant.

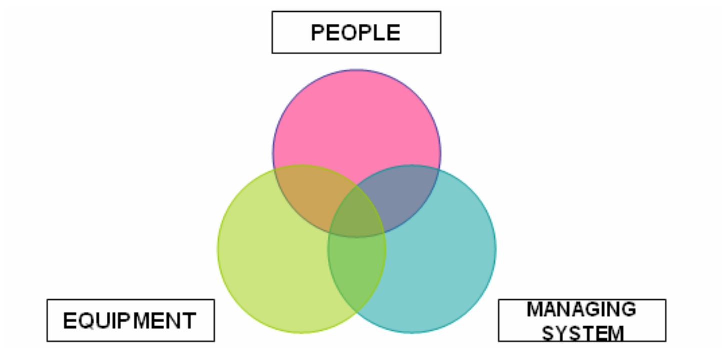


Figure 2.1: Electrical Safety Categories.

If a company has well trained people and strong managing systems but the equipment was old and not well maintained then there is still a potential for things to go wrong. Equipment fails. This is true especially if it is not maintained. Even though the people are well trained and there are procedures to deals with the equipment, incidents can occur. The intent of electrical safety is to eliminate the potential of electrical incidents from occurring.

This can be applied to other areas as well. If the equipment is new and well maintained, and the people are highly qualified, then the lack of strong managing systems leaves a void. Procedures will not be in place to guide the employees when working on or near energized electrical equipment. If the managing systems are strong and the equipment is new and well maintained but the people are not qualified then again the potential is high for incident or injury to occur. All three areas must be addressed in order for there to be a significant improvement.

Each of the areas can be broken down further. By doing this we begin to outline all of the items that need to be addressed in the pursuit of improving electrical safety.

2.2 People

Standard for Electrical Safety in the Workplace has requirements for a person to be qualified. One of the largest misconceptions regarding people is if a person is an electrician then the person is qualified. A qualified person can be defined as one who is:

- Knowledgeable of the construction and operation of the equipment to be worked on.
- Knowledgeable of the electrical hazards associated with the equipment and the task.
- Able to recognize when the electrical hazards are present.
- Able to avoid the hazards.

Another misconception is that electrical engineers and designers are qualified. Although the tasks of engineers may be different from electricians, when there is the potential for exposure to electrical hazards the same requirements for being qualified apply to them, as they do to electricians. Unless the engineer or designer meets the criteria for being qualified then they are not qualified. Basic knowledge of how electricity works does not make a person qualified nor does their title.

Training must be done with all people who interact with electrical equipment. The training must focus on the electrical equipment the person interacts with and the hazards associated with the equipment. Management personnel should be trained also. They must be aware of the electrical hazards that people are exposed to.

In Stephen Covey book (Steven Covey, 1989), specifically applied the circles to establish habits in people. By using the same circles we can apply this to establishing habits or analyzing behaviors in electrical safety. In Figure 2.2 the three circles show **Skill, Will** and **Knowledge**. Again the overlap is important.

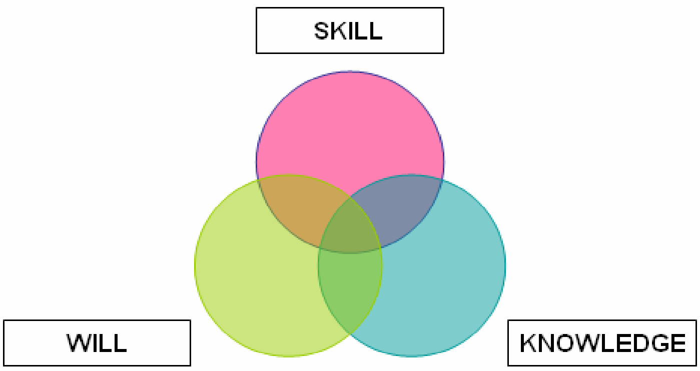


Figure 2.2: Habits in People

Skill is the ability to do something. Knowledge is knowing what to do. Will is the willingness to do it. Much attention is given to the skill level and the knowledge level of people in all occupations. The willingness to do the job comes in second. All three components must be addressed.

One area that specific training is needed in is Electrical Personal Protective Equipment (EPPE). Providing personnel with the EPPE is a good thing but training must accompany it. If personnel are not trained in its use and care then it will not be used correctly.

Electrical safety technology is advancing at a rapid rate. This rate of change is significant enough that classroom training knowledge of those providing the guidance on the job. Too many times this becomes the blind leading the blind. This is especially true if the supervisors have not received the appropriate electrical safety training.

Supervisors of electrical personnel are required to be trained. Many companies are streamlining their organizations by having electrical maintenance personnel report to non-electrical supervisors. This places a greater burden on the electrician. Unfortunately the requirement to train these supervisors is not being addressed adequately. Supervisors who do not understand the hazards of electricity cannot aid the electrician in planning hazardous tasks. This leaves the electrician to do what he/she has always done. It is imperative that management and supervisors understand the hazards of electricity in order to participate in the electrical safety process.

2.3 Equipment

Electrical equipment plays a role in the effectiveness of any electrical safety program or process. Electrical incidents and injuries occur when people interact with energized electrical equipment. As long as the two are kept apart electrical incidents and injuries of people usually don't occur.

Once again we can break down "equipment" further. In Figure 2.3 the circles show **Specification, Installation,** and **Maintenance.**

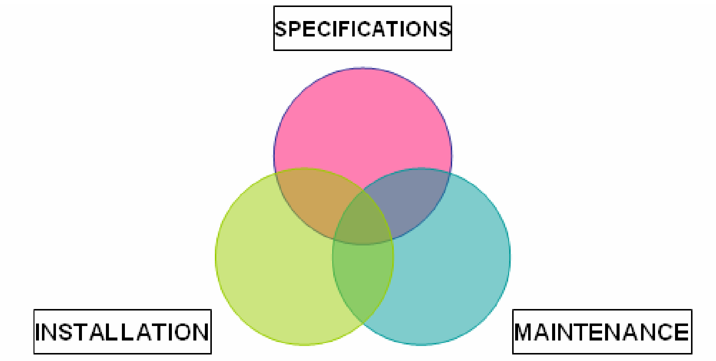


Figure 2.3: Component of the Equipment

The first link in providing a safer electrical environment is specifying equipment that contains inherently safer features (D. C. Mohla, L. B. McClung, and N.R. Rafferty, 1999). These safer aspects cost more and in today's economy the application of inherently safer designs may have to be mandated in order for their use to become widespread. Safer designs such as "touch safe" terminals are readily available but are not used widely enough. Many equipment manufacturers do not use them. Too many times manufacturers will say these safer designs are not requested. So the lack of demand prevents them from becoming main stream.

Installation of the electrical equipment is as important as specifying the right equipment. Relying on manufacturer installation requirements and the requirements in standards such are not enough. Companies must develop internal inspection processes for installations of electrical equipment to help assure the personnel to operate and maintain.

The integrity of the equipment is paramount. If the equipment has not been maintained then the probability of it failing is high. Electrical equipment can fail while in use without interaction from personnel but it is usually when people are interacting with the equipment that failures occur. Many companies are striving to reduce fixed cost to become more profitable. Equipment maintenance is one item that gets scrutiny each year and the amount of money allotted is consistently reduced.

Doughty, Epperly and Jones (1990) look at the financial aspects of electrical safety. Their conclusions on the cost impact of not providing a safe electrical environment are just as relevant today as they were sixteen years ago. One serious injury can wipe out of the financial gains made in several years' worth of the budget cutting in the maintenance of electrical equipment.

The purpose of most electrical equipment is to provide a method of safe interaction between people and electricity. Electrical equipment must be maintained so that the integrity of the equipment is safe for this interaction.

2.4 Managing Systems

Managing systems sets the parameters for people's actions. Within these systems is where most people will function. Voids in the managing systems leave those exposed to electrical hazards without guidance. Whenever there is a lack of guidance people will always fail back on their experiences and current knowledge.

Again we can break down Managing Systems further. In Figure 2.4 the circles show **Culture, Controls,** and **Procedures.**

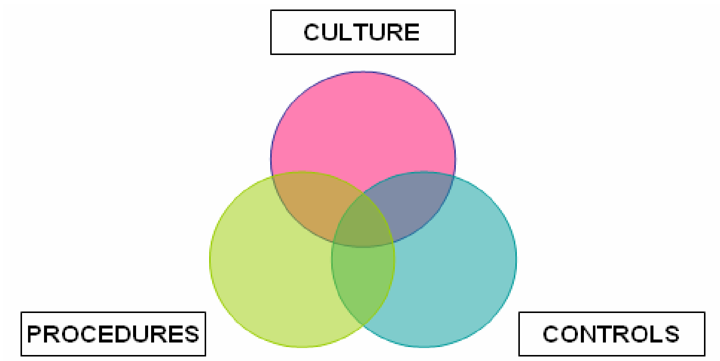


Figure 2.4: Components of the Managing Systems

Before there are any significant step changes in electrical safety there has to be a Culture that has value for electrical safety. The value management has for electrical safety has to be felt by the employees. It can not just be words in procedure or standards. One method for achieving this is active involvement in the electrical safety process by management.

Controls are those things we put in place to help assure that we are headed in the right direction, addressing the right things. If there is to be progress in electrical safety then an improvement process must be in place. For a company to understand what needs to be improved you must have some way of measuring where you are. Measuring the number of injuries and fatalities may not provide sufficient data to allow for an effective analysis. Understanding what is occurring within a company or a facility therefore become imperative. The paper How We Can Better Learn From Electrical Accidents, M. Capelli-Schellpfeffer, K. Eastwood, H.L Floyd, D.P.Liggett, (1998) can provide more information on how to gain a better understanding of the kinds of incidents that are occurring.

One important item that must be addressed is the definition of an electrical incident. Unless this step is taken the term will be interpreted differently by people based upon their motivation. In this thesis, the definition will be used. An electrical accident is an unusual event during which an injury occurred or had the potential to cause an injury as the result of exposure to an electrical hazard. An electrical shock is an electrical incident.

Controls also can be deciding to use inherently safer designs in all new installations or in overhauls. Exceptions to using these safer designs would have to be justified.

Ensuring personnel are qualified to perform tasks may be a principle but providing the training is a control. Before people can understand the concepts that may be outlined in the procedures and standards a company may have, they must first understand the basics of electrical safety.

Training cannot be a one shot deal. Electrical safety is changing and new technology is being developed. Regular training or meetings dedicated to electrical safety can be used to share the latest information on electrical safety and will help maintain higher level of awareness.

Auditing for compliance to principles, controls and procedures is a necessary step. It measures the effectiveness of the established controls. Auditing should not only be done as a first party audit but second party audits need to be performed. First party audits may help identify obvious problems. They do little to identify performance creep. Second party auditing brings fresh eyes to look at the performance and to look at the procedures.

Procedures need to be developed based upon the equipment, people and environment of the company or facility. Understanding what is occurring is important for development of applicable procedures.

2.5 Summary

Electrical safety cannot be a one-dimensional program. Electrical safety must be approached in a manner that addresses all that influences electrical safety. All of the hazards of electricity must address. Everyone must understand how people are exposed to hazards and how they can protect themselves from all of the hazards.

People must be trained in electrical safety. The awareness of those exposed to electrical hazards must be kept at a high level. People must understand the basics of electrical safety before they can apply the electrical safety concepts and work in a safe manner. Providing basic electrical safety training and keeping the awareness high will develop the willingness in people to use safe work practices.

Electrical equipment must be installed that contains the inherently safer designs such as, arc containment, touch safe terminals and voltage segregation.

Electrical equipment must be maintained in a condition that provides maximum safety. Regular maintenance should be done on all electrical equipment. Electrical equipment manufacturers have to be progressive in developing inherently safer designs. If they do not then they may find it mandated in regulations and standards.

Management must set the tone and provide the felt leadership to assure electrical safety will be an important part of the job. Management needs to understand what the electrical safety performance is in their company or at their site. Controls must be established. Procedures need to be developed to provide the guidance for those exposed to electrical hazards.

CHAPTER 3

RESULT AND ANALYSIS

3.1 Introduction

This project is concern on three types of industries which are large, medium and small. For large industry, Panasonic AVC Networks Johor Malaysia Sdn. Bhd. (PAVCJM), Pasir Gudang, Johor was chosen. Whilst Tenaga Nasional Berhad, Jalan Yahaya Awal, Johor Bahru, Johor for medium industry and Kedai Letrik Mohamad Lotfi, Kuala Pilah, Negeri Sembilan for small industry were chosen. Firstly, surveying the industries is carried out to focus of the electrical safety on current practices in those industries. Then analysis is done by data's collection. From there, the advantages and the weakness of the practices can be determined. The next step, comparison between the practices with the standard and regulation is done. Lastly, refocus of the electrical safety is carried out by defining on improvement by analyzing fault related issues and management dynamics.

3.2 Large Industry

The products manufactured by PAVCJM are:

1. Audio product:
   - i) CD Radio Cassette Recorder
   - ii) Mini Hi Fi (MD, SD, DVD & AK)
   - iii) Stereo Receiver
   - iv) Portable Mini Disc
   - v) Home Theatre
   - vi) Speaker Box System
   - vii) DVD Stereo System (VK)

2. Video product:
   - i) Video cassette recorder
   - ii) Video cassette player
   - iii) DVD/VCR Combo
   - iv) DVD/VCR Recorder

3.2.1 PAVCJM safety and health policy

PAVCJM is committed to ensure the safety, health and welfare of persons at work, and shall adhere and operate with the following concepts:

i) Amongst PAVCJM's major objectives and goals, of paramount important is the safety and health of its employees.

ii) PAVCJM emphasizes the greatest importance on the safety of its employees and will do its utmost to provide a safe working environment at all times for all employees and contractors.

iii) PAVCJM provides all employees with adequate safety training and will instill and promote safety consciousness among its employees to prevent accidents and injuries.

iv) PAVCJM's Rules and Regulations and Codes of Practice should be observed by each and every employee as well as contractors at all time.

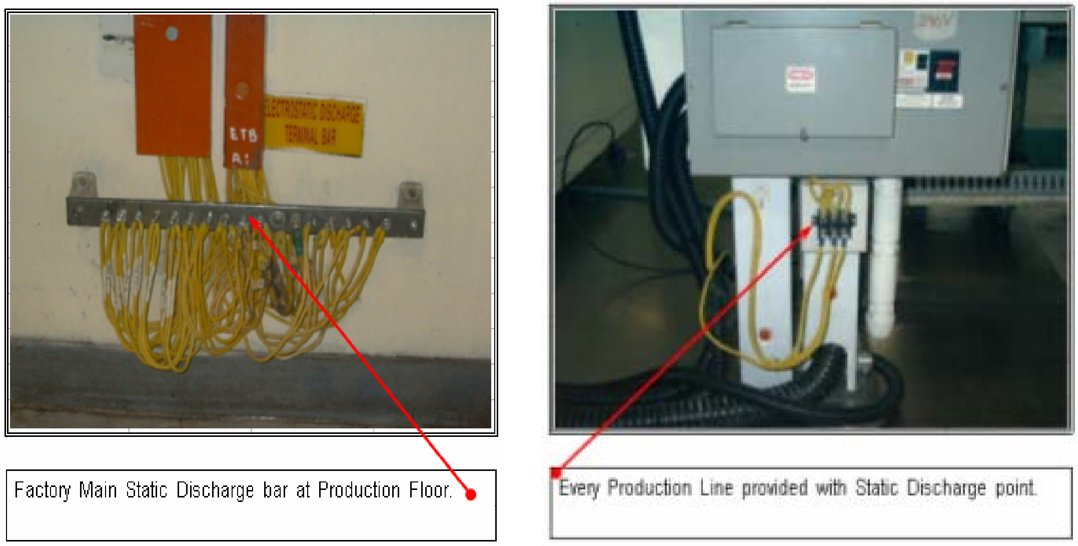
v) PAVCJM shall comply in full with all Government laws and regulations.

vi) PAVCJM's role in the prevention of accidents is a joint effort of all employees and always co-operate as a team to make PAVCJM not only clean and tidy but also the safest, most secure, healthy and best place to work in.

PAVCJM usually involves with electronic components. Integrated circuits are made from semiconductor materials such as silicon and insulating materials such as silicon dioxide, which can breakdown if exposed to high voltages. Thus electrostatic discharges (ESD) always occur on workers' bodies. What does ESD mean will be discussed next. PAVCJM has take precautions to avoid this problem. Such the use of conducting wrist straps and foot-straps to prevent high voltages from accumulating on workers' bodies, anti-static mats to conduct harmful electric charges away from the work area as mentioned in Chapter 2.

3.2.2 Electrostatic Discharge (ESD)

Electrostatic discharge is the sudden and momentary electric current that flows when an excess of electric charge, stored on an electrically insulated object, finds a path to an object at a different electrical potential (such as ground). The term is usually used in the electronics and other industries to describe momentary unwanted currents that cause damage to electronic equipment. Figure 3.1(a) and (b) shows that the PAVCJM main static discharge bar at the production floor and every production line is provided with their static discharge point themselves.



(a) (b)

Figure 3.1: Static Discharge Control (a) Main Static Discharge Bar, and (b) Static Discharge Point

3.2.3 Caused of ESD

One of the causes of charge separation that creates an ESD event is the triboelectric effect, in which certain materials become electrically charged after coming into contact with another different material and then being separated. This is why people experience ESD events after walking on a rug, descending from a car, or removing some types of packaging. In all these cases, friction between different materials causes triboelectric charging that, when discharged, become ESD.

3.2.4 Type of ESD

The most spectacular form of ESD is the spark, which occurs when a strong electric field creates an ionized conductive channel in air. This can cause minor discomfort to people, severe damage to electronic equipment, and fires and explosions if the air contains combustible gases or particles.

However, many ESD events occur without a spark, when a person carrying an electric charge touches a sensitive electronic component. Even these invisible forms of ESD can cause device failures or less obvious forms of degradation.

3.2.5 Sparks

This is triggered when the electric field strength exceeds a certain threshold value in the air, causing a rapid increase in the number of ions in the air (electrical breakdown), and these free ions temporarily cause the air to become a conductor.

The best known example of a spark is a lightning strike. In this case the potential difference between a cloud and ground can be millions of volts, and the resulting current that flows, heats the air causing an explosive release of energy.

3.2.6 Grounding

Grounding recommends a two-step procedure for grounding ESD protection equipment. The first step is to ground all components of the work area (work surfaces, people, equipment, etc.) to the same electrical ground point called the "common point ground". This common point ground is defined as a "system or method for connecting two or more grounding conductors to the same electrical potential' as in Figure 3.2.

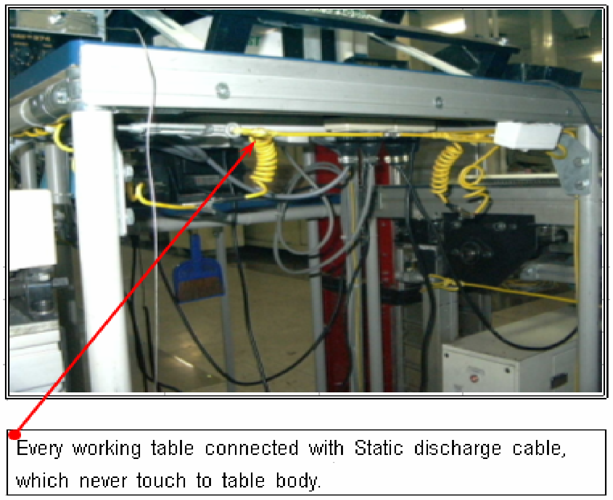


Figure 3.2: Working table with common point ground

The second step is to connect the common point ground to the equipment ground or the third wire (green) electrical ground connection. This is the preferred ground connection because all electrical equipment at the workstation is already connected to this ground. Connecting the ESD control materials or equipment to the equipment ground brings all components of the workstation to the same electrical potential.

By surveying done in PAVCJM, the management is more concern in safety than in getting the job done. They do not allow contractors to do their work or any repairing job without considered the electrical safety. They follow the Electricity Supply Act and Energy Commission procedures in monitoring electrical safety aspect of the organization.

The competent person will isolate power supply for any work to be done with electrical switchboard if the personnel's involve in risky job. The competent personnel been refers to advice for any changes for input to any of the electrical safety procedures. Besides that, the personnel's are experienced with electrical safety aspects of job assign and been trained of First Aid process as electrical safety awareness programs before assigned with specific tasks.

In PAVCJM, the electrical safety shall be practice at all the time and therefore there will be no accident happen. Before doing any modification work, they always refer to electrical drawing which has been approved. And they will check the electrical drawings for the particular area before any work commence to protect the personnel's from electrical hazards before dig the ground or penetrate a wall or floor.

For unsafe conditions and any findings related to discrepancy will be highlight to the relevant contractor and rectification must be carry-out before commence any testing. They also have external Engineer Consultant to look after the unsafe practices on electrical aspect and the status will be reported to Energy Commission by the consultant. Besides that, their Production Line Engineer usually will recheck all the parameters and procedures and ensure them are maintain in good condition.

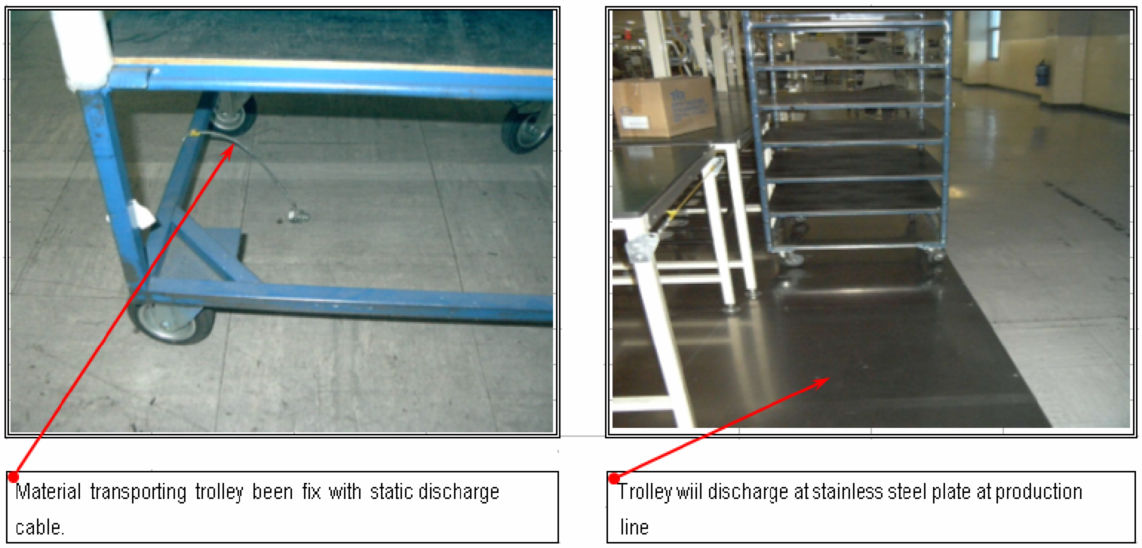
All the safety tools and equipments provided for personnel being monitor time to time for the safety practices. The personnel's also been trained before they operate the new equipments and they are allowed to join any time of electrical safety in house training which are scheduled by their management.

PAVCJM has been grant ISO 9001:2004 for manufacturing and ISO 14001:2004 for environmental protection. Therefore, PAVCJM has procedures regarding preventive and corrective actions and maintenance exercises to sustain electrical safety aspects in their place. And of course, all the documents are kept safely in a document room where it will be monitor time to time.

3.2.7 Controlling static on personnel and moving equipment

In many facilities, people are one of the prime generators of static electricity. The simple act of walking around or repairing a board can generate several thousand volts on the human body. If not properly controlled, this static charge can easily discharge into a static sensitive device.

Even in highly automated assembly and test processes, people still handle static sensitive devices. For this reason, static control programs place considerable emphasis on controlling personnel generated electrostatic discharge. Similarly, the movement of trolleys and other wheeled equipment as through the facility also can generate static charges that can transfer to the products being transported on this equipment as shown in Figure 3.3(a) and (b).



(a) (b)

Figure 3.3: Moving Equipment (a) Trolley been fix with static discharge cable, and (b) Trolley will discharge at stainless steel plate.

3.2.8 Personal Protective Equipment (PPE)

i) Wrist straps

Typically, wrist straps are the primary means of controlling static charge on personnel. When properly work and connected to ground, a wrist strap keeps the person wearing it near ground potential. Because the person and other grounded objects in the work area are at or near the same potential, there can be no hazardous discharge between them. In addition, static charges are safely dissipated from the person to ground and do not accumulate. It can be shown in Figure 3.4.

Wrist straps have two major components, the cuff that goes around the person's wrist and the ground cord that connects the cuff to the common point ground. Most wrist straps have a currents limiting resistor molded into the ground cord head on the end that connects to the cuff. The resistor most commonly used is a one megaohm (MΩ), ¼ watt (W) with a working voltage rating of 250 volts (V).

Wrist strap should be tested on a regular basis. Daily testing or continuous monitoring is recommended.

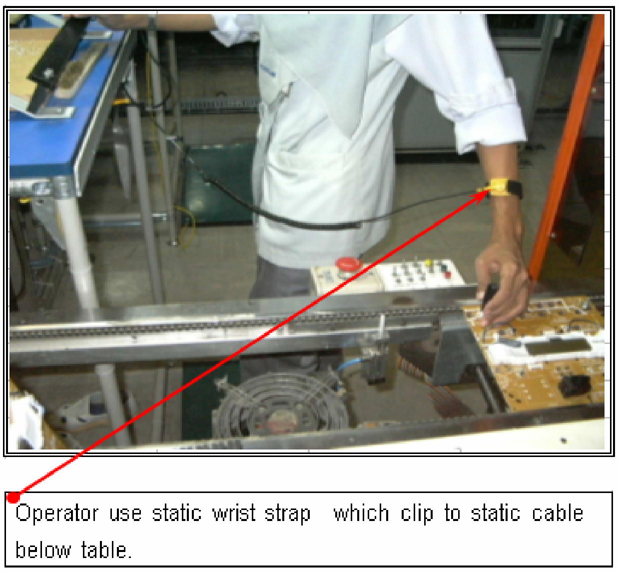
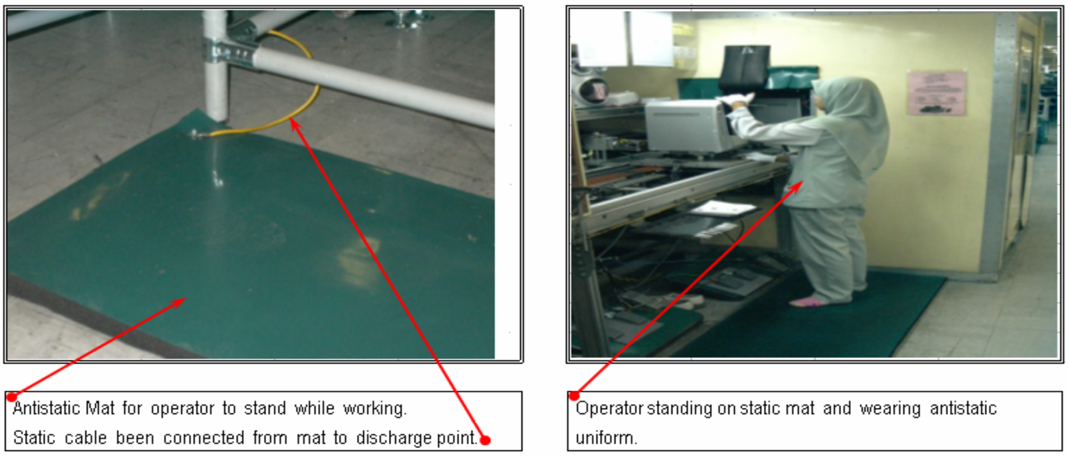


Figure 3.4: Wrist strap

ii) Floors and floor mats

A second method of controlling electrostatic charge on personnel is with the use of ESD protective floors in conjunction with ESD control footwear or foot straps. This combination of floor materials and footwear provides a ground path for the dissipation of electrostatic charge, thus reducing the charge accumulation on personnel and other objects to safe levels. Antistatic mat is shown in Figure 3.5(a) whilst 3.5(b) shows that the operator is standing on the antistatic mat.

In addition to dissipating charge, some floor materials (and floor finishes) also reduce triboelectric charging. The use of floor materials is especially appropriate in those areas where increased personnel mobility is necessary. In addition, floor materials can minimize charge accumulation on chairs, lift trucks and other objects that move across the floor. However, those items require dissipative or conductive casters or wheels to make electrical contact with the floor. When used as the primary personnel grounding system, the resistance to ground including the person, footwear and floor must be the same as specified for wrist straps (<35x10^6ohms) or the voltage accumulation on a person must be less than 100 volts.



(a) (b)

Figure 3.5: Antistatic Mat (a) Antistatic mat, and (b) Operator standing on the antistatic mat.

iii) Clothing

Clothing is a consideration in some ESD protective areas, especially in clean rooms and very dry environments. Clothing materials can generate electrostatic charges that may discharge into sensitive components or they may create electrostatic fields that may induce charges on the human body. Because clothing usually is electrically insulated or isolated from the body, charges on clothing fabrics are not necessarily dissipated to the skin and then to ground. Full static uniform is shown in Figure 3.6. Grounded static control garments are intended to minimize the effects of electrostatic fields or charges that may be present on a person's clothing.

Figure 3.6: Static uniform, head scarf, glove & wrist strap

iv) Shoes, grounders, casters

Used in combination with ESD protective floor materials, static control shoes, grounders, casters and wheels provide the necessary electrical contact between the person or object and the floor material. Insulative footwear, casters, or wheels prevent static charges from flowing from the body to the floor to ground.

Figure 3.7: Static shoe

3.2.9 Production Equipment and Protection Aids

Although personnel generated static is usually the primary ESD culprit in many environments, automated manufacturing and test equipment also can pose an ESD problem. For example, a device may become charged from sliding down a feeder. If the device then contacts the insertion head or another conductive surface, a rapid discharge occurs from the device to metal object. In addition, various production aids such as hand tools, tapes, or solvents also be ESD concerns.

Grounding is the primary means of controlling static charge on equipment and many production aids. Much electrical equipment is required by the National

Electrical Code to be connected to the equipment ground (the green wire) in order to carry fault currents. This ground connection also will function for ESD purposes. All electrical tools and equipment used to process ESD sensitive hardware require the 3 prong grounded type AC plug. Hand tools that are not electrically powered, i.e., pliers, wire cutters, and tweezers, are usually grounded through the ESD work surface and the (grounded) person using the conductive tools. Holding fixtures should be made of conductive or static dissipative materials when possible. A separate ground wire may be required for conductive fixtures not sitting on an ESD work surface or handled by a grounded person. For those items that are composed of insulative materials, the use of ionization or application of topical antistats may be required to control generation and accumulation of static charges.

3.2.10 Packaging and Handling

Direct protection of ESD's devices from electrostatic discharge is provided by packaging materials such as bags, corrugated, and rigid or semi-rigid packages. The primary use of these items is to protect the product when it leaves the facility, usually when shipped to a customer. In addition, materials handling products such as tote boxes and other containers primarily provide protection during inter or intra facility transport. The main ESD function of these packaging and materials handling products is to limit the possible impact of ESD from triboelectric charge generation, direct discharge, and electrostatic fields. The initial consideration is to have low charging materials in contact with ESD sensitive items. For example, the low charging property would control triboelectric charge resulting from sliding a board or component into the package or container. A second requirement is that the material provides protection from direct electrostatic discharge as well as shield from electrostatic fields.

Many materials are available that provide all three benefits:

i. low charging
ii. discharge protection
iii. electric field suppression

The inside of these packaging materials have a low charging layer, but also have an outer layer with a surface resistance generally in the dissipative range.

Resistance or resistivity measurements help define the material's ability to provide electrostatic shielding or change dissipation. Electrostatic shielding attenuates electrostatic fields on the surface of a package in order to prevent a difference in electrical potential from existing inside the package. Electrostatic shielding is provided by materials that have a surface resistance equal to or less than $1.0x10^3$ or a volume resistivity of equal to or less than $1.0x10^3$ ohm-cm. In addition, shielding may provided by packaging materials that provide an air gap between the package and product. Dissipative materials provide charge dissipation characteristics. These materials have a surface resistance greater than $1.0x10^4$ but less than or equal to $1.0x10^{11}$ or a volume resistivity greater than $1.0x10^5$ ohm-cm but less than or equal to $1.0x10^{12}$ ohm-cm.

3.3 Medium Industry

In this medium industry, high voltage must be taken into consideration. This is because the accident is often happen at this level.

High voltage is defined by the DOE Electrical Safety Guidelines as:
Over 600 volts, but any voltage above 50 volts should be considered life threatening, and treated accordingly. Usually high voltage circuits and equipment are marked with Hazard Signs.

References on High Voltage can be found in:

- **OSHA**
  Defines high voltage and lists training requirements and safe work practices (including approach distances).

- **NEC**
  NFPA 70 "National Electrical Code" provides additional information on high voltage equipment.

- **OTHER**
  NFPA 70E "Standard for Electrical Safety Requirements for Employee workplaces" provides detailed safe approach distances for working on high voltage equipment.

3.3.1 TNB Occupational Safety and Health Policy

Our employees are our most valuable asset. We are committed to the provision and maintenance of a safe and healthy working environment and to the compliance of statutory requirements. It is also our aim to ensure the safety of our customers, contractors, the public and others who may be affected by our activities.

In line with this policy, TNB shall:

- ❖ Ensure Occupational Safety and Health is incorporated in design, planning, evaluation and construction of all projects.
- ❖ Ensure safe work procedures are complied during operation and maintenance.
- ❖ Give a high priority to Occupational Safety and Health in the procurement of all services and equipment. Provide information and training to employees and contractors who may be exposed to hazards at work.
- ❖ Ensure all incidents, accidents and occupational diseases are reported, investigated and corrective measures taken to prevent reoccurrence.
- ❖ Promote Occupational Safety and Health awareness amongst employees and the affected public.
- ❖ Carry out regular workplace Occupational Safety and Health inspection, monitoring and auditing.

In upholding this policy, employees shall:

- ❖ Work safely and maintain good housekeeping practices.
- ❖ Use and maintain all personal protective equipment.
- ❖ Report the hazardous conditions, accidents and occupational diseases.
- ❖ Participate and support all Occupational Safety and Health Programs.

3.3.2 Occupational safety and health

TNB occupational safety and health are strictly follows the acts below:

- ❖ Occupational Safety & Health Act 1994.
- ❖ Electricity Supply Act 1990.

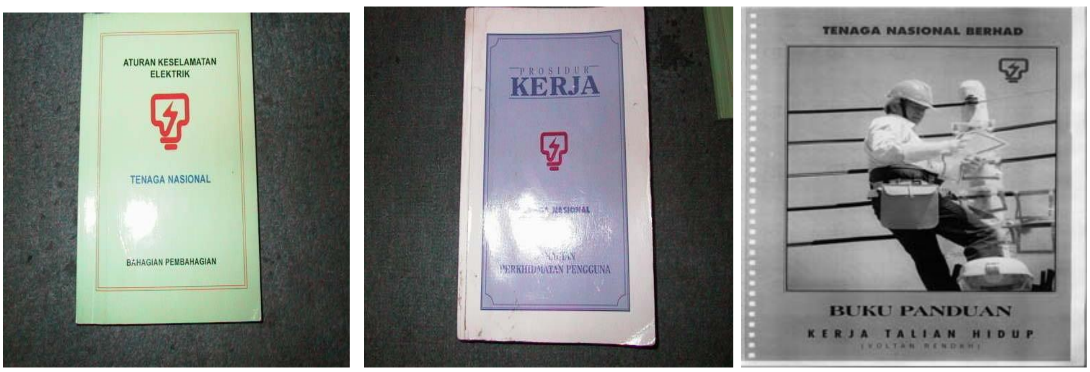
- ❖ Environmental Quality Act 1974.
- ❖ Constuction Industry Development Board (CIDB) Act 1994.

Accidents and Fire Report Regulations are stated in:

1) OSH Act Section 32
   - ❖ All accidents, hazardous condition, nearmiss, occupational diseases.

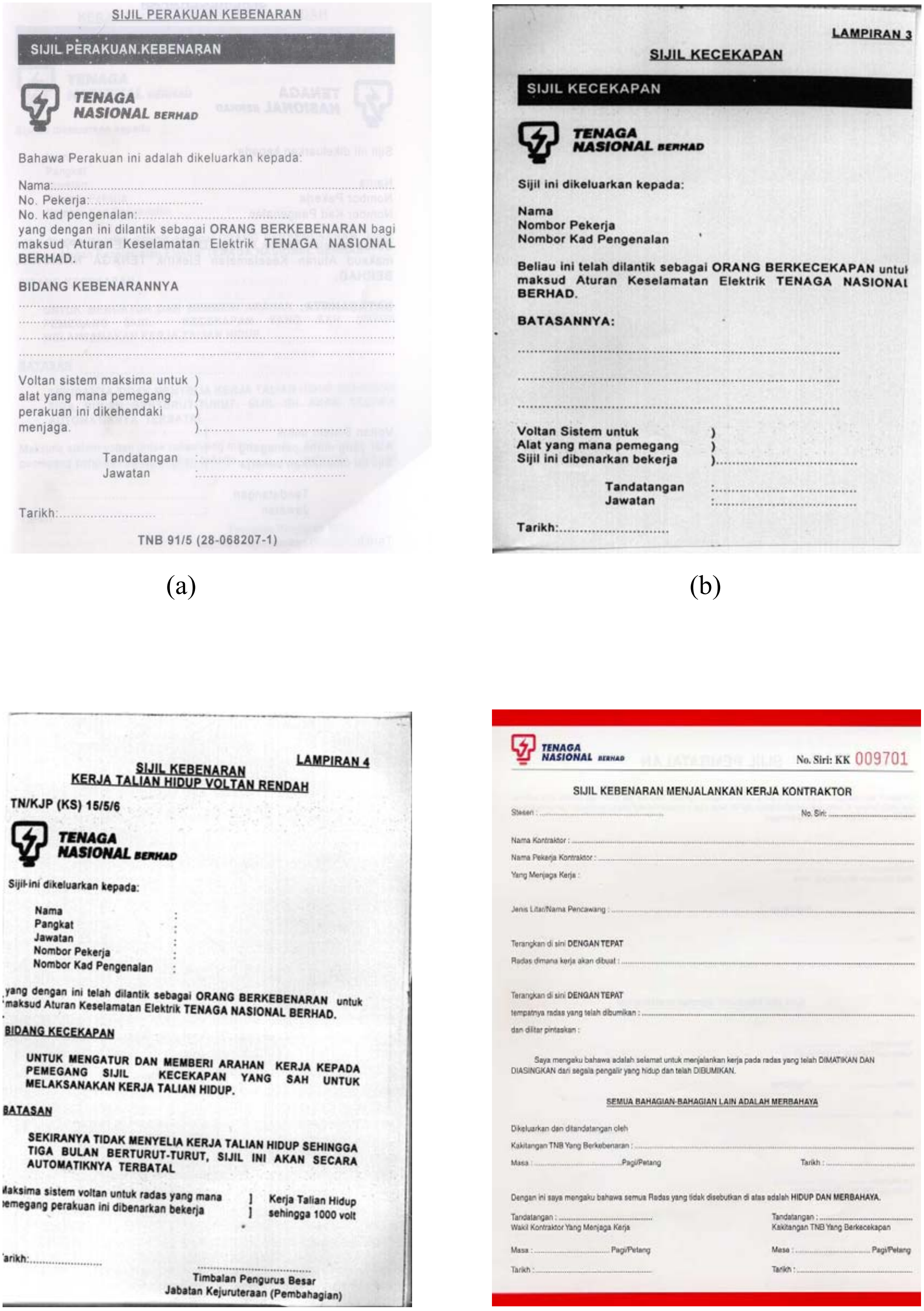
2) Electricity Supply Act Section 33
   - ❖ All accidents involved electrical wiring.
   - ❖ All fire cases.

In line with this, TNB also has their own safety rules books and procedures themselves that must be followed strictly as stated in Chapter 2. There are some of the books as shown in the Figure 3.8 below. Besides that, permit certificate, competence certificate, permit to work for power line and contractor also must be filled up before start any risky task and ensure the documents must be issued to the person in charged. The documents are shown in the Figure 3.9.



(a) (b) (c)

Figure 3.8: TNB Safety Rules and Procedures Book (a) Distribution Safety Rules, (b) Distribution Working Procedures, (c) Low Voltage Power Lines Working Procedures.



SIJIL PERAKUAN KEBENARAN

SIJIL PERAKUAN KEBENARAN

TENAGA NASIONAL BERHAD

Bahawa Perakuan ini adalah dikeluarkan kepada:

Nama:......

No. Pekerja:......

No. kad pengenalan:......

yang dengan ini dilantik sebagai ORANG BERKEBENARAN bagi maksud Aturan Keselamatan Elektrik TENAGA NASIONAL BERHAD.

BIDANG KEBENARANNYA

......

Voltan sistem maksima untuk alat yang mana pemegang perakuan ini dikehendaki menjaga.)......

Tandatangan :......

Jawatan :......

Tarikh:......

TNB 91/5 (28-068207-1)

(a)

LAMPIRAN 3

SIJIL KECEKAPAN

SIJIL KECEKAPAN

TENAGA NASIONAL BERHAD

Sijil ini dikeluarkan kepada:

Nama

Nombor Pekerja

Nombor Kad Pengenalan

Beliau ini telah dilantik sebagai ORANG BERKECEKAPAN untuk maksud Aturan Keselamatan Elektrik TENAGA NASIONAL BERHAD.

BATASANNYA:

......

Voltan Sistem untuk Alat yang mana pemegang Sijil ini dibenarkan bekerja)......

Tandatangan :......

Jawatan :......

Tarikh:......

(b)

LAMPIRAN 4

SIJIL KEBENARAN

KERJA TALIAN HIDUP VOLTAN RENDAH

TN/KJP (KS) 15/5/6

TENAGA NASIONAL BERHAD

Sijil ini dikeluarkan kepada:

Nama :

Pangkat :

Jawatan :

Nombor Pekerja :

Nombor Kad Pengenalan :

yang dengan ini telah dilantik sebagai ORANG BERKEBENARAN untuk maksud Aturan Keselamatan Elektrik TENAGA NASIONAL BERHAD.

BIDANG KECEKAPAN

UNTUK MENGATUR DAN MEMBERI ARAHAN KERJA KEPADA PEMEGANG SIJIL KECEKAPAN YANG SAH UNTUK MELAKSANAKAN KERJA TALIAN HIDUP.

BATASAN

SEKIRANYA TIDAK MENYELIA KERJA TALIAN HIDUP SEHINGGA TIGA BULAN BERTURUT-TURUT, SIJIL INI AKAN SECARA AUTOMATIKNYA TERBATAL

Maksima sistem voltan untuk radas yang mana pemegang perakuan ini dibenarkan bekerja] Kerja Talian Hidup sehingga 1000 volt

Tarikh:......

Timbalan Pengurus Besar

Jabatan Kejuruteraan (Pembahagian)

(c)

TENAGA NASIONAL BERHAD No. Siri: KK 009701

SIJIL KEBENARAN MENJALANKAN KERJA KONTRAKTOR

Stesen : ...... No. Siri: ......

Nama Kontraktor : ......

Nama Pekerja Kontraktor : ......

Yang Menjaga Kerja :

Jenis Litar/Nama Pencawang : ......

Terangkan di sini DENGAN TEPAT

Radas dimana kerja akan dibuat : ......

Terangkan di sini DENGAN TEPAT

tempatnya radas yang telah dibumikan : ......

dan dilitar pintaskan :

Saya mengaku bahawa adalah selamat untuk menjalankan kerja pada radas radas yang telah DIMATIKAN DAN DIASINGKAN dari segala pengalir yang hidup dan telah DIBUMIKAN.

SEMUA BAHAGIAN-BAHAGIAN LAIN ADALAH MERBAHAYA

Dikeluarkan dan ditandatangan oleh

Kakitangan TNB Yang Berkebenaran : ......

Masa : ...... Pagi/Petang Tarikh : ......

Dengan ini saya mengaku bahawa semua Radas yang tidak disebutkan di atas adalah HIDUP DAN MERBAHAYA.

Tandatangan : ...... Wakil Kontraktor Yang Menjaga Kerja — Tandatangan : ...... Kakitangan TNB Yang Berkecekapan

Masa : ...... Pagi/Petang — Masa : ...... Pagi/Petang

Tarikh : ...... — Tarikh : ......

(d)

Figure 3.9: Documents needed before start any task (a) Permit certificates, (b) Competence certificate, (c) PTW for power lines, and (d) PTW for contractor.

3.3.3 Personal Protective Equipment (PPE)

As Panasonic, TNB also has their own PPE that provided to all their workers. TNB spend about RM 200,000.00 on safety tools for year 2005. Some of the PPE are shown in Figure 3.10.

(a)

(b)

(c)

(d)

Figure 3.10: Personal Protective Equipment at TNB (a) Safety helmet, (b) Reflective safety vest, (c) Safety glove, and (d) Safety shoe.

3.3.4. Electrical Safety Practices

TNB always concern of their workers and ensure they should follow the electrical safety practices before start any job. Table 3.11 below shows that what is currently being practices in TNB, what are the requirements and when they have to use all the PPE provided. The most important here is to ensure that no accident will occur during working time.

Table 3.11: Electrical safety practices

Bil	Practices	Requirements	Notes
1	Wearing safety helmet	All workers	Wearing during working time
2	Wearing safety shoe	All workers	Wearing during working time
3	Wearing safety glove	All workers	Wearing during working time
4	Wearing safety vest	All workers	Working at the street
5	Wearing safety belt	Lines workers	Overhead workers
6	Wearing FRS/PPE	All AP and CP	Involved switching and operation
7	Permit to Work Certificate	All AP (HV/LV)	Involved switching ON/OFF/EARTH
8	Using safety cone	Not less than 8 pieces per lorry	Refer "Working Procedures" Customer Service Dept.
9	Using safety signboard	Not less than 4 pieces per lorry	Refer "Working Procedures" Customer Service Dept.
10	Using Barricade tape	As required	Refer "Working Procedures" Customer Service Dept.

Bil	Practices	Requirements	Notes
11	Using Flashing amber lamp	Not less than 3 pieces per lorry	Refer "Working Procedures" Customer Service Dept.
12	Using Batton light	1 piece per lorry	Working at the main road
13	Using Insulated ladder	Overhead teamwork and contractor	Refer Instruction by CEO Distribution Dept Bil. K3/2005
14	Using discharge rod	Overhead teamwork and contractor	Refer Instruction by CEO Distribution Dept Bil. K3/2005
15	OSH meeting	All station	Once in 3 month
16	Stock equipment clearance	All office	Replace the damage PPE
17	Using good tester equipment	Person involved only	Approved by Engineering Department (TNB)
18	Using tool box talk	All teamwork	Every morning before start work

3.3.5 Surveying Result

TNB motto is "Safety First" and the management more concern in electrical safety is more important than getting the job done. The organization has Electrical Safety Rules, Safe Operation Manual, Internal Circulars and Competency Authorization in monitoring electrical safety aspect. The staff is familiar with the safety procedures, but some of the staff neglects the safety procedures due to speeding up restoration of supply.

The personnel's in TNB are having an induction training and also on job training of electrical safety awareness program before assigned with specific tasks. TNB spend about RM 635,356.44 last year for the training. Most of the training for lower level is from internal trainer but occasionally for safety engineers are trained in NIOSH or by consultant.

TNB always conduct a survey and test regularly for input to any of the electrical safety procedures. Therefore unsafe conditions are rectified accordingly but some unsafe condition takes time and more powerful interference. Safety Engineers and Safety Inspectors are the person in charged in this unsafe condition. Besides that, the electrical drawing is important and always updated every time new installation energized. In case of digging the ground or penetrate a wall or floor, TNB has their own procedures by using special equipment.

During training or meeting, management always request for feedback to any of electrical safety procedures. The procedures regarding preventive and corrective actions and maintenance exercises to sustain electrical safety aspects are mentioned before. TNB also has been grant in quality management with ISO 9001:2000 to look into the electrical safety aspects of personnel's. Of course, those ISO documents are safely kept whilst the electrical equipments manual is controlled and owned by TNB Head Quarters.

3.3.6 Accidents Reported

Although TNB has provided PPE to their staff and the staff is familiar with the rules and procedures, the accident (minor and major) still happen in TNB. Most of the accident occurs because one of the following:

1. Without wearing safety helmet
2. Without wearing safety shoe

3. Without wearing safety vest
4. Without wearing safety belt
5. Without wearing safety glove
6. Without Permit To Work certificate
7. Without Authorized person
8. Without signboard
9. Without batton light
10. Without plicker light
11. Use aluminium ladder

3.3.6.1 Accidents Statistic

Figure 3.12 shows that accident statistic recorded for year 2004/2005. It can be shown that 65% accident happen at the low voltage overhead and this is a highest percentage amongst the high voltage overhead, substation, cable, street and store. Whilst in Figure 3.13, it shows the victims category by sector. And it can be seen that the highest accident occur on the TNB workers itself compare to others.

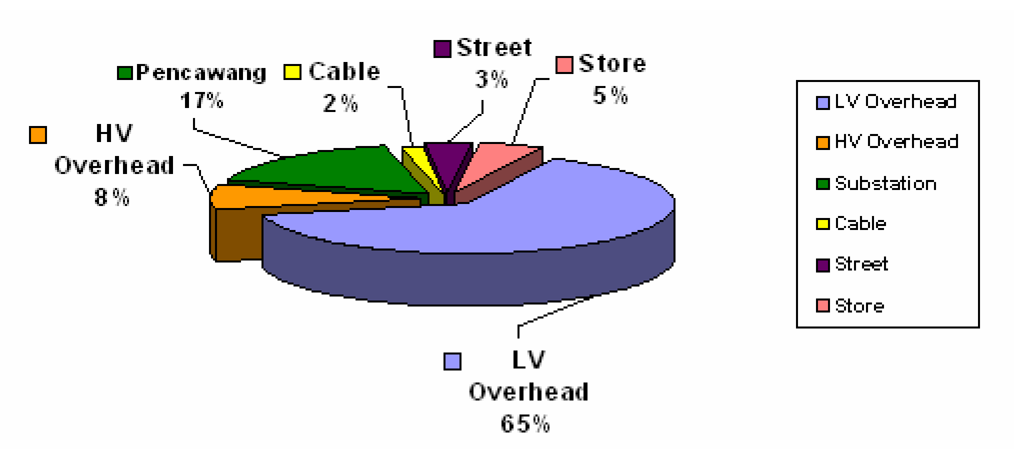


Figure 3.12: Accidents Statistic 2004/2005

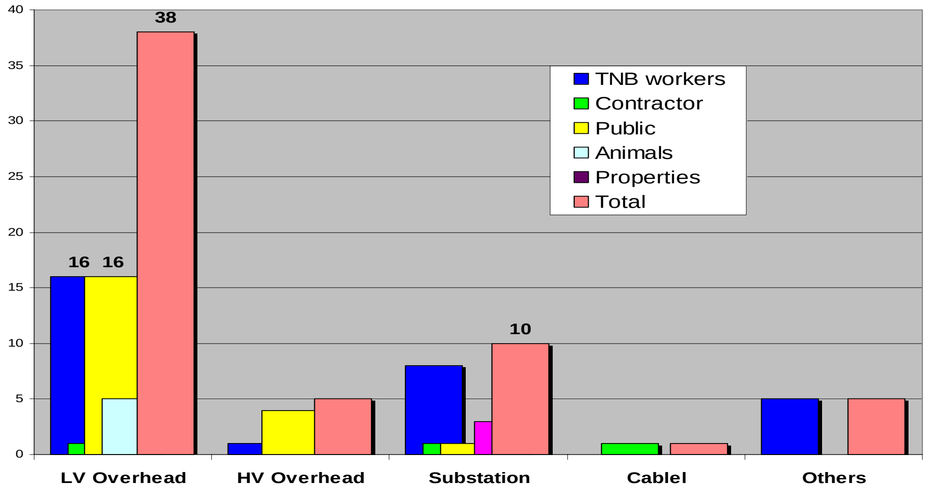


Figure 3.13: Victims category by sector

The accident is compared for year 2004 and 2005 and it can be seen that the number of whole accident happen is reduced almost about 50% as shown in Table 3.14.

Table 3.14: Comparison accident for year 2004 and 2005

ACCIDENT	2004	2005
Cable	2	4
Substation	2	1
Pole	1	-
Street	3	-
SAVR	8	3
SAVT	1	-
Burn	2	1
TOTAL	**19**	**9**

Figure 3.15 below are the picture of electric arc effect happened in TNB.

Figure 3.15: Electric Arc Effect

And the next pictures are an electric explosive effect which is shown in Figure 3.16.

Figure 3.16: Electric Explosive Effect

3.4 Small Industry

As mentioned before, for the small industry, Kedai Lektrik Mohamad Lotfi was chosen. This company is located at Kuala Pilah, Negeri Sembilan which involves in electrical wiring and sometimes doing repairing and maintenance. This company follows Electricity Supply Act and Energy Commission. There have only three permanent workers and the supervisor has a competent certificate. At times there are practical students from local institution doing their practical training at the place.

Kedai Lektrik Mohamad Lotfi practices electrical safety. Their policy is “Safety First” and to ensure the workers are always in good health while doing any task. Therefore the workers are covered with insurance before they start any job. Besides that, the workers are provided with personal protective equipment (PPE) such as hand glove, test pen which can detect current in the bricks, safety shoe, safety cloth, safety belt, pliers with high insulated and wood ladder.

The workers had attended some training courses but not so frequent. Besides that, this company also has person responsible to look after the unsafe practices. Because it is a small company, they do not grant any ISO and no auditing be made since the setup of the company. Although it is small company, all the documents such as drawing and manuals are kept safely. The purpose is to make a reference when they are involved in the same task in the future.

Although they have attended some training about electrical safety and know the dangerous of the electricity, individual attitudes do not care about safety. Due to this unfortunately, the accidents still occur. Most of the accidents happen because of the human error and not using the PPE provided.

3.4 Summary

It can be seen that generally all management of industries are following the government standard and procedure on safety. However, the workers attitude must be changed to avoid the accident. They should not simply neglect rules even though they know occurrence of the consequences of their negligent. Here I conclude that the overall analysis as shown in Table 3.17.

Table 3.17: Overall Analysis

BIL	PRACTICES	PAVCJM	TNB	WIRING SHOP
1	Management commitment	√	√	√
2	Organizational support	√	√	X
3	Electrical safety policy	√	√	√
4	Training & qualification personnel	√	√	√
5	Used of protective equipment, tester, tools & protective methods	√	√	√
6	Used of electrical equipment	√	√	√
7	Documentation	√	√	√
8	Auditing	√	√	X
9	Technical support	√	√	√
10	Emergency preparedness	√	√	√
11	Continuous Improvement	X	X	X

So far there is no accident happen at PAVCJM. Here I suggest that continuous improvement should be added such as:

- All the while, the manuals are kept in the document room. It should be better if PAVCJM can provide a set of personal computer to all its key personnel. This can make the personnel easy to search something and it will be faster instead going to a document room.

- ➢ Invite expertise in safety from any consultant (not the PAVCJM Electrical Safety Officer) to conduct a training to make the personnel learn more about safety.
- ➢ Send the personnel (not only the safety officer) to go for training outstation to expose them.
- ➢ Add more Electronic Signboard "SAFETY FIRST" or others words instead of permanent signboard to make working environment brightness and always beware on safety.

Analysis for TNB can be illustrated as in Figure 3.18.

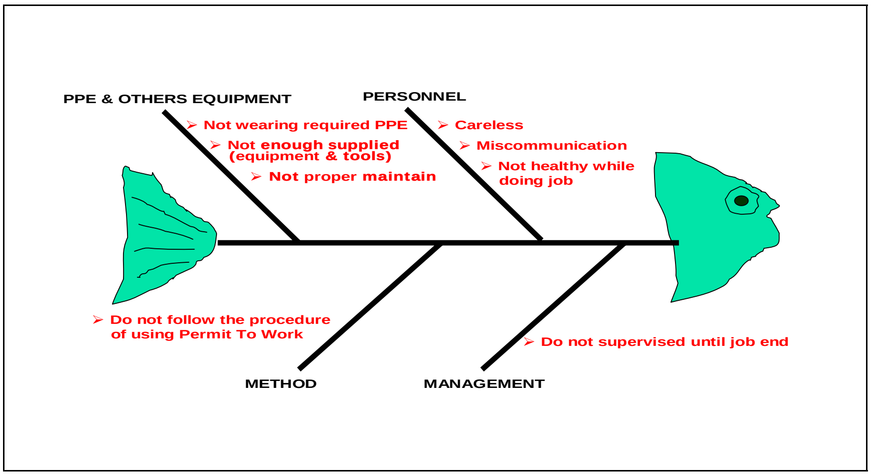


Figure 3.18: Analysis accident at TNB

Below are the recommendation for prevention and correction at TNB:

- ❖ Procedure of issuing the Permit to Work must be follow strictly.
- ❖ Competent Person must know their job and responsible when doing switching operation.
- ❖ Procedure of job hand over must be documented and approved by officer in charged.
- ❖ Always use appropriate PPE and insulated tools.

- Make sure all equipments enough before start the job.
- Person responsible must be at the field until job end.

Here I suggested for continuous improvement in TNB a “switching simulation program” to expose the workers to show the dangerous of the electricity to human being. This is just like computer aided simulator training. And the other thing, since the management is concern more to the workers, TNB and Kedai Letrik Mohamad Lotfi should go towards behaviors based safety.

The next Chapter will carried out with simulation studies to show the effect to human being when they are touching in current by AC supply at the workplace and struck by lightning.

CHAPTER 4

SIMULATION STUDIES

4.1 Introduction

This simulation is to show the effect of electrical energy on human. Basically this effect is divided into two categories which are:

1) Physiological Effects
   - ❖ Burns.
   - ❖ Delayed Effects.
   - ❖ Critical Path.

2) Biological Effects of Electrical Hazards
   Biological effects of electric current on human body can vary depending on following:
   - ❖ Source characteristics (current, frequency, and voltage of all electric energy sources).
   - ❖ Duration of the contact.
   - ❖ Body impedance and the current's pathway through the body.
   - ❖ How environmental conditions affect the body's contact resistance.

In this simulation, a model of human being is used as shown in Figure 4.1 by using ATP-EMTP software. The models are injected with two type of energizing: alternating current (AC) and impulse. This simulation is to show when human being are touch in current/lightning and to facilitate in training of personnel to be more awareness about safety. From there, we can measure how much current flow through one up to five fingers. Then the simulation result will be compared with the calculation.

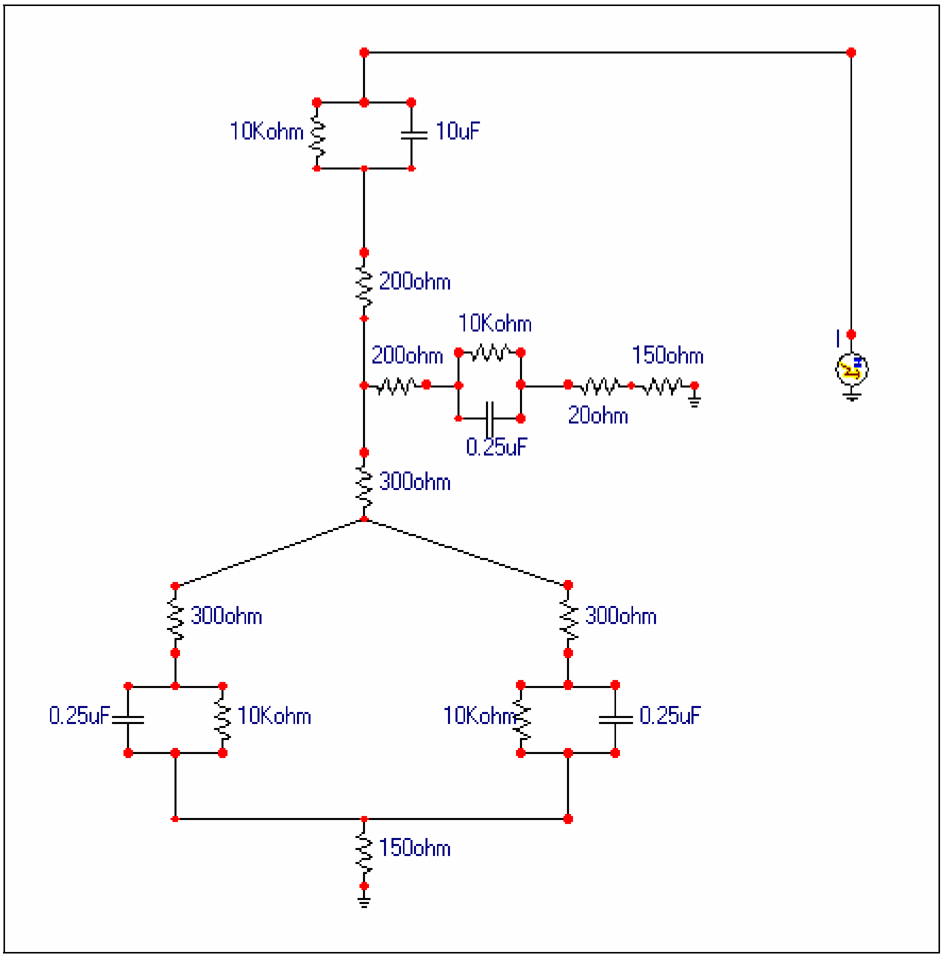


Figure 4.1: Human body model

4.2 Calculation

From the human body model above, the equivalent circuit can be simplified as shown in Figure 4.2.

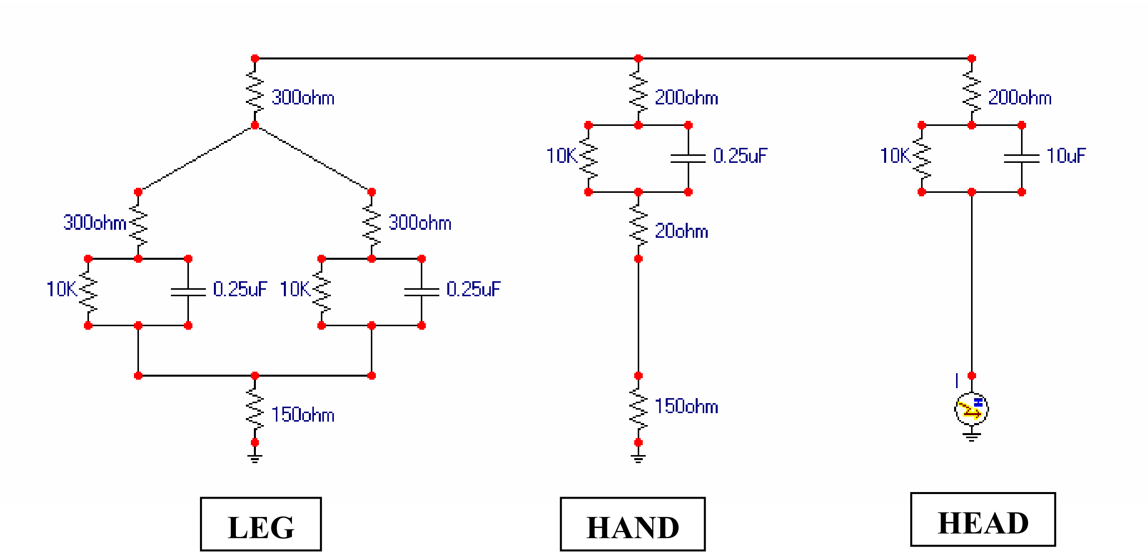


Figure 4.2: Equivalent circuit

4.2.1 Leg resistance

To calculate the leg resistance which is grounded, the circuit is shown in Figure 4.3.

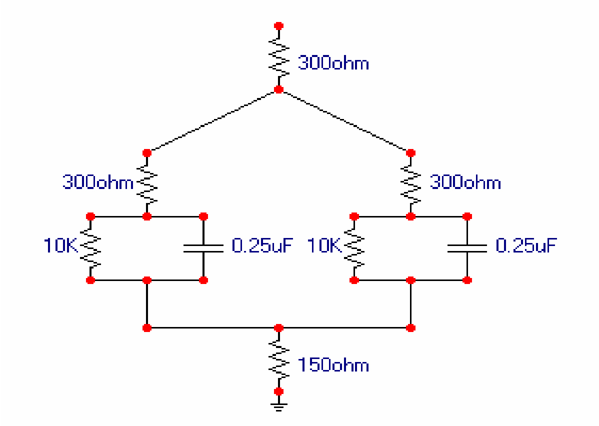


Figure 4.3: Leg circuit

Assume there is open circuit, we just consider only the resistors. So the total leg resistance (R_L) is,

$$R_L = 300 + [(300 + 10000)//(300 + 10000)] + 150$$
$$= 300 + 5150 + 150$$
$$= 5600\Omega$$

4.2.2 Hand resistance

First, calculate the hand resistance with 1 finger touching which is grounded as shown in Figure 4.4.

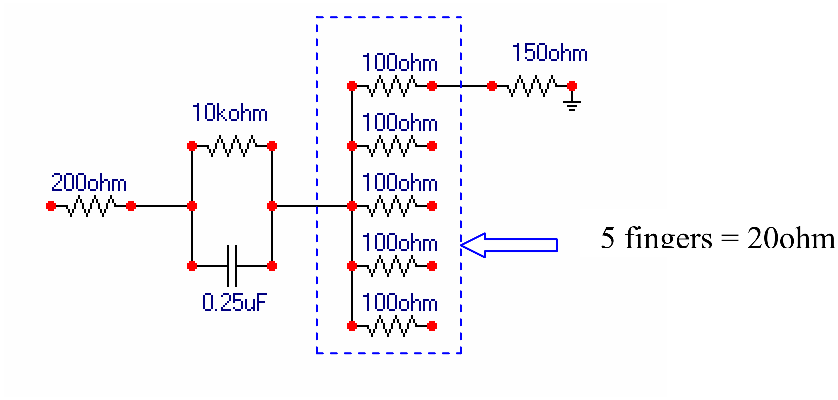


Figure 4.4: Hand resistance with one finger touching

Assume open circuit condition, the total hand resistance with one finger touching (R_{1F}) is,

$$R_{1F} = \mathbf{200 + 10000 + 100 + 150}$$
$$= \mathbf{10450\Omega}$$

Similarly, hand resistance with two fingers touching is shown in Figure 4.5.

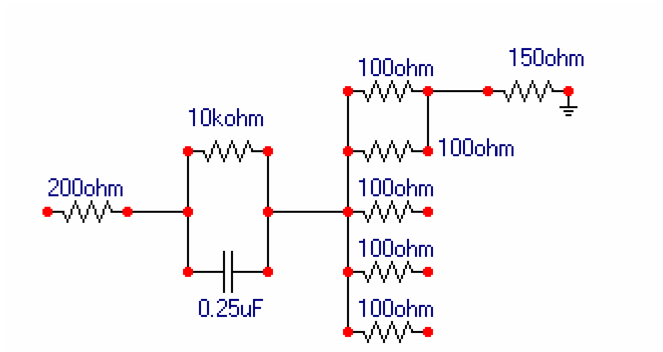


Figure 4.5: Hand resistance with two fingers touching

Assume open circuit, the total hand resistance with two fingers touching (R_{2F}) is,

$$R_{2F} = \mathbf{200 + 10000 + (100 // 100) + 150}$$
$$= \mathbf{10400\Omega}$$

Figure 4.6 shows to find the total hand resistance with three fingers touching.

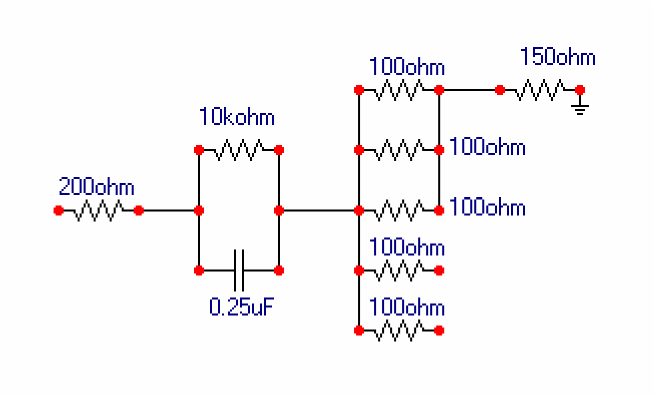


Figure 4.6: Hand resistance with three fingers touching

Assume open circuit, the total hand resistance with three fingers touching (R_{3F}) is,

$$R_{3F} = \mathbf{200 + 10000 + (100 // 100 // 100) + 150}$$
$$= \mathbf{10383.33\Omega}$$

Hand resistance with four fingers touching circuit is shown in Figure 4.7 below.

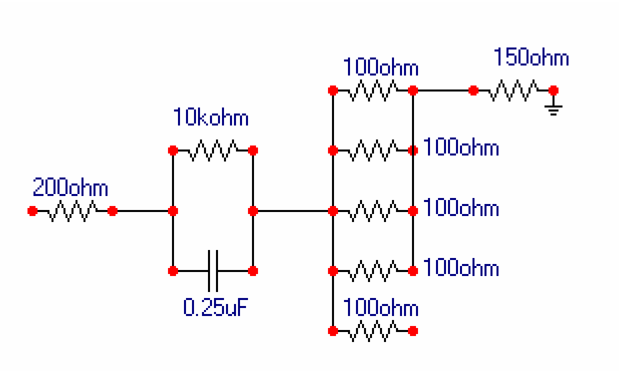


Figure 4.7: Hand resistance with four fingers touching

Assume open circuit, the total hand resistance with four fingers touching (R_{4F}) is,

$$R_{4F} = \mathbf{200 + 10000 + (100 // 100 // 100 // 100) + 150}$$
$$= \mathbf{10375\Omega}$$

Lastly, the total hand resistance with five fingers touching is shown in Figure 4.8.

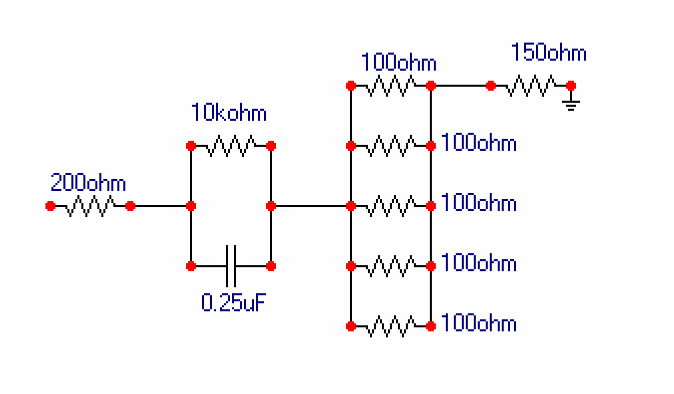


Figure 4.8: Hand resistance with five fingers touching

Assume open circuit, the total hand resistance with five fingers touching (R_{5F}) is,

$$R_{5F} = \mathbf{200 + 10000 + (100 // 100 // 100 // 100 // 100) + 150}$$
$$= \mathbf{10370\Omega}$$

4.2.3 Current calculation with AC source

For this AC source, we only injected the current (I_{AC}) with 30mA. By giving this amount of current, it can give the supply voltage almost 415V. This small current is to show when human being is touching in current at the workplace. From here, we can calculate the current flow through one finger up to five fingers by using Kirchhoff Current Law.

Current with 1 finger touching (I_{1F}) is,

$$I_{1F} = I_{AC} x \frac{R_L}{R_L + R_{1F}}$$

$$= \mathbf{30} x \frac{\mathbf{5600}}{(\mathbf{5600} + \mathbf{10450})}$$

$$= \mathbf{10.467} mA$$

Current with 2 fingers touching (I_{2F}) is,

$$I_{2F} = I_{AC} x \frac{R_L}{R_L + R_{2F}}$$

$$= \mathbf{30} x \frac{\mathbf{5600}}{(\mathbf{5600} + \mathbf{10400})}$$

$$= \mathbf{10.500} mA$$

Current with 3 fingers touching (I_{3F}) is,

$$I_{3F} = I_{AC} x \frac{R_L}{R_L + R_{3F}}$$

$$= \mathbf{30} x \frac{\mathbf{5600}}{(\mathbf{5600} + \mathbf{10383.33})}$$

$$= \mathbf{10.510} mA$$

Current with 4 fingers touching (I_{4F}) is,

$$I_{4F} = I_{AC} x \frac{R_L}{R_L + R_{4F}}$$

$$= \mathbf{30} x \frac{\mathbf{5600}}{(\mathbf{5600} + \mathbf{10375})}$$

$$= \mathbf{10.516} mA$$

Current with 5 fingers touching (I_{5F}) is,

$$I_{5F} = I_{AC} x \frac{R_L}{R_L + R_{5F}}$$

$$= \mathbf{30} x \frac{\mathbf{5600}}{(\mathbf{5600} + \mathbf{10370})}$$

$$= \mathbf{10.519} mA$$

4.2.4 Current calculation with impulse source

For this impulse source, we injected the current (I_{imp}) with 5kA. This high current is to show when human being is touching in lightning. Similarly as before, we can calculate the current flow through one finger up to five fingers by using Kirchhoff Current Law.

Current with 1 finger touching (I_{1F}) is,

$$I_{1F} = I_{imp} x \frac{R_L}{R_L + R_{1F}}$$

$$= \mathbf{5000} x \frac{\mathbf{5600}}{(\mathbf{5600} + \mathbf{10450})}$$

$$= \mathbf{1744.55} A$$

Current with 2 fingers touching (I_{2F}) is,

$$I_{2F} = I_{imp} x \frac{R_L}{R_L + R_{2F}}$$

$$= \mathbf{5000} x \frac{\mathbf{5600}}{(\mathbf{5600} + \mathbf{10400})}$$

$$= \mathbf{1750} A$$

Current with 3 fingers touching (I_{3F}) is,

$$I_{3F} = I_{imp} x \frac{R_L}{R_L + R_{3F}}$$

$$= \mathbf{5000} x \frac{\mathbf{5600}}{(\mathbf{5600} + \mathbf{10383.33})}$$

$$= \mathbf{1751.83} A$$

Current with 4 fingers touching (I_{4F}) is,

$$I_{4F} = I_{imp} x \frac{R_L}{R_L + R_{4F}}$$

$$= \mathbf{5000}x\frac{\mathbf{5600}}{(\mathbf{5600}+\mathbf{10375})}$$

$$= \mathbf{1752.74}A$$

Current with 5 fingers touching (I_{5F}) is,

$$I_{5F} = I_{imp}x\frac{R_L}{R_L + R_{5F}}$$

$$= \mathbf{5000}x\frac{\mathbf{5600}}{(\mathbf{5600}+\mathbf{10370})}$$

$$= \mathbf{1753.28}A$$

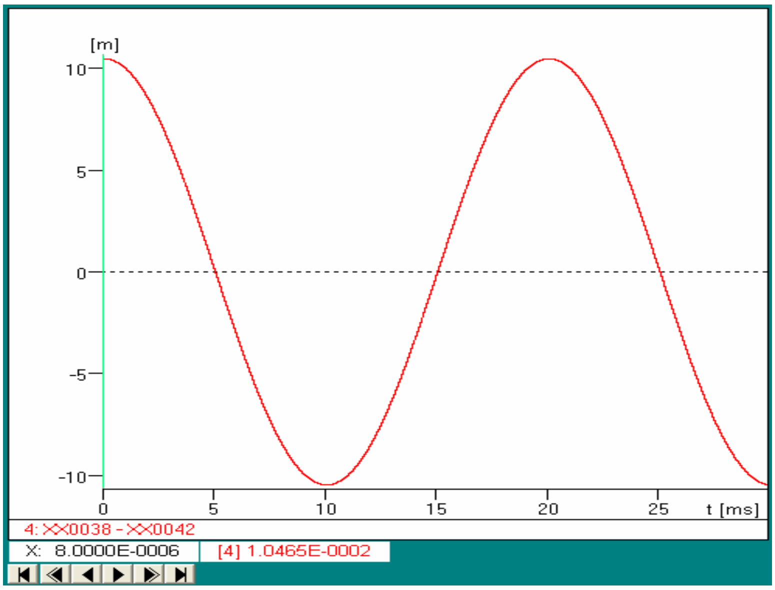
4.3 Simulation results

This simulation is done by using ATP-EMTP software. The waveform for both sources (ac and impulse) is shown below to measure the value of current when human being is touching in current/lightning. We also can determine the value of the voltage for certain amount of current when the human touching on it by this simulation and verify them by calculation.

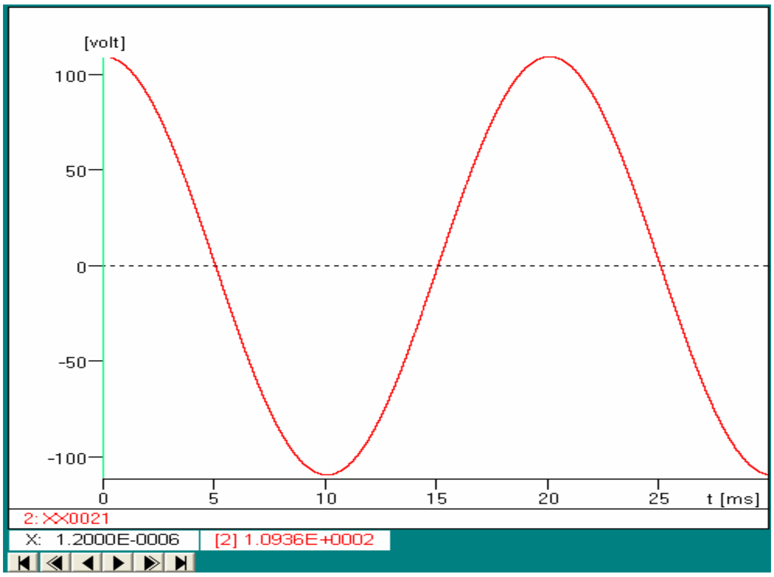
Figure 4.9 to 4.13 show the waveform injected by alternating current source. The current injected is 30mA with frequency 50Hz. The waveform setting for x-axis is for time with time step of simulation $1x10^{-7}$ seconds and the end time for simulation is 0.03 seconds. Whilst in Figure 4.14 to 4.19 show the waveform injected by impulse source. The current injected is 5kA with front duration of 8μs and tail duration of 20μs for current and 1.2/50μs for voltage setting. The waveform setting for x-axis is for time with time step of simulation $1x10^{-7}$ seconds and the end time for simulation is 50μs for current and 60μs for voltage.

4.3.1 Simulation by AC source

(i) 1 finger touching



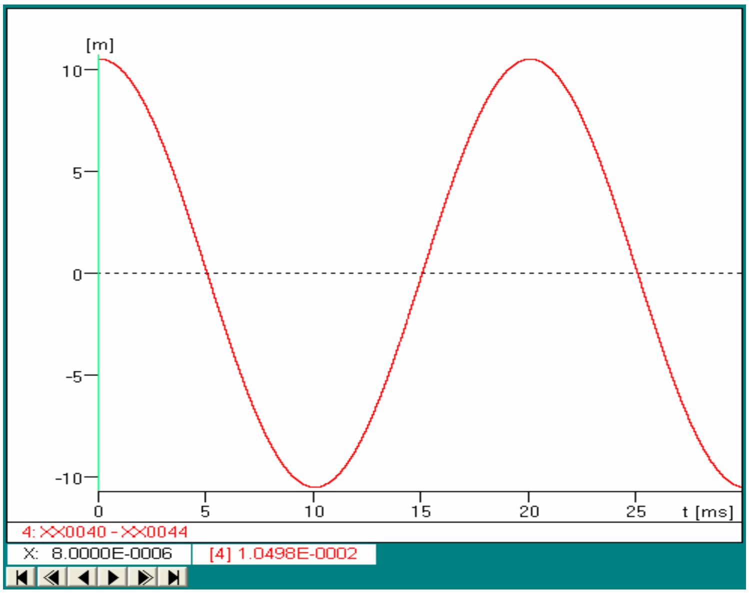
(a)



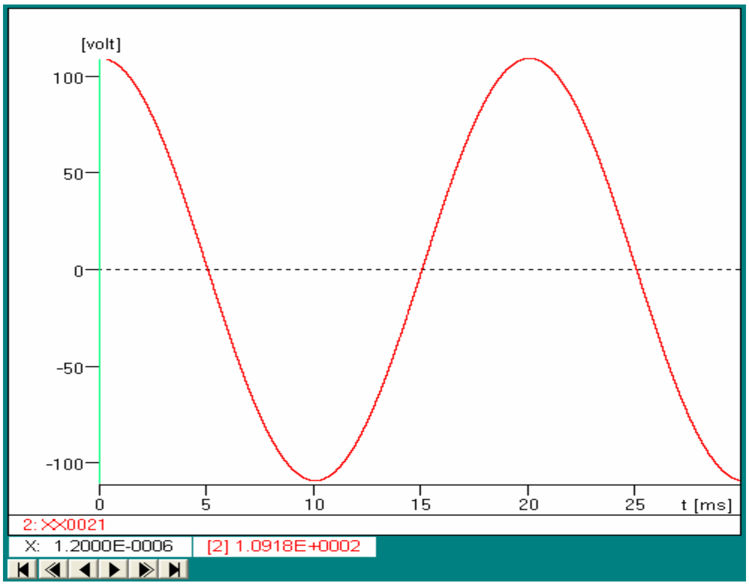
(b)

Figure 4.9: Current and voltage waveform with 1 finger touching (a) Current at 8μs, and (b) Voltage at 1.2μs

(ii) 2 fingers touching



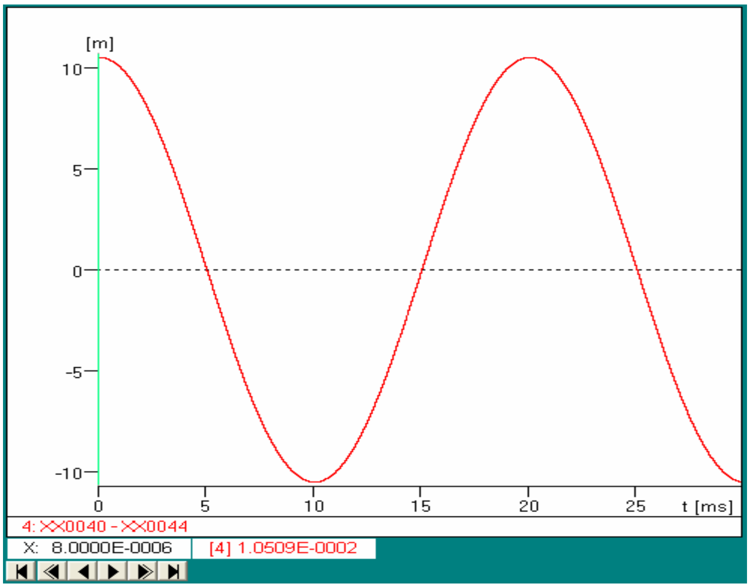
(a)



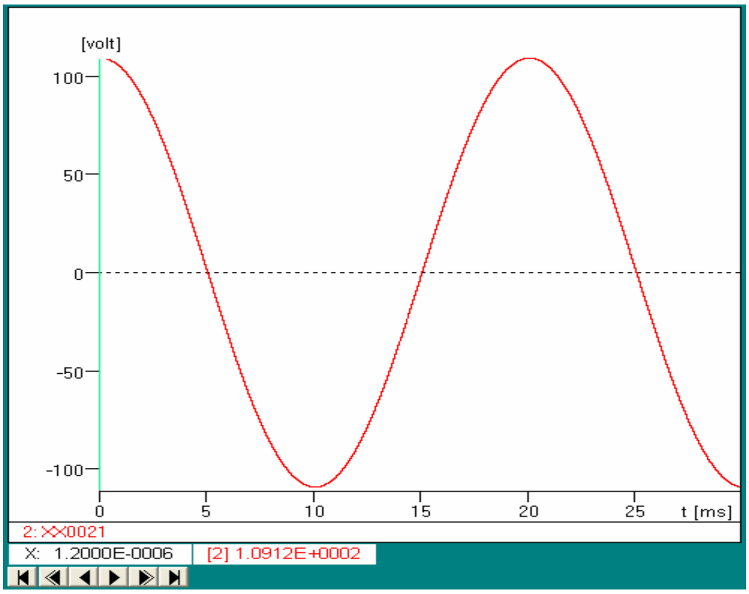
(b)

Figure 4.10: Current and voltage waveform with 2 fingers touching (a) Current at 8µs, and (b) Voltage at 1.2µs

(iii) 3 fingers touching



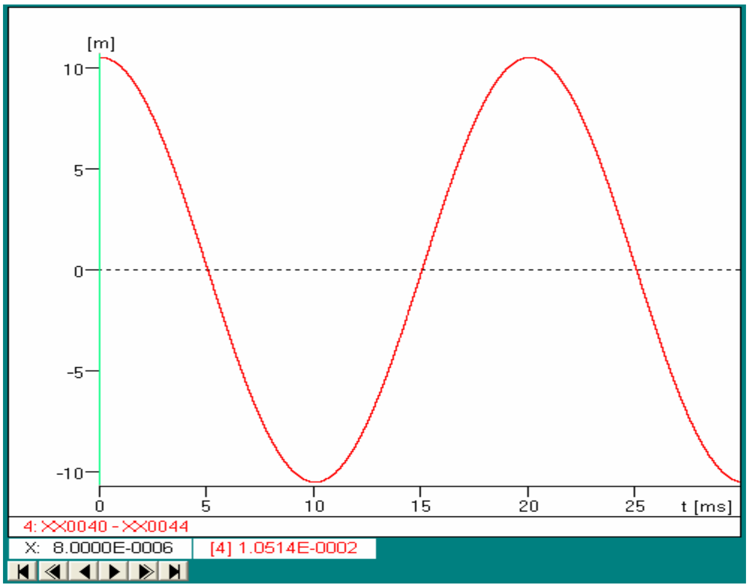
(a)



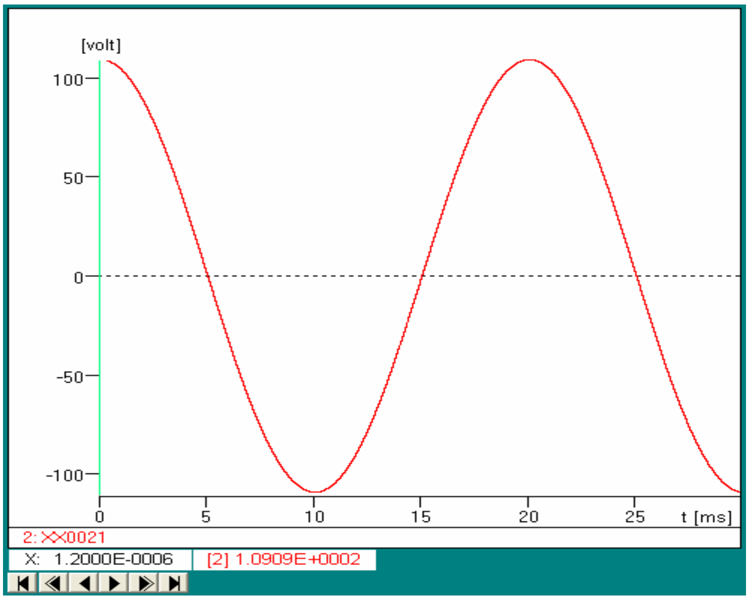
(b)

Figure 4.11: Current and voltage waveform with 3 fingers touching (a) Current at 8μs, and (b) Voltage at 1.2μs

(iv) 4 fingers touching



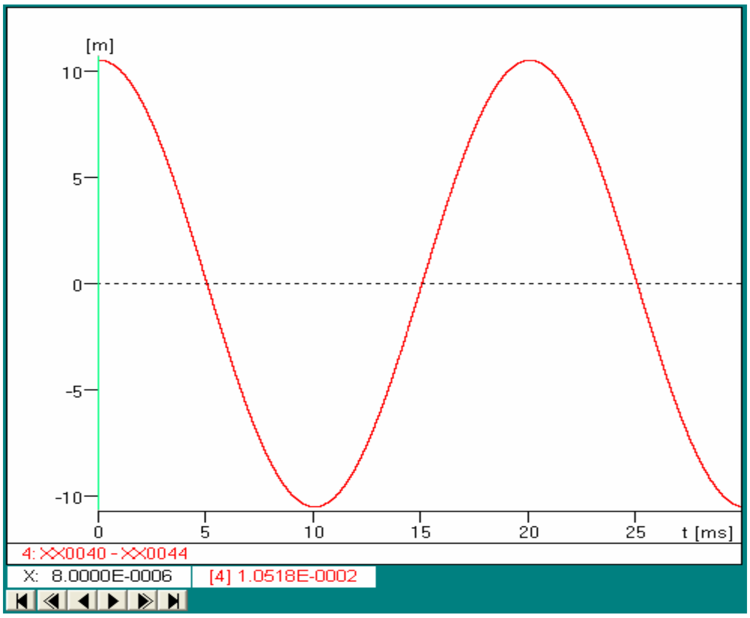
(a)



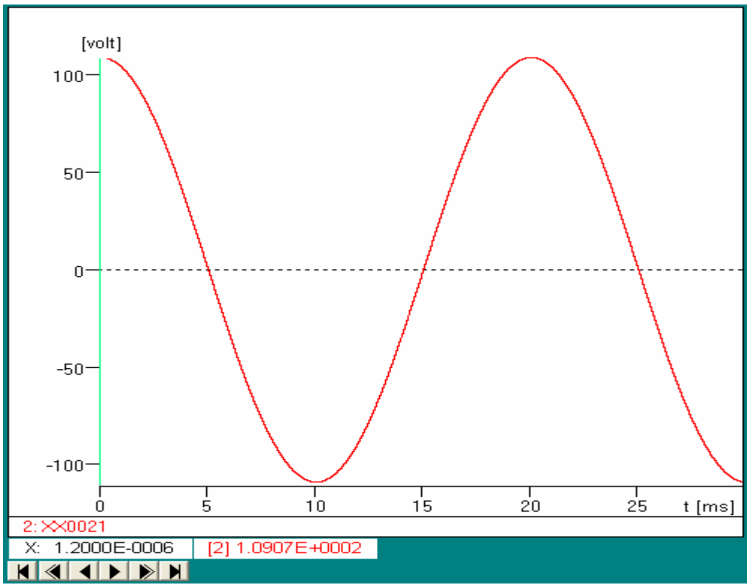
(b)

Figure 4.12: Current and voltage waveform with 4 fingers touching (a) Current at 8μs, and (b) Voltage at 1.2μs

(v) 5 fingers touching



(a)

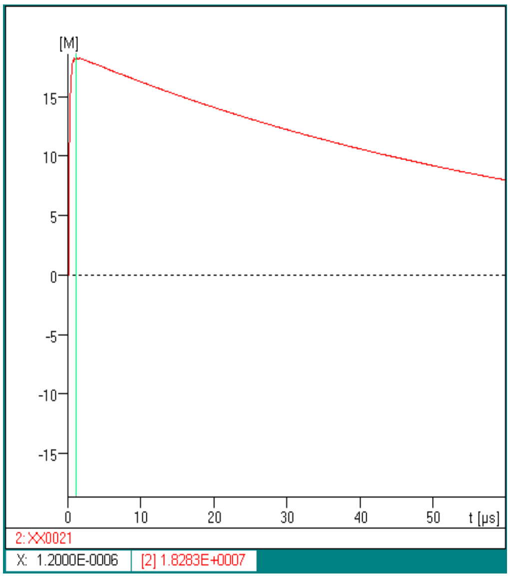


(b)

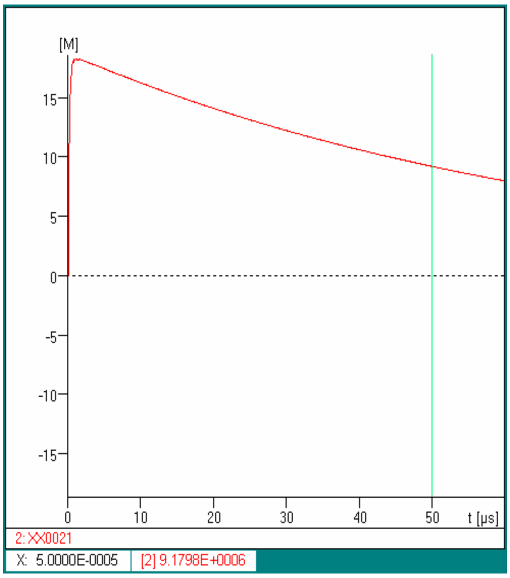
Figure 4.13: Current and voltage waveform with 5 fingers touching (a) Current at 8μs, and (b) Voltage at 1.2μs

4.3.2 Simulation by impulse source

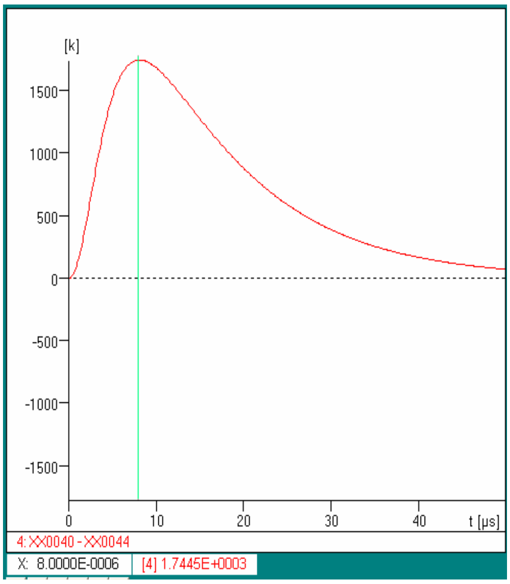
(i) 1 finger touching



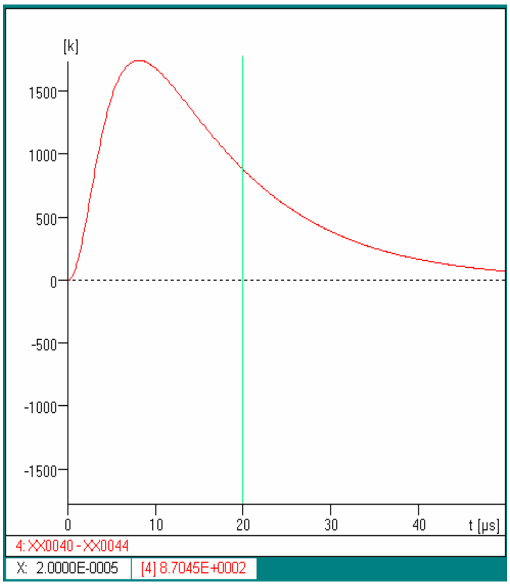
(a)



(b)



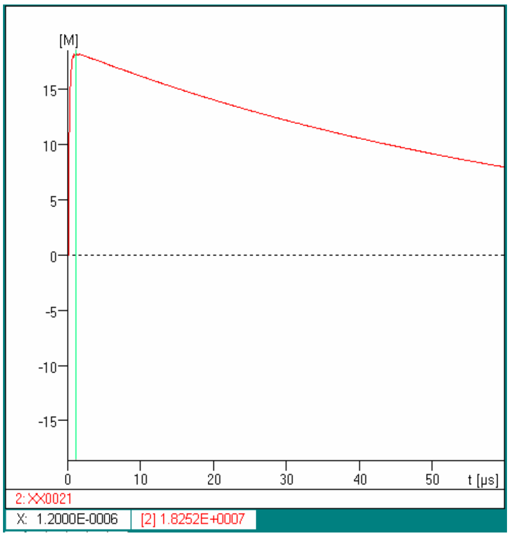
(c)



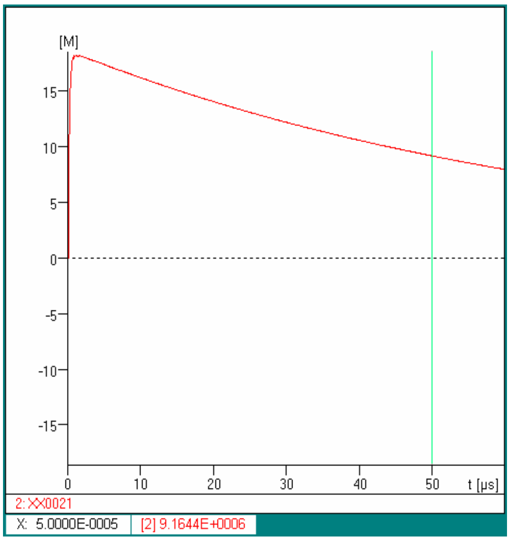
(d)

Figure 4.14: Voltage and current waveform with 1 finger touching (a) & (b) for voltage at 1.2/50µs, and (c) & (d) current at 8/20µs

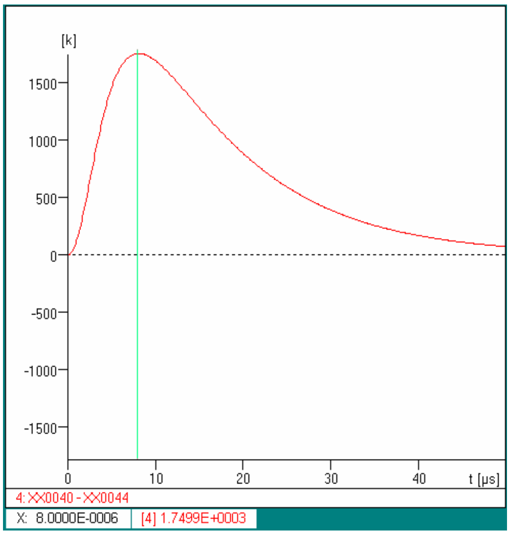
(ii) 2 fingers touching



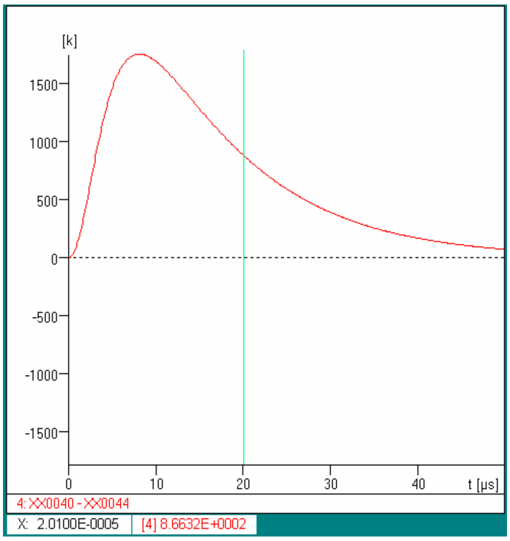
(a)



(b)



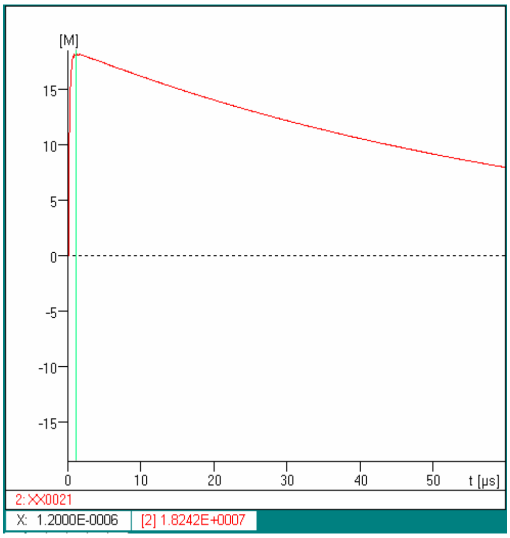
(c)



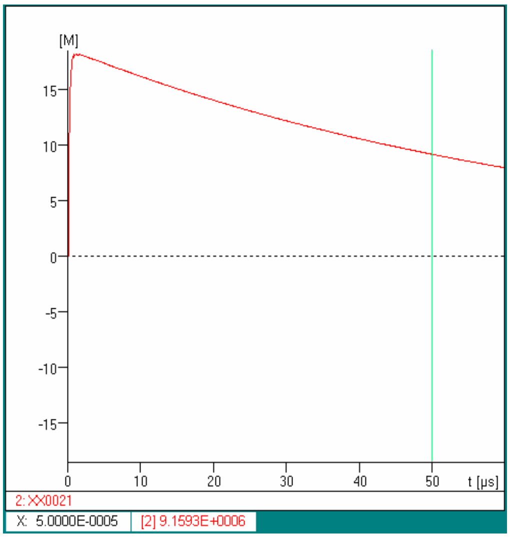
(d)

Figure 4.15: Voltage and current waveform with 2 fingers touching (a) & (b) for voltage at 1.2/50µs, and (c) & (d) current at 8/20µs

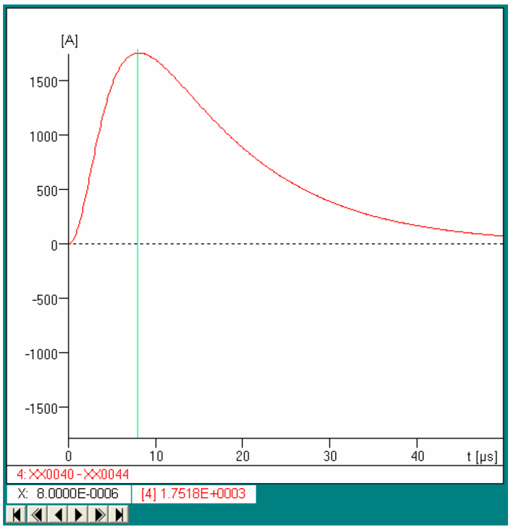
(iii) 3 fingers touching



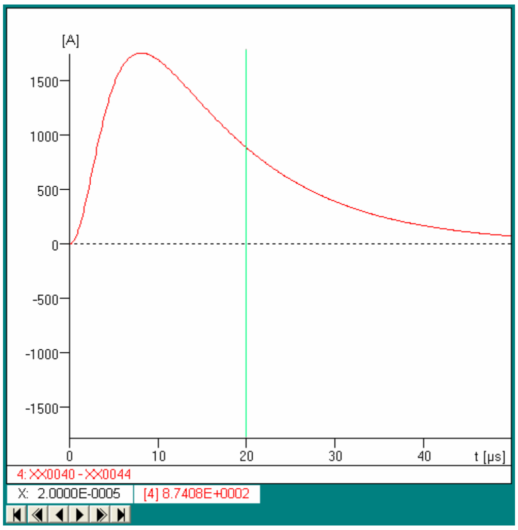
(a)



(b)



(c)



(d)

Figure 4.16: Voltage and current waveform with 3 fingers touching (a) & (b) for voltage at 1.2/50µs, and (c) & (d) current at 8/20µs

(iv) 4 fingers touching

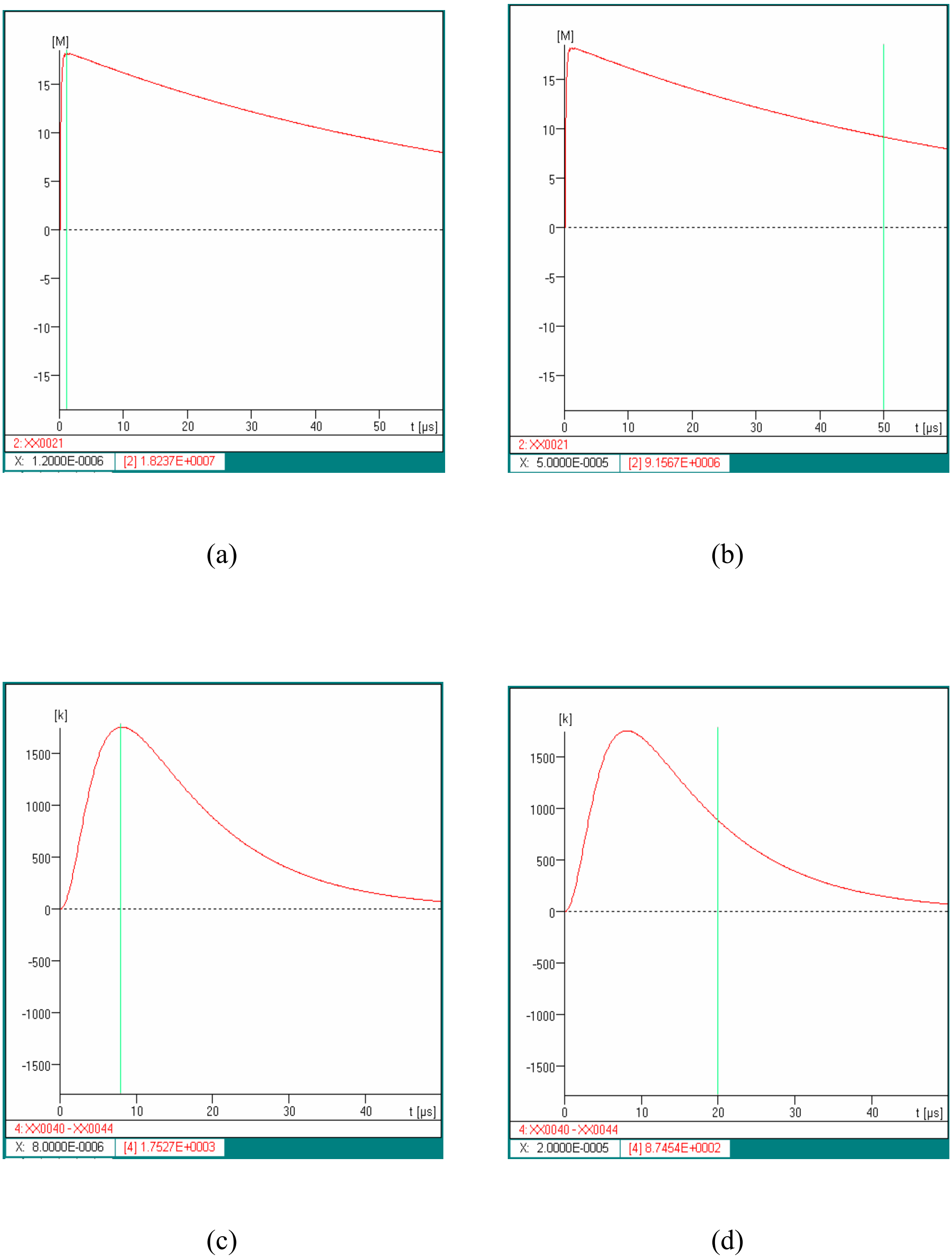
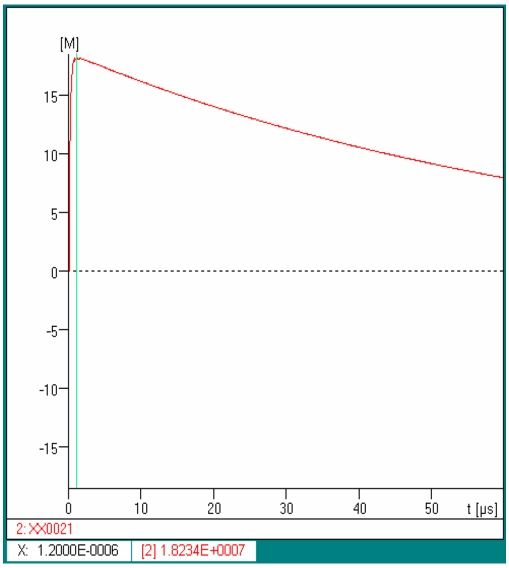
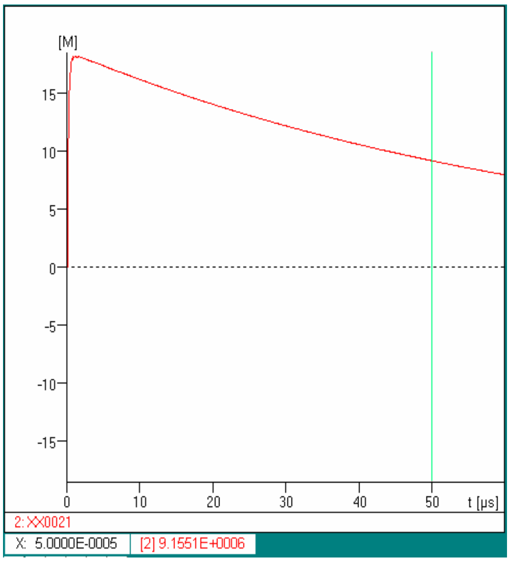


Figure 4.17: Voltage and current waveform with 4 fingers touching (a) & (b) for voltage at 1.2/50µs, and (c) & (d) current at 8/20µs

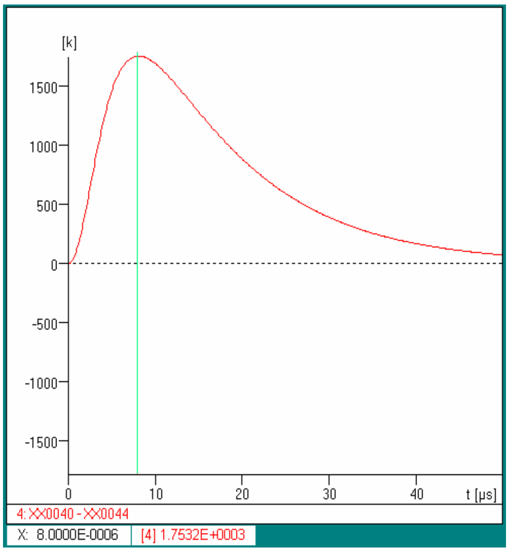
(v) 5 fingers touching



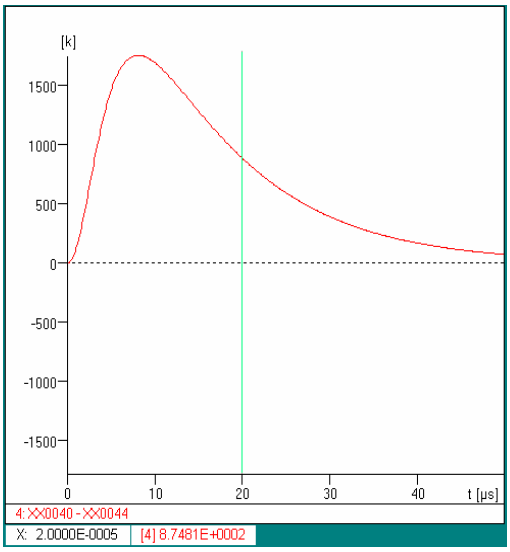
(a)



(b)



(c)



(d)

Figure 4.18: Voltage and current waveform with 5 fingers touching (a) & (b) for voltage at 1.2/50µs, and (c) & (d) current at 8/20µs

4.4 Summary

Table 4.19 and 4.20 are the summarized for the simulation which are injected by AC source and impulse source. The result then compared with the calculation.

Table 4.19: Result for using AC source

Finger(s)	Resistance (kΩ)	Current (mA)		Voltage (V)	
		Calculation	Simulation	Calculation	Simulation
1 finger	10.450	10.467	10.465	109.38	109.36
2 fingers	10.400	10.500	10.496	109.18	109.18
3 fingers	10.383	10.510	10.509	109.12	109.12
4 fingers	10.375	10.516	10.514	109.10	109.09
5 fingers	10.370	10.519	10.518	109.08	109.07

Table 4.20: Result for using impulse source

Finger(s)	Resistance (kΩ)	Current (kA)		Voltage (MV)	
		Calculation	Simulation	Calculation	Simulation
1 finger	10.450	1.7445	1.7445	18.230	18.283
2 fingers	10.400	1.7500	1.7499	18.200	18.252
3 fingers	10.383	1.7518	1.7518	18.189	18.242
4 fingers	10.375	1.7527	1.7527	18.184	18.237
5 fingers	10.370	1.7532	1.7532	18.181	18.234

It can be shown that if human hold something with 5 fingers, the current flows will be increased compare to 1 finger as the resistance become reduced. When the simulation result is compared with the calculation, it gives almost the same answer for both impulse and ac injected.

In calculating the body resistance, this thesis is refer to Table 4.21 (taken Environmental, Safety and Health Manual) from where we can see that if the body contact such as finger-thumb grasp, the resistance in dry condition is about 10kΩ to 30kΩ. It become worst scenario, if it happen in the wet condition where the resistance is reduced to about 2kΩ to 5kΩ. Of course the current will be more than 10mA (for using AC source) and can make the individual die immediately.

From the Table 4.22 (also taken from Environmental, Safety and Health Manual) shows that if a men being touching in about 10mA from ac source, he will get painful but voluntary muscle control will maintained while if a women touching the same value of current, she will get painful and unable to let go of wires. In case of the impulse source, the human being will of course die because of the high current.

Table 4.21: Human resistance for various skin-contact

Body Contact Condition	Dry (kΩ)	Wet (kΩ)
Finger touch	40-1000	4-15
Hand holding wire	15-50	3-5
Finger-thumb grasp	10-30	2-5
Hand holding a pliers	5-10	1-3
Palm touch	3-8	1-2
Hand around 1.5in. pipe	1-3	0.5-1.5
2-hand around 1.5in. pipe	0.5-1.5	0.25-0.75
Hand immersed	-	0.2-0.5
Leg immersed	-	0.1-0.3

Table 4.22: Electric current effect an individual

Body Effect	Gender	50 Hz, AC
Slight sensation felt at hand(s)	Men	0.4mA
	Women	0.3mA
Threshold of perception	Men	1.1mA
	Women	0.7mA
Painful, but voluntary muscle control maintained	Men	9mA
	Women	6mA
Painful, unable to let go of wires	Men	16mA
	Women	10.5mA
Severe pain, difficulty breathing	Men	23mA
	Women	15mA
Possible heart fibrillation after 3 seconds	Men	100mA
	Women	100mA

CHAPTER 5

CONCLUSION AND FUTURE WORK

5.1 Conclusion

An electrical safety practices cannot be successful or effective if it is not strongly supported at the highest management level. Management should not delegate electrical safety responsibility, but must show genuine interest in all management levels. Management must believe there is real value in an electrical safety program, both from humanitarian and financial standpoints.

Management should first establish an electrical safety policy and then identify the line organization(s) to implement the policy. Management should also ensure that the program be audited and continually improved. Management should demonstrate by its commitment that safety is truly a top priority in business. To demonstrate this importance, management must be consistent by not lowering safety standards when confronted with other business pressures.

Just as management structures its organization to accomplish other business objectives, the same organizational effort must be directed toward the electrical safety objective. From the top level of management down, management must develop an organization of individuals or teams to perform the functions needed to accomplish the electrical safety objective, that is: management, design, installation, facility operations, maintenance, training, purchasing, visitor and contractor liaison, general industrial safety and electrical safety authority.

In large organization, the managers who have ultimate authority usually do not have the expertise themselves to make decisions in specific technical areas. They delegate that authority or solicit advice from specialists before making final decisions.

Management's electrical safety policy may be stated in a policy manual or in the electrical safety program. Unfortunately, these words are sometimes the extent of management's direction. If management stops with lip service and does not provide adequate direction and resources to carry the policy through implementation, most likely electrical safety performance will be poor.

Electrical equipment integrity is a fundamental part of an electrical safety program. Particular emphasis should be placed on the integrity of the enclosures, insulation, grounding, and circuit protective devices.

Safe electrical work practices are perhaps the most important part of the whole electrical safety program. It is a fact that most injuries and facilities are a result of the actions of people as opposed to workplace conditions. Electrical safety principles should be identified and taught to employees. Electrical safety principles are:

❖ Plan every job.

- ❖ Anticipate unexpected events.
- ❖ Use the right tool for the job.
- ❖ Isolate the equipment.
- ❖ Minimize the hazard.
- ❖ Protect the person.
- ❖ Assess people's abilities.
- ❖ Audit these principles.

The best way to help people avoid hurting themselves is to train them. It is impractical and unnecessary to train all employees to be electrical experts, however, it is important to train them to recognize where electrical hazards might be located both in the workplace and at home. At minimum, employees should be trained on the equipment they use and know how to recognize when something is wrong with any electrical components in their vicinity. They should also be trained to understand what they are not allowed to do.

Persons more directly related to the electrical business need a much deeper and more specific level of training. They need training that covers all of the equipment on which they might work, safe practices and methods, and the use and care of personal protective equipment, tools and test equipment. Training in some emergency response procedures is also important.

Another effective tool for creating electrical safety awareness in the workplace is to display electrical safety-related pictures or posters at strategic locations throughout the employer's facility.

Evaluate every job to determine what protective equipment and tools would lessen the risk of injury. Protective methods are the little extra safety precautions that can be taken to reduce personnel exposure to hazards.

Identify and classify work examples as Energized Circuit or Live Work (Working On), Proximity Work (Working Near), and Testing. Appropriate personal and other protective equipment should be listed for each work example (S. Jamil, H. L. Floyd, and D. A. Pace, 1997).

Typical protective equipment includes, but is not limited to, items such as: voltage-rated gloves with leather protectors, approved test instruments and leads, live-line tools, protective grounding equipment, and grounding cables, fire retardant clothing, nonconductive safety glasses with side shields, nonconductive safety hardhats, arc flash protection face shield with hood, blankets, insulating mats, arc flash protection jackets, etc.

People are not only surrounded by electrically powered equipment, but they also operate and use the equipment. There is fixed equipment such as switchgear, control panels, and wall switches. There is portable equipment such as power tools, extension cords, and test equipment. Provide direction for the proper use of such equipment. The most important thing, properly ground all fixed and portable equipment.

At the start of the each shift, visually inspect and/or test instruments, equipment, all associated test leads, cables, power cords, probes, and connectors. This inspection and testing is the responsibility of the person(s) who will be using these items. If there are defects or evidence of damage that might expose an employee to injury, the defective or damaged item shall not be used until any required repairs or tests have been made (M. Capelli-Schellpfeffer, R. C. Lee, M. Toner, and K. Diller, 1998).

There is a fair amount of documentation that is required in order to have an effective electrical safety program. These documents may include work authorizations, standards, procedures, guidelines, drawings and equipment records.

A good document management system is very important to the safe operation and maintenance of a facility. Outdated or erroneous documents not only cause confusion and delays, but they can also cause electrical-related incidents. Rigorously control distribution of documents so that only the current applicable version is readily available on the job. Superseded documents can be archived, if necessary.

On a regular schedule, perform a self-assessment to determine how well the written electrical safety program is actually being implemented. To be of value, the assessment should be very objective, without trying to blame people. The goal is to improve the safety performance, not to punish employees. Occasionally, it is also prudent to have the company's safety organization, or even an outside-contracted safety auditor, perform an electrical safety audit. This way, a set of eyes not so familiar with the facility and without fear of retaliation from local management, can discover things that self-assessors might overlook.

Audit the written program periodically to identify new or revised requirements based on regulations, standards, or new technologies.

Whenever electrical safety-related incidents or accidents occur, conduct a thorough investigation to determine the root cause and contributing factors. Distribute "Lessons Learned" information to all personnel who could get involved in, or influence decisions about, similar future situations.

The company should have, or have access to, a qualified engineering organization and/or qualified consultants. These persons can be either in-house or contracted employees. These engineers can provide guidance on all aspects of operation, maintenance and safety.

Emergency preparedness is being able to respond quickly to an electrical shock or burn injury could be the difference between the life and death of the victim. All electrical workers should be trained in first aid and CPR.

Know the location and phone number of nearby qualified medical assistance. A phone or some other communication method should be available at every job location that involves work on energised conductors, or has other elements of risk.

Extensive medical research has proven that providing the treating medical facility with vital information on the environment and circumstances related to an electric shock or burn victim is critical and can improve the victim's chances for survival.

Improving any of the elements discussed in this thesis can make improvements in electrical safety performance. However, step change improvements can only be made by addressing electrical safety in a holistic manner. Electrical safety is a process and processes only work effectively when all parts of that process are working correctly.

The simulation studies done is to show how much current flow through the body and the effect to the human when they are touch in current/lightning.

5.2 Suggestion for Future Work

After analyzed data from the industries, most of the accidents occur in the medium industry (TNB). Therefore, for future work I suggest that we focus the electrical safety practices in TNB in every state in Malaysia, analyze the hazard analysis and study on the performance and practically of the new technique/method which to be proposed to make improvement and better performance by reduce the number of injury. As suggested before, TNB can make a continuous improvement in “switching simulation program” to expose the workers to show the dangerous of the electricity to human being should go towards behaviors based safety.

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APPENDIX A

CASE STUDY

Non-Death Accident Case
At Jln Tan Swee Hoe, Tmn Bkt Pasir,
Batu Pahat, Johor
On 02 Dec 2005

Case Background

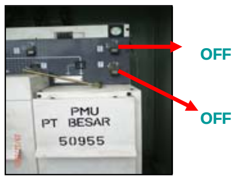
- **Electrical Accident (Non-Death)**
- **Involved TNB worker (Batu Pahat)**
- **Date Happened**
  02 Dec 2005 (Friday), Time 01:30 a.m.
- **Location** :
  At Jalan Tan Swee Hoe, Tmn Bkt Pasir Batu Pahat, Johor Darul Takzim
- **Touching Arc Flash during jointing HV Cable, 11kV**

Flows of Incident..

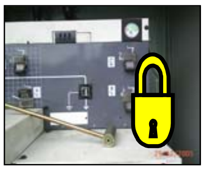
01 Dec 2005, Supply No#11, PMU Prt Besar was sprawled. AP Hamzah Mohd noticed that the fault was caused from HV cable PMU Prt Besar to C/S Jln Kundang No.1

21:30, Cik Fareha (OIC) assigned AP Tn. Hj. Ismon to do the repairing work

Tn Hj Ismon with his '*Competant Person*' En Mohaini Bin Ahmad, went to C/S Jln Kundang No.1



'Cable Earth' slot & 'Circuit' slot are in "OFF" position



Lock with 'nonstandard lock' and start doing "cutting and jointing" work.

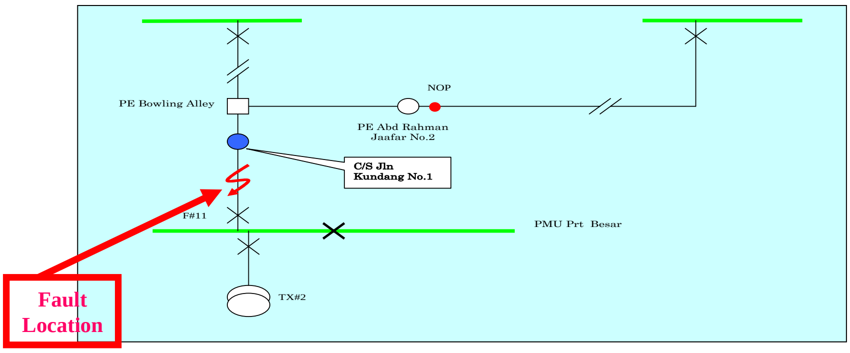
02 Dec 2005 @ 01:30, Arc flash occurred during the Jointer Cable Team doing the jointing.

Condition of Victim Hand..

En. Faryzzal Harun right hand was blistered at

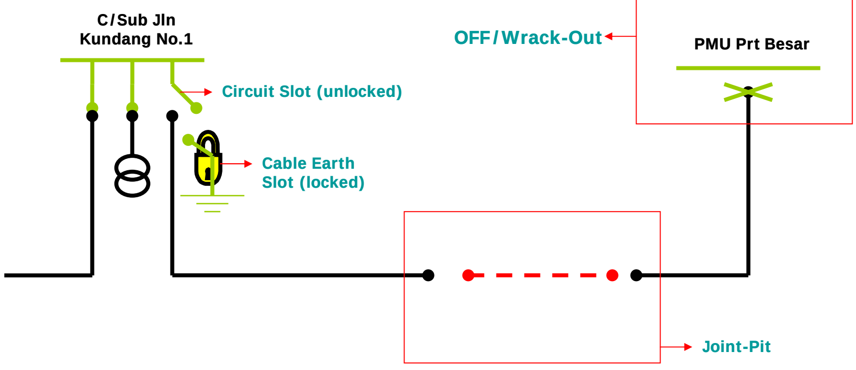
1st Degree burn from palm of the hand up to his wrist.

At the Site..



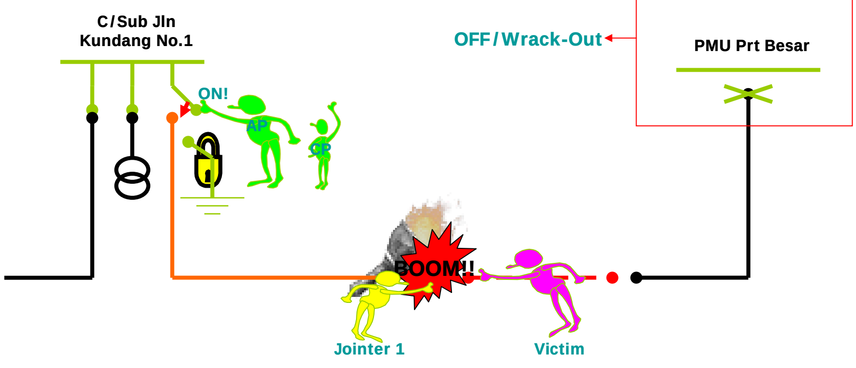
Schematic diagram : HV underground cable 11kV from PMU Prt Besar to C/Sub Jln Kundang No.1

At the site..



*AP was putting '*nonstandard lock*' at the slot '*cable earth*' and not at the slot '*circuit*' on the switch *Merlin Gerin* di C/S Jln Kundang No.1

At the site..



*AP do not inform the Jointer that he will be going to C/Sub Kundang No.1 for install the 'resistor' for 'dead phasing' activity.

Analysis at the site..

- AP do not issued the PTW to CP/Jointer whose doing the repairing work.
- Communication between AP & CP is slow and CP do not ‘counter check’ the AP activity.

Analysis at the site..

Location : Jln Tan Swee Hoe, Tmn Bkt Pasir
(The effect of span over cable)

Analysis at the site..

- Exchange of AP to continue the repairing the fault cable works.
- Tn. Hj. Ismon just finished his work on new installation and feel tired when he received instruction from Cik Fareha.

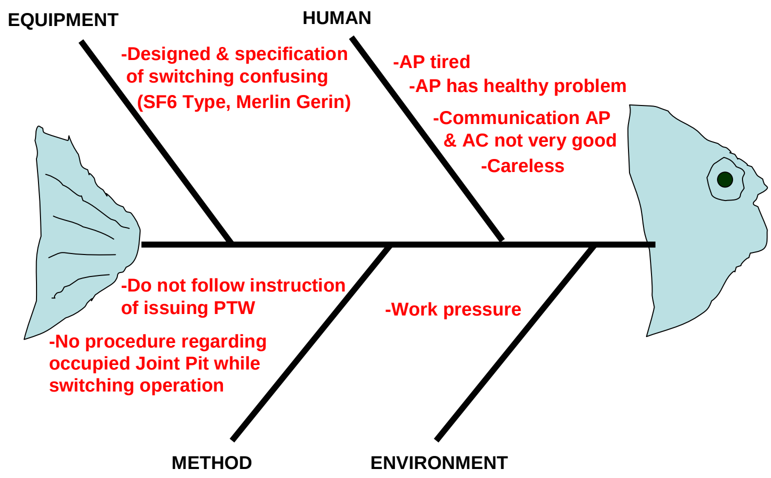
Analysis at the site..

The positions of 'cable earth' slot and 'circuit' slot confusing because not clearly label.

Causes of the Accident..

- The accident occur because of the electric arc flash at the HV underground cable while the Cable Jointer Team is cutting and to skin the cable was switch on unpurposely.
- The switching is switch at the wrong slot. (The switching was done at ***circuit*** slot not at the ***cable earth*** slot).

ANALYSIS



Suggestion for Correction/ Prevention Action

- **Strictly follow the instruction of issuing PTW.**
- ***Competant Person* (CP) must be exposed to his work and responsible while doing switching operation. This can be done by attending regarding awareness and safety courses/training.**
- **Instruction must be done to Cable Jointer Team for not to hold the cable/stay near the Joint Pit while switching operation is made at the same circuit.**
- **Job hand over procedure should be documented between AP to AP approved by OIC.**
- **Designation and specification of switching Merlin Gerin type must be take into account to avoid from confusing.**

Conclusion

- **Accident can be avoid if discussion / counter check is done before and after any action taken between the CP and AP involved during the switching operation.**
- **Cable Jointer Team must not stay in the Joint Pit area / holding any cable during switching operation in the same circuit.**
- **Certificate of Competence of the AP was suspended temporarily.**

APPENDIX B

ELECTRICAL SAFETY

TRAINING AID

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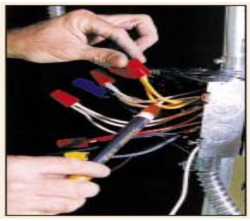
Electricity is Dangerous

Whenever you work with power tools on electrical circuits there is a risk of electrical hazards, especially electrical shock. Anyone can be exposed to these hazards at home or at work. Workers are exposed to more hazards because job sites can be cluttered with tools and materials, fast-paced, and open to the weather. Risk is also higher at work because many jobs involve electric power tools.

Electrical trade workers must pay attention to electrical hazards because they work on electrical circuits. Coming in contact with an electrical voltage can cause current to flow through the body, resulting in electrical shock and burns. Serious injury or even death may occur.



Always test a circuit to make sure it is de-energized before working on it

How is an Electrical Shock Received?

- **When electrical current passes through the body.**
- **Current will pass in a variety of situations.**
- **Whenever two wires are at different voltages, current will pass between them if they are connected. Your body can connect the wires if you touch both of them at the same time. Current will pass through your body.**
- **If you are in contact with a live wire or any live component of an energized device, and also in contact with any grounded objects, you will receive a shock.**
- **Your risk of receiving a shock is greater if you stand in a puddle of water.**
- **Wet clothing, high humidity, and perspiration also increase your chances of being electrocuted. Of course, there is always a chance of electrocution, even in dry conditions.**

Metal electrical boxes should be grounded to prevent shock.

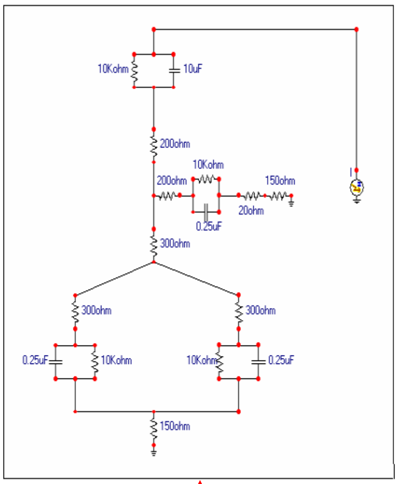
Danger of Electrical Shock

-The severity of injury from electrical shock depends on the amount of electrical current and the length of time the current passes through the body.

- e.g. 1/10 Amp of electricity going through the body for just 2 seconds is enough to cause death.

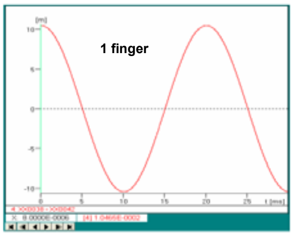
- The amount of internal current a person can withstand and still be able to control the muscles of the arm and hand can be less than 10 mA.

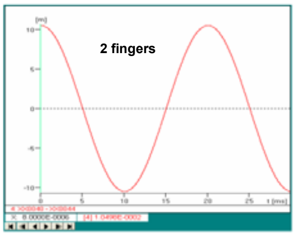
- Current above 10 mA can paralyze. A persons is no longer able to release a tool, wire, or other object. The electrified object may be held even more tightly, resulting in longer exposure to the shocking current. For this reason, hand-held tools that give a shock can be very dangerous.

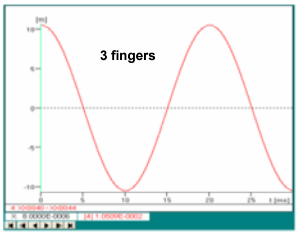


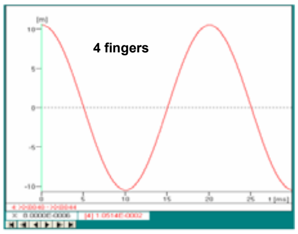
The current passes through body can be simulate by human body model using AC supply of 30mA, 50Hz.

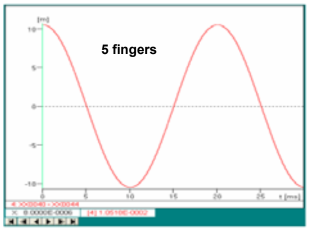
Simulation result using ATP-EMTP software to show the effect of the current to human when they are in touch with 1 to 5 fingers











Simulation Result

Finger(s)	Resistance (kΩ)	Current (mA)
1	10.450	**10.465**
2	10.400	**10.496**
3	10.383	**10.509**
4	10.375	**10.514**
5	10.370	**10.518**

It can be shown that if human hold something with 5 fingers, the current flows will be increased compare to 1 finger as the resistance become reduced.

Table below shows what usually happens for a range of currents lasting 1 second. Longer exposure times increase the danger to the shock victim.

Effects of Electrical Current* on the Body

Current	Reaction
1 milliamp	Just a faint tingle.
5 milliamps	Slight shock felt. Disturbing, but not painful. Most people can "let go." However, strong involuntary movements can cause injuries.
6–25 milliamps (women)† **9–30 milliamps** (men)	Painful shock. Muscular control is lost. This is the range where "freezing currents" start. It may not be possible to "let go."
50–150 milliamps	Extremely painful shock, respiratory arrest (breathing stops), severe muscle contractions. Flexor muscles may cause holding on; extensor muscles may cause intense pushing away. Death is possible.
1,000–4,300 milliamps (1–4.3 amps)	Ventricular fibrillation (heart pumping action not rhythmic) occurs. Muscles contract; nerve damage occurs. Death is likely.
10,000 milliamps (10 amps)	Cardiac arrest and severe burns occur. Death is probable.
15,000 milliamps (15 amps)	Lowest overcurrent at which a typical fuse or circuit breaker opens a circuit!

*Effects are for voltages less than about 600 volts. Higher voltages also cause severe burns.
†Differences in muscle and fat content affect the severity of shock.

High Voltage

- **Sometimes HV lead to additional injuries.**
- **HV can cause violent muscular contractions. You may lose your balance and fall, which can cause injury/death if you fall into machinery that can crush you.**
- **HV can also cause severe burns.**
- **At 600 volts, the current through the body may be as great as 4 A, causing damage to internal organs such as heart.**
- **Even if the electrical current is too small to cause injury, your reaction to the shock may cause you to fall, resulting in bruises, broken bones, or even death.**

Electrical burn on hand and arm

Arm with 3rd degree burn from HV line

Burns Caused by Electricity

- The most common shock-related, nonfatal injury is a burn.
- Burns caused by electricity :
  i. Electrical burns
  ii. Arc burns
  iii. Thermal contact burns
- Electrical burns can result when a person touches electrical wiring or equipment that is used or maintained improperly.
- Electrical burns are one of the most serious injuries you can receive.
- They need to be given immediate attention.
- Clothing may catch fire and a thermal burn may result from the heat of the fire.
- Arc blasts occur when powerful high-amperage currents arc through the air.
- Arching is the luminous electrical discharge that occurs when high voltages exists across a gap between conductors and current travels through the air.
- This situation is often caused by equipment failure due to abuse or fatigue.

Contact electrical burns.
The knee on the left was energized, and the knee on the right was grounded.

What Should I Do If a Co-Worker is Shocked or Burned by Electricity?

- Shut off the electrical current if the victim is still in contact with the energized circuit. While you do this, have someone else call for help.
- If you cannot get to the switchgear quickly, pry the victim from the circuit with something that does not conduct electricity such as dry wood.

Do not touch the victim yourself if he/she is still in contact with an electrical circuit.

- Do not leave the victim unless there is absolutely no other option. You should stay with the victim while Emergency Medical Services is contacted. The caller should come back to you afterwards to verify that the call was made.
- If the victim is not breathing, does not have a heartbeat, or is badly injured, quick response by a team of emergency medical technicians or paramedics gives the best chance for survival.
- Once you know that electrical current is no longer flowing through the victim, call out the victim to see if he /she is conscious (awake).

Continue….

❖ If the victim is conscious, tell the victim not to move. Quickly examine the victim for signs of major bleeding. If there is a lot of bleeding, place a cloth over the wound and apply pressure. Keep the victim warm and talk to him/her until help arrives.

❖ If the victim is unconscious, check for signs of breathing. Move the victim as little as possible. If the victim is not breathing, someone trained in CPR should begin artificial breathing, then check to see if the victim has a pulse. To be effective, CPR must performed within 4 minutes of the shock.

What Must Be Done to Be Safe?

❖ Use the three-stage safety model :
recognize, evaluate & control hazards.
❖ To be safe, think about your job and plan for hazards.
❖ To avoid injury or death, you must understand and recognize hazards.
❖ You need to evaluate the situation you are in & assess you're your risks.
❖ You need to control hazards by creating a safe work practices, and by reporting hazards to a supervisor.

If you do not recognize, evaluate & control hazards, you may be injured or killed by the electricity itself, electrical fires, or falls.

Recognize Hazards…..

❖ It is best to discuss and plan hazard recognition tasks with your co-workers.
❖ Careful planning of safety procedures reduces the risk of injury.
❖ Decisions to lock out and tag out circuits and equipment need to be made during this part of the safety model.

OSHA regulations provide a wide range of safety information. Knowledge of OSHA standards is an important part of training for electrical apprentices.

Always lock out and tag out circuits

Evaluate Hazards…..

❖ It is best to identify all possible hazards first, then evaluate the risk of injury from each hazards. Do not assume the risk is low until you evaluate the hazard.
❖ It is dangerous to overlook hazards. Job sites are especially dangerous because they are always changing and exposed to bad weather.
❖ A reasonable place to work on a bright, sunny day might be very hazardous in the rain.

The risks in your work environment need to be evaluated all the time. Then, whatever hazards present need to be controlled.

Control Hazards…..

❖ Once electrical hazards have been recognized and evaluated, they must be controlled. Control electrical hazards in 2 ways:

i. create a safe work environment, and
ii. Use safe work practices.

Controlling electrical hazards reduces the risks of injury or death.

How Do You Recognize Hazards?

The 1st step toward protecting yourself is recognizing the many hazards you face on the job. To do this, you must know which situation can place you in danger. Knowing where to look helps you to recognize hazards.

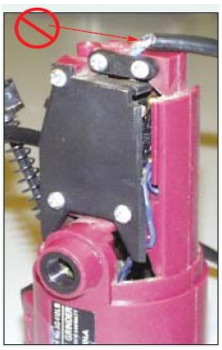
1) Inadequate wiring is dangerous.
2) Exposed electrical parts are dangerous.
3) Overhead power lines are dangerous.
4) Wires with bad insulation can give you a shock.
5) Electrical systems & tools that are not grounded or double-insulated are dangerous.
6) Overloaded circuits are dangerous.
7) Damaged power tools & equipment are electrical hazards.
8) Using the wrong PPE & tools are dangerous.
9) Some on-site chemicals are harmful.
10) Defective ladders & scaffolding are dangerous.
11) Ladders that conduct electricity are dangerous.
12) Electrical hazards can be made worse, if the worker, location, or equipment is wet.

1. Inadequate Wiring Hazards

- An electrical hazard exists when the wire is too small gauge for the current it will carry. Normally, the circuit breaker in a circuit is matched to the wire size.
- However, in older wiring, branch lines to permanent ceiling light fixtures could be wired with a smaller gauge than the supply cable. The current capacity of the branch wire could be exceeded. When a wire is too small for the current it is supposed to carry, the wire will heat up. The heated wire could cause a fire.

2. Exposed Electrical Parts Hazards

- Electrical hazards exists when wires or other electrical parts are exposed. Wires and parts can be exposed if a cover is removed from a wiring or breaker box.

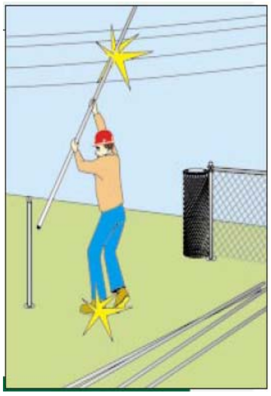


This hand-held sander has exposed wires and should not be used.

3. Overhead Power Line Hazards

➢ Overhead power lines are not insulated. More than half of all electrocutions are caused by direct worker contact with energized power lines. Due to such incidents, all linemen now wear special rubber gloves that protect them up to 34,500 volts.

Overhead power lines killed many workers



4. Defective Insulation Hazards

➢ Insulation that is defective or inadequate is an electrical hazard. Usually, a plastic or rubber covering insulates wires. Insulation prevents conductors from coming in contact with each other and with people.

5. Improper Grounding Hazards

➢ When an electrical system is not grounded properly, a hazard exists.

➢ The metal parts of an electrical wiring systems that we touch should be grounded and at 0 volts.

➢ If the system is not grounded properly, these parts may become energized and a hazards exists because unwanted voltage cannot be safely eliminated.

➢ If there is no safe to ground for fault currents, exposed metal parts in damaged appliances can become energized.

➢ A Ground Fault Circuit Interrupter (GFCI) is an inexpensive life-saver. GFCI's detect any difference in current between the two circuit wires. The difference in current could happen when electrical equipment is not working correctly, causing leakage current.

➢ If leakage current (a ground fault) is detected in a GFCI protected circuit, the GFCI switches off the current in the circuit, protecting you from a dangerous shock.

6. Overload Hazards

- Overloads in an electrical system are hazardous because they can produce heat or arcing.
- Wires and other components in an electrical system or circuit have a maximum amount of current they can carry safely. If too many devices are plugged into a circuit, the electrical current will heat the wires to a very high temperature.
- The temperature of the wires can be high enough to cause a fire. If the insulation melts, arcing may occur. Arcing can cause a fire in the area where the overload exists, even inside the wall.
- In order to prevent too much current in a circuit, a circuit breaker or fuse is placed in the circuit. If there is too much current in the circuit, the breaker "trips" and opens like a switch.
- If an overload circuit is equipped with a fuse, an internal part of the fuse melts, opening the circuit.
- Both breakers and fuses do the same thing: open the circuit to shut off the electrical current.

Overloads are the major cause of fires.

7. Wet Condition Hazards

- Working in wet conditions is hazardous because you may become an easy path for electrical current.
- If you touch a live wire or other electrical component, and you are well-grounded because you are standing in even a small puddle of water, you will receive a shock.
- Wet clothing, humidity, and perspiration also increase your chances of being electrocuted.

8. Additional Hazards

In addition to electrical hazards, other types of hazards are present at job sites. Remember that all of these hazards can be controlled.

- Frequent overhead work can cause tendinitis (inflammation) in your shoulders.
- Intensive use of hand tools that involve force or twisting can cause tendinitis of hands, wrist, or elbow. Use of hand tools can also cause carpal tunnel syndrome, which results when nerves in the wrist are damaged by swelling tendons or contracting muscles.

Overhead work can cause long term shoulder pain.

Continue Additional Hazards…..

Lift with your legs, not your back.

➢ Low back pain can result from lifting objects the wrong way or carrying heavy loads of wire or other material. Back pain can also occur as a result of injury from poor working surfaces such as wet or slippery floor.

➢ Chips and particles flying from tools can injure your eyes. Wear eye protection.

➢ Falling objects can hit you. Wear a hard hat.

➢ Sharp tools and power equipment can cause cuts and other injuries. If you receive a shock, you may react and be hurt by a tool.

➢ You can be injured or killed by falling from a ladder or scaffolding.

➢ You expose yourself to hazards when you do not wear PPE.

How Do You Evaluate Your Risk?

➢ After recognize a hazard, your next step is to evaluate your risk from the hazard.

➢ Obviously, exposed wires should be recognized a hazard. If the exposed wires are 15 feet off the ground, your risk is low. However, if you are going to be working on a roof near those same wires, your risk is high.

➢ The risk of shock is greater if you will be carrying metal conduit that could touch the exposed wires. You must constantly evaluate your risk.

➢ Combination of hazards increase your risk. Improper grounding and a damaged tool greatly increase your risk.

➢ You will need to make decisions about the nature of hazards in order to evaluate your risk and do the right thing to remain safe.

Combinations of hazards increase risk.

Continue…..How Do You Evaluate Your Risk?

You must evaluate the "clue" and decide what action should be taken to control the hazard. There are a number of other conditions that indicate a hazard.

1) Tripped circuit breakers and blown fuses show that too much current is flowing in a circuit. This condition could be due to several factors, such as malfunctioning equipment or a short between conductors. You need to determine the cause in order to control the hazard.
2) An electrical tool, appliance, wire, or connection that feels warm may indicate too much current in the circuit or equipment. You need to evaluate the situation and determine your risk.
3) An extension cord that feels warm may indicate too much current for the wire size of the cord. You must decide when action needs to be taken.
4) A cable, fuse box, or junction box that feels warm may indicate too much current in the circuit.
5) A burning odor may indicate overheated insulation.
6) Worn, frayed, or damaged insulation around any wire or other conductor is an electrical hazard because the conductors could be exposed. Contact with an exposed wire could cause a shock. Damaged insulation could cause a short, leading to arcing or a fire. Inspect all insulation for scrapes and breaks. You need to evaluate the seriousness of any damage you find and decide how to deal with the hazard.
7) A GFCI that trips indicates that is current leakage from the circuit. First, you must decide the probable cause of the leakage by recognizing any contributing hazards. Then, you must decide what action needs to be taken.

How Do You Control Hazards?

➢ In order to control hazards, you must first **create a safe work environment**, then work in a safe manner. When OSHA regulations are followed, safe work environment are created.

➢ You never know when materials or equipment might fail. Prepare yourself for the unexpected by using safe work practices. Use as many safeguards as possible. If one fails, another may protect you from injury or death.

How Do You Create a Safe Work Environment?

- A safe work environment is created by controlling contact with electrical voltages and the currents they can cause.
- Electrical currents need to be controlled so they do not pass through the body.
- In addition to preventing shocks, a safe work environment reduces the chance of fires, burns, and falls.

Continue….. How Do You Create A Safe Work Environment?

You need to guard against contact with electrical voltages and control electrical currents in order to create a safe work environment. Make your environment safer by doing the following :

a) Treat all conductors (even "de-energized" ones) as if they are energized until they are locked out and tagged.
b) Lock out and tag out circuits and machines.
c) Prevent overloaded wiring by using the right size and type of wire.
d) Prevent exposure to live electrical parts by isolate them.
e) Prevent exposure to live wires and parts by using insulation.
f) Prevent shocking currents from electrical systems and tools by grounding them.
g) Prevent shocking currents by using GFCI's.
h) Prevent too much current in circuits by using overcurrent protection devices.

Lock Out and Tag Out Circuits & Equipment

- Before working on a circuit, you must turn off the power supply.
- Once the circuit has been shut off and de-energized, lock out the switchgear to the circuit so the power cannot be turned back on inadvertently.
- Then, tag out the circuit with an easy-to-see sign or label that lets everyone know that you are working on the circuit.
- If you are working on or near machinery, you must lock out and tag out the machinery to prevent startup.
- Before you begin work, you must test the circuit to make sure it is de-energized.

Always test a circuit to make sure it is de-energized before working on it.

Lock-out/tag-out saves lives.

Control Inadequate Wiring Hazards

- Electrical hazards result from using the wrong size or type of wire.
- You must control such hazards to create a safe work environment.
- You must choose the right size wire for the amount of current safely.
- The wire's insulation must be appropriate for the voltage and touch enough for the environment.
- Connections need to be reliable and protected.

Control Hazards of Fixed Wiring

The wiring methods and size of conductors used in a system depend on several factors:

- Intended use of the circuit system.
- Building materials.
- Size and distribution of electrical load.
- Location of equipment (such as underground).
- Environmental conditions (such as dampness)
- Presence of corrosives.
- Temperature extremes.

Control Hazards of Exposed Live Electrical Parts: Isolate Energized Components

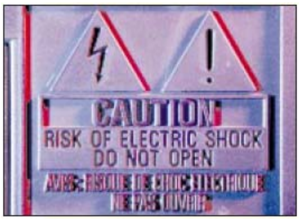
- Electrical hazards exist when wires or other electrical parts are exposed.
- These hazards need to be controlled to create a safe work environment.
- Isolation of energized electrical parts makes them inaccessible unless tools and special effort are used.
- Isolation can be accomplished by placing the energized parts at least 8 feet high and out of reach, or by guarding.

Use covers to prevent accidental contact with electrical circuits.

Continue…..

Take the following precautions to prevent injuries from contact with live parts:

- Immediately report exposed live parts to a supervisor.
- Provide guards or barriers if live parts cannot be enclosed completely.
- Use covers, screens, or partitions for guarding that require tools to remove them.
- Replace covers that have been removed from panels, motors, or fuse boxes.
- Even when live parts are elevated to the required height (8 feet), care should be taken when using objects that can contact these parts.
- Close unused conduit openings in boxes so that foreign objects cannot get inside and damage the circuit.



This cover cannot be removed without special tools.

Control Hazards of Exposure to Live Electrical Wires: Use Proper Insulation

- Insulation is made of material that does not conduct electricity.
- Insulation covers wires and prevents conductors from coming in contact with each other conductor.
- If conductors are allowed to make contact, a short circuit is created.
- In a short circuit, current passes through the shorting material without passing through a load in the circuit, and the wire becomes overheated.
- Insulation keeps wires and other conductors from touching, which prevents electrical short circuits.
- Insulation prevents live wires from touching people and animals, thus protecting them from electrical shock.
- Insulation helps protect wires from physical damage and conditions in the environment.

Control Hazards of Shocking Currents

- **Ground circuits and equipment.**

Equipment needs to be grounded under any of these circumstances:

i. The equipment is within 8 feet vertically and 5 feet horizontally of the floor walking surface.
ii. The equipment is within 8 feet vertically and 5 feet horizontally of grounded metal objects you can touch.
iii. The equipment is located in a wet or damp area and is not isolated.
iv. The equipment is connected to a power supply by cord & plug and is not double-insulated.

Grounding rod in the earth

- **Use GFCI's in high risk situation.**

i. Electricity is used near water.
ii. The user of electrical equipment is grounded.
iii. Circuits are providing power to portable tools or outdoor receptacles.
iv. Temporary wiring or extension cords are used.

Portable GFCI

Continue…..

- **Bonding components to assure grounding path.**

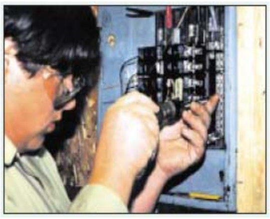
In order to assure a continuous, reliable electrical path to ground, a bonding jumper wire is used to make sure electrical parts are connected.

Some physical connections, like metal conduit coming into a box, might not make a good electrical connection because of paint or possible corrosion. To make a good electrical connection, a bonding jumper needs to be installed.

Install bonding jumpers around conductive material.

Control Overload Current Hazards

- When a current exceeds the current rating of equipment or wiring, a hazard exists.
- The wiring in the circuit, equipment, or tool cannot handle the current without heating up or even melting.
- Not only will the wiring or tool be damaged, but the high temperature of the conductor can also cause a fire.
- To prevent this from happening, an overcurrent protection device (circuit breaker or fuse) is used in a circuit.
- This devices open a circuit automatically if they detect current in excess of the current rating of equipment or wiring.
- This excess current can be caused by an overload, short circuit, or high-level ground fault.



Use overcurrent protection devices (circuit breakers or fuses) in circuits.

CONTROLLING HAZARDS: SAFE WORK PRACTICES

How Do You Work Safely?

- Safe work practices help you control your risk of injury or death from workplace hazards.
- If you are working on electrical circuits or with electrical tools and equipment, you need to use safe work practices.
- Before you begin a task, ask yourself:
  - What could go wrong?
  - Do I have the knowledge, tools, and experience to do this work safely?
- All workers should be very familiar with the safety procedures for their jobs.
- Control electrical hazards through safe work practices:
  1. Plan your work and plan for safety.
  2. Avoid wet working condition and other dangers.
  3. Avoid overhead powerlines.
  4. Use proper wiring and connectors.
  5. Use and maintain tools properly.
  6. Wear correct PPE.

1. Plan Your Work and Plan For Safety

- ❖ Take time to plan your work, by yourself and with others.
- ❖ Safety planning is important part of any task.
- ❖ It takes effort to recognize, evaluate, and control hazards.
- ❖ Planning with others is especially helpful. It allows you to coordinate your work and take advantage of what others know about identifying and controlling hazards.
- ❖ The following is a list of some things to think about as you plan:
  - ❑ Work with a "buddy" - Do not work alone. Both of you should trained in CPR and must know what to do in an emergency.
  - ❑ Know how to shut off and de-energized circuits – You must find where circuit breakers, fuses, and switches are located. Then, the circuits that you will be working on (even low-voltage circuits) MUST BE TURNED OFF! Test the circuits before beginning work to make sure they are completely de-energized.

Test circuits to make sure they are de-energized

Continue…..

❑ Plan to lock out and tag out circuits and equipment – Make certain all energy sources are locked out and tagged out before performing any work on an electrical circuit or electrical device. Working on energized (hot) circuits is one of the most dangerous things any worker could do. If someone turns on a circuit without warning, you can be shocked, burned, or electrocuted. The unexpected starting of electrical equipment can cause severe injury or death.

This worker is applying a group of lock-out device. The equipment cannot be re-started until their workers remove their locks.

❑ Remove jewelry and metal objects – Remove them from your body before beginning work. These things can cause burns if worn near high currents and can get caught as you work.

❑ Plan to avoid falls – Injuries can result from falling off scaffolding or ladders. Other workers may also be injured from equipment and debris falling from scaffolding and ladders.

Ladder Safety

To prevent injury when climbing, follow these procedures:

1. Position the ladder at a safe angle to prevent slipping. The horizontal distance from the base of the ladder to the structure should be one-quarter the length of the ladder. If you do not have a way to make this measurement, follow the steps below to determine if the ladder is positioned at a safe angle.
   - Put your feet at the base of the ladder and extend your arms straight out.
   - If you can touch the closest part of the ladder without bending your arms, the ladder is probably at the correct angle.
   - If you have to bend your arms to touch the closest part of the ladder or if you can not reach the ladder at all, the ladder is not positioned at a safe angle.
2. Make sure the base of the ladder has firm support and the ground or floor is level. Be very careful when placing a ladder on wet, icy, or otherwise slippery surfaces. Special blocking may be needed to prevent slipping in these cases.
3. Follow the manufacturer's recommendations for proper use.
4. Check the condition of the ladder before using it. Joints must be tight to prevent wobbling or leaning.

Continue…..

5. When using a stepladder, make sure it is level and fully open. Always lock the hinges. Do not stand on or above the top step.
6. When using scaffolding, use a ladder to access the tiers. Never climb the cross braces.
7. Do not use metal ladders. Instead, use ladders made of fiberglass. (Although wooden ladders are permitted, wood can soak up water and become conductive)
8. Beware of overhead powerlines when you work with ladders and scaffolding.

2. Avoid Wet Working Conditions & Other Dangers

Remember that any hazard becomes much more dangerous in damp or wet conditions. To be on the safe side, assume there is dampness in any work location, even if you do not see water. Even sweat can create a damp condition!

- Do not work wet
  - Do not work on circuits or use electrical equipment in damp or wet areas.
  - If necessary, clear the area of loose materials or hanging objects.
  - Cover wet floors with wooden planking that can be kept dry.
  - Wear insulating rubber boots or shoes.
  - Your hands must be dry when plugging and unplugging power cords and extension cords.
  - Do not get cleaning solutions on energized equipment.

- Use a GFCI
  - Always use a GFCI when using portable tools and extension cords.

3. Avoid Overhead Powerlines

- Be very careful not to contact overhead powerlines or other exposed wires.
- More than half of all electrocutions are caused by contact with overhead lines.
- When working in an elevated position near overhead lines, avoid locations where you (and any conductive object you hold) could contact an unguarded or uninsulated line.
- Vehicle operators should also pay attention to overhead wiring.
- Dump trucks, front-end loaders, and cranes can lift and make contact with overhead lines.
- If you contact equipment that is touching live wires, you will be shocked and may be killed.
- If you are in the vehicle, stay inside.
- Always be aware of what is going on around you.

4. Use Proper Wiring and Connectors

➢ Avoid overloads – Do not overload circuits.

➢ Test GFCI's – Test GFCI's monthly using the "test" button.

➢ Check switches and insulation – Tools and other equipment must operate properly. Make sure that switches and insulating parts are in good condition.

➢ Use three-prong plugs – Never use a three-prong grounding plug with the third prong broken-off. When using tools that require a third-wire ground, use only three-wire extension cords with three-prong grounding plugs and three-hole electrical outlets. Never remove the grounding prong from a plug! You could be shocked or expose someone else to a hazard. If you see a cord without a grounding prong in the plug, remove the cord from service immediately.

➢ Use extension cords properly – If an extension cord must be used, choose one with sufficient ampacity for the tool being used. An undersized cord can overheat and cause a drop in voltage and tool power. Check the tool manufacturer's recommendations for the required wire gauge and cord length. Make sure the insulation and the grounding prong are intact.

Portable GFCI

Never use a 3-prong grounding plug with the 3rd prong broken-off.

Continue…..

➢ Check power cords and extensions – Electrical cords should be inspected regularly using the following procedure:

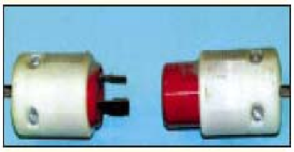
1. Remove the cord from the electrical power source before inspecting.
2. Make sure the grounding prong is present in the plug.
3. Make sure the plug and receptacle are not damaged.
4. Wipe the cord clean with a diluted detergent and examine for cuts, breaks, abrasions, and defects in the insulation.
5. Coil or hang the cord for storage. Do not use any other methods. Coiling or hanging is the best way to avoid tight kinks, cuts, and scrapes that can damage insulation or conductors.

You should also test electrical cords regularly for ground continuity using a continuity tester as follows:

1. Connect one lead of the tester to the ground prong at one end of the cord.
2. Connect the second lead to the ground wire hole at the other end of the cord.
3. If the tester lights up or beeps, the cord's ground wire is okay. If not, the cord is damaged and should not be used.

Continue…..

- Do not pull on cords – Always disconnect a cord by the plug.
- Use correct connectors
    1. Use electrical plugs and receptacles that are right for your current and voltage needs.
    2. Connectors are designed for specific currents and voltages so that only matching plugs and receptacles will fit together. This safeguard prevents a piece of equipment, a cord, and a power source with different voltage and current requirements from being plugged together.
- Use locking connectors – Use locking-type attachment plugs, receptacles, and other connectors to prevent them from becoming unplugged.



Locking-type attachment plug.

5. Use and Maintain Tools Properly

- You must use the right tools for the job.
- Proper maintenance of tools and other equipment is very important.
- Inadequate maintenance can cause equipment to deteriorate, creating dangerous conditions.
- You must take care of your tools so they can help you and not hurt you.
    - ✓ Inspect tools before using them – Check for cracked casings, dents, missing or broken parts, and contamination (oil, moisture, dirt, corrosion). Damaged tools must be removed from service and properly tagged. These tools should not be used until they are repaired and tested.
    - ✓ Use the right tool correctly – Follow the safety instructions and operating procedures recommended by the manufacturer. When working on a circuit, use approved tools with insulated handles. However, do not use these tools to work on energized circuits. Always shut off and de-energized circuits before beginning work on them.

This cord has been spliced using a wire nut. Spliced cords are very dangerous!

Continue…..

✓ Protect your tools – Keep tools and cords away from heat, oil, and sharp objects. These hazards can damage insulation. If a tool or cord heats up, stop using it! Report the condition to a supervisor immediately. If equipment has been repaired, make sure that it has tested and certified as safe before using it. Never carry a tool by the cord. Disconnect cords by pulling the plug – not the cord!

✓ Use double-insulated tools – Portable electrical tools are classified by the number of insulation barriers between the electrical conductors in the tool and the worker. Equipment that has two insulation barriers and no exposed metal parts is called double-insulated. When used properly, double-insulated tools provide reliable shock protection without the need for a third ground wire. Power tools with metal housings or only one layer of effective insulation must have a third ground wire and three-prong plug.

✓ Use multiple safe practices – Remember: A wire may not be wired correctly. Wires may contact other "hot" circuits. Someone else may do something to place you in danger. Take all possible precautions.

6. Wear Correct PPE.

OSHA requires that you be provided with PPE. The equipment must meet OSHA requirements and be appropriate for the parts of the body that need protection and the work performed. PPE helps keep you safe.

Wear and maintain PPE

Wear safety glasses to avoid eye injury

❖ Wear safety glasses – to avoid eye injury
❖ Wear proper clothing – wear clothing that is neither floppy nor too tight. Loose clothing will catch on corners and rough surfaces. Clothing that binds is uncomfortable and distracting.
❖ Contain and secure loose hair – wear your hair in such a way that it does not interfere with your work or safety.
❖ Wear proper foot protection – wear shoes/boots that have been approved for electrical work.
❖ Wear a hard hat – to protect your head from bumps and falling objects.
❖ Wear hearing protectors – to prevent hearing loss in noisy areas.
❖ Follow directions – follow the manufacturer's direction for cleaning and maintaining PPE.

CONCLUSION

This training aid has to serve establish best work practices to reduce electrical incidents and prevent injuries to personnel at work place. It is also to facilitate them to be more disciplines and awareness about electrical safety.