Technical Guide

ELECTRICAL SAFETY

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Small and Medium Enterprises Development Authority

Ministry of Industries & Production

Government of Pakistan

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1 Disclaimer

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2 Introduction to SMEDA

The Small and Medium Enterprises Development Authority (SMEDA) was established in October 1998 with an objective to provide fresh impetus to the economy through development of Small and Medium Enterprises (SMEs).

With a mission "to assist in Employment Generation and Value Addition to the national income, through development of SME sectors, by helping increase the number, scale and competitiveness of SMEs", SMEDA has carried out ‘sectoral research’ to identify Policy, Access to Finance, Business Development Services, strategic initiatives and institutional collaboration & networking initiatives.

Preparation and dissemination of prefeasibility studies in key areas of investment has been a successful hallmark of SME facilitation by SMEDA.

Concurrent to the prefeasibility studies, a broad spectrum of Business Development Services is also offered to the SMEs by SMEDA. These services include identification of experts and consultants and delivery of need-based capacity building programs of different types in addition to business guidance through help desk services.

2.1 Industry Support Program

In order to enhance competitiveness of SMEs and achieve operational excellence, SMEDA established an Industry Support Cell (ISC) for provision of foreign technical support and knowledge transfer in collaboration with International Development Organizations. SMEDA’s Industry Support

Program (ISP) initially launched with Japan International Cooperation Agency (JICA) and actively engaged in reducing energy inefficiencies and improving production and quality of products with the support of Japanese Experts. Later on, similar activities with other international partner organizations like German Corporation for International Cooperation (GIZ), Training and Development Centers of the Bavarian Employers' Association (bfz), Germany, and United Nations Industrial Development Organization (UNIDO) were also successfully implemented.

3 Introduction to Electrical Safety

Safety at the workplace is first and foremost priority for employee and employer alike. It is especially important for those who install and service electrical systems. No matter how much an employer tries to safeguard its workers or how much safety training is provided; the ultimate responsibility lies with the worker. The human factor is part of every accident or injury. The purpose of this guidebook is to identify electrical safety hazards and present ways to minimize or avoid their consequences. This guide envelope the ways for improving electrical safety and contains information about safety regulations, industry-accepted standards and work practices. It presents ways to meet the standards and reduce the hazards. While parts of the safety standards, regulations, and codes especially relating to electrical safety are quoted or summarized herein, it is the responsibility of the user to comply with all applicable standards in their entirety.

3.1 What is Electricity?

Electricity is everywhere in our lives. Though it cannot be seen but everyone is aware of it every day. It is used in countless ways. One cannot taste or smell electricity, but one can feel it. It lights up our homes, cooks our food, powers our computers, television sets, and other electronic devices. Electricity (DC Current) from batteries starts our cars and makes our flashlights shine in the dark. Before we understand what electricity is , we need to know a little bit about atoms and their structure.

All matter is made up of atoms, and atoms are made up of smaller particles. The three main particles making up an atom are the proton, the neutron and the electron. Electrons spin around the center, or nucleus. The nucleus is made up of neutrons and protons. Electrons contain a negative charge, protons a positive charge. Neutrons are neutral, they have neither a positive nor a negative charge. Each atom has a specific number of electrons, protons and neutrons. But no matter how many particles an atom has, the number of electrons usually needs to be the same as the number of protons. If the numbers are the same, the atom is called balanced, and it is very stable. So, if an atom had six protons, it should also have six electrons. The element with six protons and six electrons is called carbon. Carbon is found in abundance in the sun, stars, comets, atmospheres of most planets, and the food we eat. Coal is made of carbon; so are diamonds. Some kinds of atoms have loosely attached electrons. An atom that loses electrons has more protons than electrons and is positively charged. An atom that gains electrons has more negative particles and is negatively charged. A charged atom is called an "ion."

Electricity is characterized by the 'flow of electrons through a conductor.' Electrons can be made to move from one atom to another in a flow. When those electrons move between the atoms, a current of electricity is created from one end to other.

3.2 Why Electrical Safety is Important?

Electrical Safety is not an option — it is an absolute necessity for workers and employers alike

Electrically powered equipment can pose a significant hazard to workers, particularly when mishandled or not maintained. Many electrical devices have high voltage or high power requirements, carrying even more risk. Electrical hazards have always been recognized, yet serious injuries, deaths, and property damage occur daily.

The moral obligation to protect workers who may be exposed to electrical hazards is fundamental, but there are legal and other factors that require every facility to establish a comprehensive Electrical Safety Program. Meeting Occupational Safety and Health Administration (OSHA) regulations, reducing insurance costs, and minimizing downtime and repair costs are additional benefits of Electrical Safety programs. When electrical faults occur, the electrical system is subjected to both thermal and magnetic forces. These forces can severely damage equipment and are accompanied by fires, explosions and severe arcing. Such violent damage often causes death or severe injury to personnel. Costs of repairs, equipment replacements, and medical treatment can run into millions of dollars. Loss of production and damaged goods are also important considerations. Other major factors include the cost of OSHA fines and litigation. Severe electrical faults may shut down a complete process or assembly plant, sending hundreds or thousands of workers home for weeks while repairs are being made. It is also possible that one tragic event could close a plant permanently.

Therefore, every facility must ensure the implementation of a proper electrical safety program to avoid such unpleasant consequences.

Implementing and following a well-designed Electrical Safety Program will protect employees and employers against:

1. Injury to personnel
2. OSHA citations and fines
3. Increased costs for insurance and workman compensation
4. Unplanned equipment repair or replacement costs

4 Electrical Safety CODES & STANDARDS

Several organizations have developed and continue to revise standards to address the numerous concerns involving electrical power. These standards and safety organizations have been originated in the United States of America and include:

- **OSHA: Occupational Safety & Health Administration**

- **NFPA: National Fire Protection Association**
- **IEEE: Institute of Electrical and Electronic Engineers**
- **ANSI: American National Standards Institute**

4.1 OSHA

The primary goal of the Occupational Safety and Health Administration (OSHA) is "to ensure safe and healthful conditions for every worker." OSHA currently has thousands of rules and regulations that cover workplace safety. Federal and state OSHA programs enforce regulations throughout workplace inspections, voluntary assistance programs, and training activities. Citations and fines are also levied for violations found during inspections.

- **<u>The General Duty Clause</u>**

  Section 5(a)(1) of the Occupational Safety and Health Act of 1970 reads:

  "Each Employer shall furnish to each of his employees' employment and a place of employment which are free from recognized hazards that are causing or are likely to cause death or serious physical harm to his employees."

- **<u>OSHA Regulations</u>**

  Published by the U.S. Federal Register, OSHA regulations can be found in the **Code of Federal Regulations (CFR)** under Title 29. More specifically, and legally enforced by OSHA, Subpart S (Parts 1910.301 to 1910.399) addresses "Electrical" safety standards and covers the practical safeguarding of electrical workers. Subpart S is divided into four major divisions: Design safety standards, Safety-related work practices, Safety-related maintenance requirements, Safety requirements for special equipment

Other OSHA standards outline some of the general requirements for electrical installations and general safe work practices:

29 CFR 1910.132 - Personal Protective Equipment General Requirements

29 CFR 1910.335 - Electrical Personal Protective Clothing

29 CFR 1910.147 - Control of Hazardous Energy (Lockout/tagout)

29 FR 1910.269 - Power Generation, Transmission, & Distribution

4.2 IEEE

The Institute of Electrical and Electronic Engineers Inc. (IEEE) is an association of electrical and electronic engineers established to advance the theory and application of electro-technology and allied sciences. The Industry Application Society (IAS) of the IEEE is the group that addresses power distribution in industrial and similar facilities. There are numerous sub-committees that meet regularly to research, publish, and update standards and guidelines for the testing, evaluation, and application of their particular industry or specialty. In 2002, the Petroleum and Chemical Industry Committee IAS published IEEE1584, entitled, IEEE Guide for Performing Arc-Flash Hazard Calculations. Although there are other methods of determining Arc-Flash hazards, IEEE 1584 has quickly become the de-facto standard for determining the extent of potential Arc-Flash Hazards

4.3 NFPA

The primary organization in the U.S. for fire and electrical safety standards is the NFPA. Their document, **NFPA 70E: Standard for Electrical Safety in the Workplace**, has been adopted by the American National Standards Institute (ANSI) as an American National Standard. This standard covers safety related work practices, defines qualified and unqualified workers and provides guidance to establish an electrical safety program. It also requires an electrical hazard analysis for shock and flash, discusses energized work permits, and proper lockout/tagout procedures. NFPA 70E defines and establishes shock and Arc-Flash approach boundaries to energized equipment and addresses how to select appropriate PPE (personal protective equipment) and protective clothing.

In order to help meet the required OSHA regulations for electrical safety and training, OSHA refers to NFPA 70E as a national consensus standard for electrical safety in the workplace. NFPA also publishes NFPA 70, otherwise known as the National Electrical Code, and other standards that address public safety and practices. Together, OSHA and the NFPA continue to work to improve workplace safety. To ensure the safety of your plant and personnel, OSHA and NFPA standards should always be followed.

4.4 ANSI

The American National Standards Institute (ANSI) is a private, non-profit organization that administers and coordinates the U.S. voluntary standardization and conformity assessment system. Working in conjunction with organizations such as NFPA, IEEE, NEMA, ASME (American Society of Mechanical Engineers), ASCE (American Society of Civil Engineers), AIMME (American Institute of Mining and Metallurgical Engineers), and ASTM (American Society of Testing and Materials) ANSI coordinates and adopts these various industry consensus standards and publishes standards to promote US and Global conformity. ANSI has adopted many NFPA, NEMA, and ASTM standards for procedures, materials, and personal protective equipment used by electrical workers.

5 COMMON ELECTRICAL HAZARDS

An electrical hazard can be defined as a dangerous condition where a worker could make electrical contact with energized equipment or a conductor, and from which the person may sustain an injury from shock; and/or, - there is potential for the worker to receive an arc flash burn, thermal burn, or blast injury.

The primary hazards associated with electricity and its use are listed as below

5.1 Shock

Electric shock occurs when the human body becomes part of a path through which electrons can flow. The resulting effect on the body can be either be direct or indirect.

- **Direct**. Injury or death can occur whenever electric current flows through the human body. Currents of less than 30 mA can result in death. A thorough coverage of the effects of electricity on the human body is contained in the section of this module entitled Effects of Electricity on the Human Body.

- **Indirect**. Although the electric current through the human body may be well below the values required to cause noticeable injury, human reaction can result in falls from ladders or scaffolds, or movement into operating machinery. Such reaction can result in serious injury or death.

5.2 BURNS

Burns can result when a person touches electrical wiring or equipment that is improperly used or maintained. Typically, such burn injuries occur on the hands.

5.3 ARC-BLAST

Arc-blasts occur from high-amperage currents arcing through air. This abnormal current flow (arc-blast) is initiated by contact between two energized points. This contact can be caused by persons who have an accident while working on energized components, or by equipment failure due to fatigue or abuse. Temperatures as high as 35,000 F have been recorded in arc-blast research. The three primary hazards associated with an arc-blast are:

- **Thermal Radiation**: In most cases, the radiated thermal energy is only part of the total energy available from the arc. Numerous factors, including skin color, area of skin exposed, type of clothing have an effect on the degree of injury. Proper clothing, work distances and overcurrent protection can improve the chances of curable burns.
- **Pressure Wave**: A high-energy arcing fault can produce a considerable pressure wave. Research has shown that a person 2 feet away from a 25kA arc would experience a force of approximately 480 pounds/ 218 kg on the front of their body. In addition, such a pressure wave can cause serious ear damage and memory loss due to mild concussions.
  In some instances, the pressure wave may propel the victim away from the arc-blast, reducing the exposure to the thermal energy. However, such rapid movement could also cause serious physical injury.
- **Projectiles:** The pressure wave can propel relatively large objects over a considerable distance. In some cases, the pressure wave has sufficient force to snap the heads of 3/8 inch steel bolts and knock over ordinary construction walls.

The high-energy arc also causes many of the copper and aluminum components in the electrical equipment to become molten. These "droplets" of molten metal can be propelled great distances by the pressure wave. Although these droplets cool rapidly, they can still be above temperatures capable of causing serious burns or igniting ordinary clothing at distances of 10 feet or more. In many cases, the burning effect is much worse than the injury from shrapnel effects of the droplets.

5.4 EXPLOSIONS

Explosions occur when electricity provides a source of ignition for an explosive mixture in the atmosphere. Ignition can be due to overheated conductors or equipment, or normal arcing (sparking) at switch contacts.

5.5 FIRE

Electricity is one of the most common causes of fire both in the home and at the workplace. Defective or misused electrical equipment is a major cause, with high resistance connections being one of the primary sources of ignition. High resistance connections occur where wires are improperly spliced or connected to other components such as receptacle outlets and switches. Heat is developed in an electrical conductor by the flow of current at the rate I^2R. The heat thus released elevates the temperature of the conductor material. A typical use of this formula illustrates a common electrical hazard. If there is a bad connection at a receptacle, resulting in a resistance of 2 ohms, and a current of 10 amperes flows through that resistance, the rate of heat produced (W) would be:

$$W = I^2R = 10^2 \text{ x } 2 = 200 \text{ watt}$$

If you have ever touched an energized 200 watt light bulb, you will realize that this is a lot of heat to be concentrated in the confined space of a receptacle. Situations similar to this can contribute to electrical fires.

6 ELECTRICAL HAZARD ANALYSIS

Electric Hazard Analysis is required for all areas of the electrical system that operate at 50 volts or higher. Both OSHA and NFPA 70E require an Electrical Hazard Analysis prior to beginning work on or near electrical conductors that are or may become energized. The analysis must include all electrical hazards such as shock, Arc-Flash, Arc-Blast, and burns. The results of the Electrical Hazard Analysis will determine the work practices, protection boundaries, personal protective equipment, and other procedures required to protect employees from Arc-Flash or contact with energized conductors.

6.1 Shock Hazard Analysis

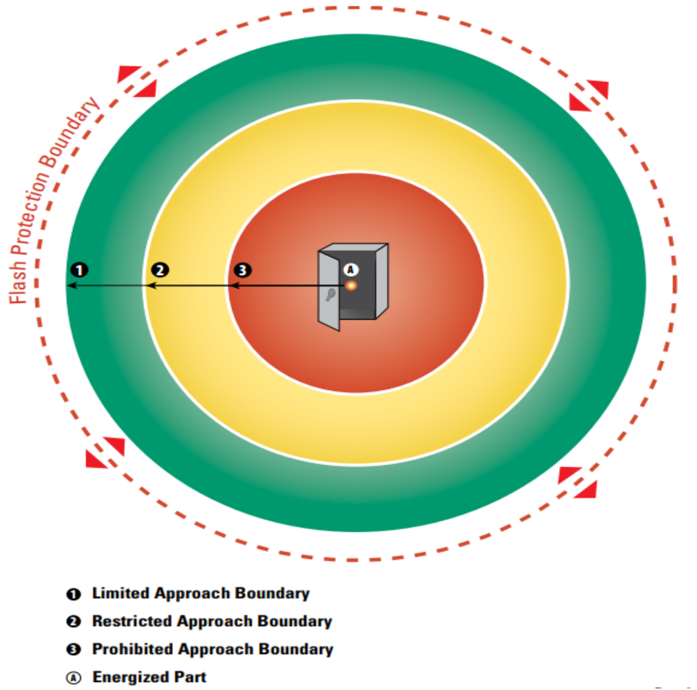
The Shock Hazard Analysis determines the system voltage to which personnel can be exposed, the protection boundary requirements as established in NFPA 70E, and identifies personal protective equipment (PPE) required to minimize shock hazards.

Shock protection boundaries are based on system voltage and whether the exposed energized components are fixed or movable. NFPA 70E has established three shock protection boundaries:

1. Limited Approach Boundary

2. Restricted Approach Boundary

3. Prohibited Approach Boundary



In summary, a Shock Hazard Analysis is performed to reduce the potential for direct shock. It will establish shock protection boundaries and determine PPE required for protecting workers against shock hazards.

6.2 Flash Hazard Analysis

A complete electrical hazard analysis must also contain a Flash Hazard Analysis.

"A Flash Hazard Analysis shall be done in order to protect personnel from the possibility of being injured by an Arc-Flash. The analysis shall determine the Flash Protection Boundary and the personal protective equipment that people within the Flash Protection Boundary shall use."

The analysis requires the available fault current to be calculated and documented at every point in the electrical system. This includes all components contained in the electrical system. The end result of this research will be an accurate, documented one-line diagram, which will provide the data for a short circuit analysis, and other calculations that determine the Flash Protection Boundary and required level of PPE.

The Flash Protection Boundary (FPB) is the distance in feet from a given arc source that will produce a second-degree burn on exposed bare skin. Unlike the Shock Hazard Protection Boundaries that are based solely on system voltage, the Flash Protection Boundary is not fixed. In order to determine the potential Arc-Flash hazard, Flash Protection Boundaries must be calculated at every point where service on energized equipment, devices, or conductors may be required.

IEEE 1584 outlines 9 steps necessary to properly perform an Arc-Flash hazard calculation.

Step 1: Collect the system and installation data

Step 2: Determine the system modes of operation

Step 3: Determine the bolted fault currents

Step 4: Determine the arc fault currents

Step 5: Find the protective device characteristics and the duration of the arcs

Step 6: Document the system voltages and classes of equipment

Step 7: Select the working distances

Step 8: Determine the incident energy for all equipment

Step 9: Determine the flash protection boundary for all equipment

7 GENERAL ELECTRICAL SAFE WORK PRACTICES

The most basic safe work practice while doing an electrical job is that before starting work all circuits of 50 volts or more should be de-energized, locked, tagged and tested, all power sources should be de-energized and disconnected from all electric energy sources.

NFPA 70E guidelines and practices are generally considered the “How to” of conforming to the OSHA regulations when performing a hazard assessment and determining the required PPE. There are many practices that will help reduce Arc-Flash and other electrical hazards while conforming to OSHA and NFPA 70E regulations and guidelines.

Circuit designers and electrical maintenance engineers should carefully consider each of the following recommendations:

1. Design a safer system
2. Use and upgrade to current-limiting overcurrent protective devices
3. Implement an Electrical Safety Program
4. Observe safe work practices
5. Use Personal Protective Equipment (PPE)
6. Use Warning Labels
7. Use an Energized Electrical Work Permit
8. Avoid hazards of improperly selected or maintained overcurrent protective devices
9. Achieve or Increase Selective Coordination.

A fundamental principle of electrical safety is that only Qualified Electrical Workers (QEWs) may be authorized to perform electrical work. This includes both live and deenergized work, for build, service, maintenance, and repair of equipment.

- **a.** A QEW is one who has demonstrated skills and knowledge related to the construction and operation of electrical equipment and installations, has received safety training to identify and avoid the hazards involved, and who has been approved by the relevant Electrical Safe Work Practices.
- **b.** Any person who is not a QEW is called a non-QEW.
- **c.** A non-QEW may perform deenergized electrical work under the direct field supervision of a QEW.

8 ELECTRICAL SAFETY DEVICES

Electrical safety devices protect electrical circuits from short circuits or overloads. Using these electrical safety devices correctly and maintaining them can be a lifesaver. Plus, they also work to preserve the life of electrical equipment, saving you money on replacements and property damage. The most commonly used electrical safety devices are listed below.

8.1 Fuse

Normally, a fuse is a copper wiring with a set current fusion value. If the current exceeds the set fusion value, the fuse will blow and the path of flow will be broken, thus preventing overloading. A fuse must be installed on “live” wires. When replacing a fuse, the new fuse must be same current fusion value as the old one.

8.2 Circuit breakers

Circuit breakers are based on the principle of the electromagnetic field. The current entered may enable the coils of the circuit breaker to magnetize. When the current exceeds the set value (i.e., overloading), the magnetization intensifies, switching off the circuit breaker and disconnecting the electric source.

8.3 Earthing

Earthing provides a low resistance way of discharging electricity to the ground in case of current leakage. This means that during an electric shock, the current passes through the "earth" wire and is prevented from entering the human body and causing injury.

8.4 Earth leakage circuit breaker (ELCB or RCD)

Current leakage protection is also called residual current protection or earthing fault current protection. Earth leakage circuit breakers monitor the operation of the "neutral" or "live" wires in the electrical circuit. During an imbalance in the electrical circuit, or when not all the current flows to the electrical appliance through the "live" wire and returns through the "neutral" wire, part of the current flows away (leaks) into other sources. The earth leakage circuit breaker will immediately detect such an imbalance and cut-off the electrical source in 0.4 seconds (time setting may vary as per sensitivity rating and manufacturer). Rating of the tripping current shall not exceed 30mA.

If ELCB is not fixed in main circuit box or the worker works in high risk environment (e.g. humid condition), portable RCD (Residual Current Devices) should be installed to reduce the chance of getting an electric shock.

8.5 Double insulation

An electrical appliance with double insulation is protected by a supplementary insulation layer in addition to basic insulation. Electrical appliances with double insulation bear the " " mark. No earth connection is required for such appliances since double insulation provides sufficient protection.

8.6 Using Extra-low voltage

Using electrical tools with an extra-low voltage of less than 50 V may minimize injury in case of electric shock. When extra-low voltage is used, an earthing connection may not be required.

9 MINIMIZING ELECTRICAL HAZARDS

There exists several ways to protect workers from the threat of electrical hazards. Some of the methods are for the protection of qualified employees doing work on electrical circuit and other methods are geared towards nonqualified employees who work nearby energized equipment.

Here are a few of the protective methods:

- Prevent overloaded wiring by using the right size and type of wire

- Prevent exposure to live electrical parts by isolating them
- Prevent exposure to live wires and parts by using insulation
- Prevent shocking currents from electrical systems and tools by grounding them
- Prevent shocking currents by using Ground Fault Circuit Interrupters (GFCIs)
- Prevent fault/excessive current in circuits by using overcurrent protection devices.
- Prevent against electric shock or arc blast when working live by using proper PPE and protective tools
- De-energize the circuit
- Control electrical hazards through safe work practices
- Use barricades

Additionally, the use of alerting techniques are effective ways to warn employees (especially non-qualified) of the dangers present. Alerting techniques might include safety signs, safety symbols, or accident prevention tags. Often, the use of such signs alone is not adequate as an employee (especially a non-qualified employee) may accidentally come in direct contact with an energized circuit. In these instances, a barricade shall be used in conjunction with safety signs. A barrier is an effective way to prevent or limit employee access to work areas exposing employees to uninsulated energized conductors or circuit parts. Conductive barricades may not be used where they might cause an electrical contact hazard. If signs and barricades do not provide sufficient warning and protection from electrical hazards, an attendant shall be stationed to warn and protect employees.

In an effort to limit electrical injuries in the workplace, **OSHA** has passed law that only allows a **“Qualified”** person to work on or around energized circuits or equipment.

10 PERSONAL PROTECTIVE EQUIPMENT (PPE)

Personal protective equipment, commonly referred to as "PPE", is equipment worn to minimize exposure to hazards that cause serious workplace injuries and illnesses. PPE may include items such as gloves, safety glasses, shoes, earplugs or muffs, hard hats, respirators, coveralls, vests, and full body suits. All personal protective equipment should be safely designed and constructed and should be maintained in a clean and reliable fashion.

10.1 General Requirements

Employees working in areas where there are potential electrical hazards must be provided with and use personal protective equipment (PPE) that is appropriate for the specific work to be performed. The electrical tools and protective equipment must be specifically approved, rated, and tested for the levels of voltage of which an employee may be exposed. Such equipment shall include Arc Flash apparel (until a full arc flash hazard analysis is made), eye protection, head protection, hand protection, insulated footwear, and face shields where necessary.

10.2 Protective Clothing Characteristics

- Employees shall wear nonconductive head protection whenever there is a danger of head injury from electric shock or burns due to contact with live parts or from flying objects resulting from an electrical explosion.
- Employees shall wear protective equipment for the eyes whenever there is a danger of injury from electric arcs, flashes, or from flying objects resulting from an electrical explosion.
- Employees shall wear rubber insulating gloves where there is a danger of hand or arm contact with live parts or possible exposure to arc flash burn.
- Where insulated footwear is used as protection against step and touch potential, dielectric overshoes shall be required. Insulated soles shall not be used as primary electrical protection.
- Face shields without arc rating shall not be used for electrical work. Safety glasses or goggles must always be worn underneath face shields.
- Additional illumination may be needed when using tinted face shields as protection during electrical work.
- Electrical Protective Equipment must be selected to meet the criteria established by the America National Standards Institute (ANSI).
- Insulating equipment made of materials other than rubber shall provide electrical and mechanical protection at least equal to that of rubber equipment.
- PPE must be maintained in a safe, reliable condition and be inspected for damage before each day's use and immediately following any incident that can reasonably be suspected of having caused damage.
- Employees must use insulated tools and handling equipment that are rated for the voltages to be encountered when working near exposed energized conductors or circuit. Tools and handling equipment should be replaced if the insulating capability is decreased due to damage.
- Protective gloves must be used when employees are working with exposed electrical parts above fifty (50) volts. Fuse handling equipment (insulated for circuit voltage) must be used to remove or install fuses when the fuse terminals are energized. Ropes and hand lines used near exposed energized parts must be non-conductive.
- Protective shields, barriers or insulating materials must be used to protect each employee from shock, burns, or other electrical injuries while that person is working near exposed energized parts that might be accidentally contacted or where dangerous electric heating or arcing might occur.

10.3 Flame-Resistant (FR) Apparel & Under Layers

- FR apparel shall be visually inspected before each use. FR apparel that is contaminated or damaged shall not be used. Protective items that become contaminated with grease, oil flammable liquids, or combustible liquids shall not be used.

- The garment manufacturer's instructions for care and maintenance of FR apparel shall be followed.
- When the apparel is worn to protect an employee, it shall cover all ignitable clothing and allow for movement and visibility.
- FR apparel must cover potentially exposed areas as completely as possible. FR shirt sleeves must be fastened and FR shirts/jackets must be closed at the neck.
- Non-melting, flammable garments (i.e. cotton, wool, rayon, silk, or blends of these materials) may be used as under layers beneath FR apparel.
- Meltable fibers such as acetate, nylon, polyester, polypropylene, and spandex shall not be permitted in fabric under layers next to skin. (An incidental amount of elastic used on non-melting fabric innerwear or socks shall be permitted).
- FR garments worn as outer layers over FR apparel (i.e. jackets or rainwear) must also be made from FR material.
- Flash suits must permit easy and rapid removal by the user.

10.4 Rubber Insulating Equipment

- Rubber insulating equipment includes protective devices such as gloves, sleeves, blankets, and matting.
- Insulating equipment must be inspected for damage before each day's use and immediately following any incident that could have caused damage.
- An air test must be performed on rubber insulating gloves before each use.
- Insulating equipment found to have defects that might affect its insulating properties must be removed from service until testing indicates that it is acceptable for continued use.
- Where the insulating capability of protective equipment is subject to damage during use, the insulating material shall be protected by an outer covering of leather or other appropriate materials.
- Rubber insulating equipment must be tested according to the schedule supplied by the manufacturer.
- Rubber insulating equipment must be stored in an area protected from light, temperature extremes, excessive humidity, ozone, and other substances and conditions that my cause damage.
- No repairs to rubber insulating equipment shall be attempted without the approval of a certified safety inspector.

10.5 Insulated Tools and Materials

- Only insulated tools and equipment shall be used within the Limited Approach Boundary of exposed energized parts.
- Insulated tools shall be rated for the voltages on which they are used.
- Insulated tools shall be designed and constructed for the environment to which they are exposed and the manner in which they are used.
- Fuse or fuse holder handling equipment, insulated for the circuit voltage, shall be used to remove or install a fuse if the fuse terminals are energized.

- Ropes and hand-lines used near exposed energized parts shall be nonconductive.
- Portable ladders used for electrical work shall have nonconductive side rails.

11 PAKISTAN ELECTRIC AND TELECOMMUNICATION SAFETY CODE

The **Institute of Electrical and Electronic Engineers (IEEE)** and the **Pakistan Engineering Council (PEC)** have worked together to develop a system for electrical safety standards in Pakistan. The new Pakistan Electric and Telecommunication Safety Code (PETSAC-2014) is based on the **National Electrical Safety Code (NESC)**, which the IEEE has managed since 1972. NESC provides rules for safe practices "during the installation, operation, or maintenance of electrical supply and communication lines, equipment, and associated work practices employed by a public or private electric supply, communications, railway, or similar utility in the exercise of its function as a utility," according to the IEEE standards association. This is one of the oldest and most universal safety codes; it has been in continuous use since August 1914.

Pakistan Electric and Telecom Safety Code (PETSAC) provides a unified system of safety standards for safeguarding human lives and reducing material loss. The objective is to reduce fatal and nonfatal accidents of employees and general public and ensure the safety of assets of the related entities.

The Provisions of Pakistan Electric and Telecommunication Safety Code-2014 provide rules for safe practices in design, installation, operation and maintenance of electric supply and telecommunication systems that shall be adopted by electrical power and telecommunication utilities, both public and private.

12 CONCLUSION

Electrical Safety in the workplace can only be attained when workers and employers diligently follow OSHA and industry accepted standards and regulations. It is expected that this guidebook shall be quite helpful in informing the reader of the importance of Electrical Safety while providing methods and information on how to reduce electrical hazards effectively and safely.