An Overview Of Electrical Hazards And Safety Tips: On The Job/Office And Home Awareness Call

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Abstract— Electrical safety is a very important factor that needs urgent attention. This paper provides an overview of basic electrical safety on the job and at home. Electricity is essential to modern life, both at home and on the job. The purpose of this article is to inform the community and users of electricity about the electrical safety and the serious consequence when it is not properly and regularly performed. Information and data were collected from Occupational Safety and Health Administration 3075. Results revealed that some multi -socket power lines, as well as some power cords were outside of the limits provided by the international protocols. Observations were properly analyzed and conclusions was made based on the observation.

Index Terms— Electrical Safety, Electrical Safety Analyzer, awareness, OSHA 3075, RCD, CPR, ESFI.

1 Introduction

Some employees such as engineers, electricians, electronic technicians, and power line workers, among others work with electricity directly. Others, such as office workers and sales personnel, etc work with it indirectly. Perhaps because it has become such a familiar part of the daily life, many persons pay less attention to how much this work depends on a reliable source of electricity. Thus tend to overlook the hazards electricity poses and fail to treat it with the respect it deserves (Elaine L. Chao, John L. Henshaw,, 2002). Electricity can kill or severely injure people and cause damage to property. Every year many accidents at work involving electric shock or burns are reported to the Health and Safety Executive (HSE). Most of the fatal incidents are caused by contact with overhead power lines. Even non-fatal shocks can cause severe and permanent injury. For example, shocks from faulty equipment may lead to falls from ladders, scaffolds or other work platforms. Those using or working with electricity may not be the only ones at risk – poor electrical installations and faulty electrical appliances can lead to fire, which may also cause death or injury to others. Most of these accidents can be avoided by careful planning and straightforward precautions (HSE, 2016)].

1.1: BASIS OF ELECTRICITY

Electricity flows more easily through some materials than others. Some substances such as metals generally offer very little resistance to the flow of electric current and are called conductors. A common but perhaps overlooked conductor is the surface or subsurface of the earth. Glass, plastic, porcelain, clay, pottery, dry wood, and similar substances generally slow or stop the flow of electricity. They are called insulators. Even air, normally an insulator, can become a conductor, as occurs during an arc or lightning stroke.

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1.2: WATER AS A CONDUCTOR OF ELECTRICITY

Pure water is a poor conductor. But small amounts of impurities in water like salt, acid, solvents, or other materials can turn water itself and substances that generally act as insulators into conductors or better conductors. Dry wood, for example, generally slows or stops the flow of electricity. But when saturated with water, wood turns into a conductor. The same is true of human skin. Dry skin has a fairly high resistance to electric current. But when skin is moist or wet, it acts as a conductor. This means that anyone working with electricity in a damp or wet environment needs to exercise extra caution to prevent electrical hazards.

2: ELECTRICAL HAZARDS

Electricity has long been recognized as a serious workplace hazard, exposing employees to electric shock, electrocution, burns, fires, and explosions. In 2009, for example, 278 workers died from electrocutions at work, accounting for almost 5% of all on-the-job fatalities that year, according to the Bureau of Labor Statistics. What makes these statistics more tragic is that most of these fatalities could have been easily avoided.

2.1: CATEGORIES OF ELECTRICAL HAZARDS

Basically, electrical hazards can be categorized into three types;

i. Electrical shock.
ii. Electrical burns
iii. Effects of blasts which include pressure impact, flying particles from vaporized conductors and first breath considerations (Study Guide Electrical Safety harzards awareness).

2.2: ELECTRICAL SHOCKS

Electricity travels in closed circuits, normally through a conductor. But sometimes a person's body. Human body can mistakenly become part of the electric circuit. This can cause an electrical shock. When a person receives a shock, electricity flows between parts of the body or through the body to a ground or the earth.

Electric shock occurs when the body becomes part of an electrical circuit. Shocks can happen in three ways.

• A person may come in contact with both conductors in a circuit.

• A person may provide a path between an ungrounded conductor and the ground.

• A person may provide a path between the ground and a conducting material that is in contact with an ungrounded conductor.

The terms high voltage and low voltage are relative terms. In transmission-line terminology, "low voltage" is much higher than the 600 volts. At home, you would not think of 600 volts as being low voltage.

Even when applied to 120-volt circuits, the term low voltage is deceiving. To some people low voltage means low hazard. Actually, low voltage does not necessarily mean low hazard, because potential difference is only one factor making up the dangerous effects of electricity. Low voltage could be a potential difference of 24-600 volts.

The extent of injury accompanying electric shock depends on three factors.

• The amount of current conducted through the body.

• The path of the current through the body.

• The length of time a person is subjected to the current.

The amount of the current depends on the potential difference and the resistance. The effects of low current on the human body range from a temporary mild tingling sensation to death. An electric shock can injure a person in either or both of the following.

• A severe shock can stop the heart or the breathing muscles, or both.

• The heating effects of the current can cause severe burns, especially at points where the electricity enters and leaves the body.

Other effects include severe bleeding, breathing difficulty, and ventricular fibrillation. In addition, one may strike something, or have some other accident as a result of response to the shock.

2.3: EFFECTS OF ELECTRICAL SHOCKS ON THE BODY

An electric shock can result in anything from a slight tingling sensation to immediate cardiac arrest. The severity depends on the following: **(i)** the amount of current flowing through the body, **(ii)** the current's path through the body, **(iii)** the length of time the body remains in the circuit, and **(iv)** the current's frequency.

The table below shows the general relationship between the amount of current received and the reaction when current flows from the hand to the foot for just 1 second.

Table 1: Effects of electric current on human body (Kouwenhoven, November 1968)

Current	Reaction
Below 1 milliampere	Generally not perceptible
1 milliampere	Faint tingle
5 milliamperes	Slight shock felt; not painful but disturbing. Average individual can let go. Strong involuntary reactions can lead to other injuries.
6–25 milliamperes (women)	Painful shock, loss of muscular control*
9–30 milliamperes (men)	The freezing current or "let-go" range.* Individual cannot let go, but can be thrown away from the circuit if extensor muscles are stimulated.
50–150 milliamperes	Extreme pain, respiratory arrest, severe muscular contractions. Death is possible.
1,000–4,300 milliamperes	Rhythmic pumping action of the heart ceases. Muscular contraction and nerve damage occur; death likely
10,000 milliamperes	Cardiac arrest, severe burns; death probable

If the extensor muscles are excited by the shock, the person may be thrown away from the power source.

Current is the killing factor in electrical shock. Voltage is important only in that it determines how much current will flow through a given body resistance. The current necessary to operate a 10 watt light bulb is eight to ten times more current than the amount that would kill a person. A pressure of 120 volts is enough to cause a current to flow which is many times greater than that necessary to kill.

The following values are given for human resistance to electrical current in Table 2.

Table 1: Human resistance to electrical current

TYPE OF RESISTANCE	RESISTANCE VALUES
Dry skin	100,000 to 600,000 Ohms
Wet skin	1,000 Ohms
Hand to Foot	400 to 600 Ohms
Ear to Ear	100 Ohms

With 120 volts and a skin resistance plus internal resistance totaling 1200 Ohms, the current flowing would be 1/10 ampere, i.e 100 milliamperes. If skin contact in the circuit is maintained while the current flows through the skin, the skin resistance gradually decreases. During this time, proper first aid can mean the difference between life and death. Sufficient circulation can sometimes be maintained by heart compression, which should always be supported with mouth-to-mouth resuscitation. This combination of treatments is commonly known as cardiopulmonary resuscitation, CPR.

3: ELECTRICAL SAFETY

Some items of equipment can also involve greater risk than others. Extension sockets are particularly liable to damage – to their plugs, sockets, connections and the cable itself. Other flexible leads, particularly those connected to equipment which is often moved, can suffer from similar problems.

3.1: RCD SAFETY DEVICE

If equipment operating at 230 volts or higher is used, an RCD (residual current device) can provide additional safety. An RCD is a device which detects some, but not all, faults in the electrical system and rapidly switches off the supply. The best place for an RCD is built into the main switchboard or the socket outlet, as this means that the supply cables are permanently protected. If this is not possible, a plug incorporating an RCD or a plug-in RCD adaptor can also provide additional safety. RCDs for protecting people have a rated tripping current (sensitivity) of not more than 30 milliamps (mA) (7671:2008, 2011).

3.2: RCD GUIDE

i. An RCD is a valuable safety device. It should never be bypassed;
ii. if it trips, it is a sign there is a fault – check the system before using it again;
iii. if it trips frequently and no fault can be found in the system, consult the manufacturer of the RCD; and the RCD has a test button to check that its mechanism is free and functioning.

Damaged or defective equipment should be removed from use and either repaired by someone competent or disposed of to prevent its further use.

3.3: OFFICE HARZARDS

The high volume of electrical equipment in a typical office can expose workers to serious electrical hazards, including shocks, burns and fire. Electrical accidents that occur in an office environment are usually as a result of faulty or defective equipment, unsafe installation, or misuse of equipment specifically, extension cords, power strips and surge protectors (Safety and health magazine, 2016).

To protect against electrical incidents;

- Even when using a surge protector, care should be made ensuring that the electrical load is not too much for the circuit.
- Avoid overloading outlets with too many appliances. Never plug in more than one high-wattage appliance at a time.
- Unplug appliances when not in use to save energy and minimize the risk of shock and fire.
- Inspect electrical cords once a month to ensure they are not frayed, cracked or otherwise damaged.
- Do not run electrical cords through high-traffic areas, under carpets or across doorways.
- Consider having a licensed electrician install additional outlets where needed, rather than relying on extension cords and power strips.

Ensure all electrical equipment is certified by a nationally recognized laboratory, and read all manufacturers' instructions carefully.

An office with computers, printers, monitors, scanners, lamps, CD players, cell phones and iPod chargers plugged into one inexpensive, overloaded power strip, the nonprofit Electrical Safety Foundation International (ESFI) cautions that such a practice not only is unsightly but also dangerous (Josh, 2007).

According to ESFI, overloaded electrical circuits pose both an electrocution and fire hazard. While the number of outlets in offices often is a factor that is out of employers' and employees' control, ESFI recommends these steps to stay safe from electrical hazards:

- If one must use a power strip, a name-brand product from a reputable retailer should be used. Low-quality power strips may contain wiring that isn't adequate to carry the load.
- Place power strips where there is plenty of air circulation to disperse heat.
- Do not attempt to plug grounded (three-prong) cords into ungrounded (two-slot) outlets.
- Do not bind, kink or knot electrical cords.
- Never run power cords under rugs or where chairs can roll over them.
- Keep cords close to a wall to avoid trip hazards.
- Keep all non-critical electrical items unplugged until need to use them arises.
- Consider charging battery-operated devices in another area.

- If your computer screen flickers or fades, or you detect a burning smell, power down and immediately contact the building engineer.

- If you work from home, have a licensed electrician conduct an electrical inspection.

Most office environments are considered low-risk in terms of electrical hazards, particularly when compared to other industries. While this may be true, it does not make the hazards any less significant. An office could be equally as dangerous as, say, working in engineering, if control measures are completely absent and regular assessment of risks not carried out.

Correctly installing and regularly maintaining safe electrical equipment is an employer's responsibility. Under the **Electricity at Work Regulations (1989),** employers need to take action for ensuring all electrical equipment on the premises is safe for use and will not pose any dangers. This includes:

- Ensuring that all electrical equipment selected for workers is safe for work activities and for their intended purpose.

- Ensuring that all electrical equipment has gone through the necessary checks before being brought onto the premises.

- Ensuring that all electrical equipment is properly installed and maintained by a qualified person.

- Arranging for equipment to be regularly inspected for faults, to be isolated immediately if faults are discovered, and to be repaired by a suitably trained person.

- Preventing all live parts of electrical equipment from being accessed during normal operation.

- Providing all employees with information and training on electrical safety and the correct use of electrical equipment.

The preventive measures implemented by the employer will be sufficient in safeguarding everyone. Although nothing is ever perfect and sometimes things may go wrong no matter how cautious the employee are. It is then important the hazards to take the employee off guard. **All employee need to be alert.** Spot the hazards before they lead to an accident and nip them in the bud.

Employees should look out for hazards in the office that could lead to electricity-related accidents. These includes;

i. Electrical cables that are frayed, loose, or have exposed wires.

ii. Rattling plugs

iii. Electrical equipment that gives off a strange odour.

iv. Overheating equipment (those that are not heated by normal operation).

v. Overloaded outlets or extension cords.

vi. Equipment that is not working properly.

Any faulty equipment, wiring, plugs, etc. should be removed from the premises immediately and reported to the supervisor or whoever is in charge who must be a competent person. Outlets should not be overloaded, so either take action to plug equipment elsewhere or tell the competent person, who should take action and minimize the need for overloading them.

This may involve, for example, having a licensed electrician install additional outlets where overloading existing ones and relying heavily on extension cords seems to be an issue.

3.4: Tips for minimizing electrical hazards (High speed training Website, n.d.)

i. Switch off and unplug appliances when they are not in use and before cleaning.

ii. Turn off all appliances at the end of the day.

iii. Do not force a plug into an outlet if it does not fit.

iv. Do not run electrical cords through high-traffic areas, under carpets, or across doorways – this will prevent cords from being worn down and minimizes accidents.

v. Maintain at least 3 feet of clearance in front of all electrical panels.

4: STEP AND TOUCH POTENTIAL

A. Step Potential

During a ground fault, current flows through the grounding system to a ground rod or some type of system ground (steel structure, guy wire) seeking a return to its source. This current flow could possibly exist in, or along the surface of the ground

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for quite some distance around the point where the earth becomes energized. The current will follow, as nearly as possible, the conductors supplying the fault current. Step potential is caused by the flow of fault current through the earth. The closer a person is to the ground rod or grounded device, the greater the concentration of current and higher the voltage. The current flow creates a voltage drop as it flows through the earth's surface and a person standing with their feet apart bridges a portion of this drop thus creating a parallel path for current flow as seen in the these two illustrations of Fig.1

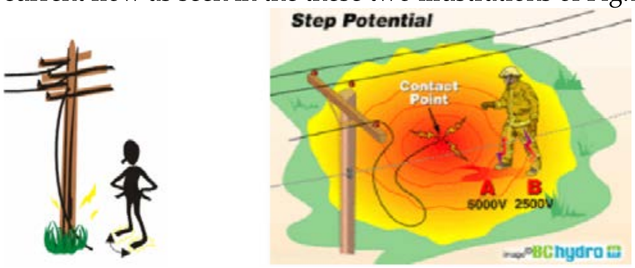


Fig. 1: Step potential
Source: *Electrical Hazards Awareness EFCOG Electrical Safety Improvement Project*

The wider apart a person's legs are, the larger the voltage difference across the body. Protection from the step potential hazard should be to stay in the zone of equipotential while working. Simply being alert to this hazard is the best defense. For this reason, unqualified personnel standing on the ground are cautioned to stay clear of structures.
This means that a person standing near the point where fault current enters the earth may have a large potential difference from foot-to-foot. The potential difference over the same span will be less and less as the span is moved away from either the fault current entry point or the fault current return point at the source.

B. Touch Potential

Touch potential is similar to step potential. It also involves a fault current flow in the earth establishing a potential difference between the earth contact point and some nearby conductive structure or hardware.

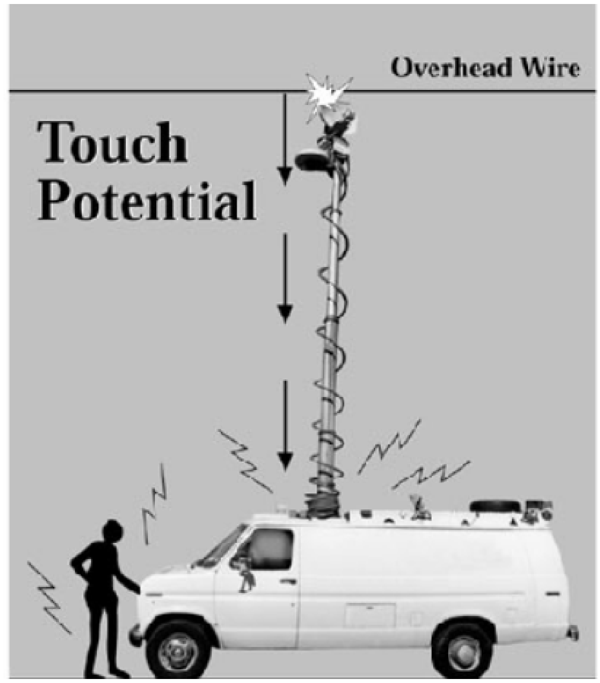


Fig. 2: Touch Potential
Source*: Electrical Hazards Awareness EFCOG Electrical Safety Improvement Project*

Protection for step and touch potential is the use of switch operating platforms and ground grids. The worker must remain upon a local conductive mat as the highest voltage gradient has been moved to the mat's edges. Sub stations on Site have a ground grid located under the rocks, but if an individual is located outside this area and while standing on the earth, touches a ground or a grounded object, a difference in potential may exist during a ground fault.

5: GENERAL SAFE WORK PRACTICES

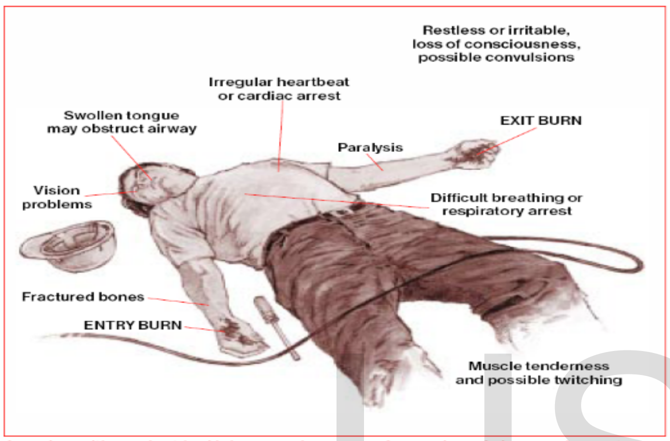
The first step in developing a safe work environment is to have procedures in place which provide guidelines for employees to perform various tasks safely. The procedure should help eliminate injuries by providing rules and guidelines for people working on or near energized electrical circuit conductors. It should address qualifications, tools, protective equipment, approval levels and attendance required for various tasks, as well as other additional cautionary information. Also this procedure should address safe approach distances for qualified and unqualified personnel.
When conductors are or may become energized, an alternative way of ensuring safety from the electrical hazards is to observe a safe approach distance (or clearance) from exposed conductors. It is important to know how close persons, or conductive objects which they might be carrying, can approach without endangering themselves. These clearances are greater for an unqualified person than for a qualified person.

5.2: ELECTRICAL EMERGENCIES

The actions to be taken when an electrical emergency arises.

Electrical accidents cause countless injuries and cost the lives of hundreds of people each year. Injury could be minimized and many lives saved if proper rescue techniques and treatment are used. Electrical accidents may occur at almost any time or place. Timely response and treatment of victims is a major concern.

When an electrical accident occurs, due to the effect of muscle clamping, a victim is often incapable of moving or releasing the electrical conductor. Attempts to rescue an accident victim may pose as great a hazard for the rescuer as it does for the victim. Caution should be a primary consideration during any electrical accident or emergency. There should always be an emergency response plan for scheduled electrical maintenance or work.



A worker with an electrical injury may have any of a number of signs and symptoms.

Fig.3: Worker with an Electrical Injury (OSHA, 1910)

5.3: ELECTRICAL RESCUE TECHNIQUES

A. Approaching the accident:

Never rush into an accident situation.
Call the medical team as soon as possible.
Get the aid of trained electrical personnel if possible.
Approach the accident scene cautiously.

B. Examining the scene

Visually examine victims to determine if they are in contact with energized conductors. Metal surfaces, objects near the victim or the earth itself may be energized. You may become a victim if you touch an energized victim or conductive surface. Do not touch the victim or conductive surfaces while they are energized. De-energize electrical circuits if possible.

C. How to de-energize

An extension or power cord probably powers portable electrical equipment. Unplug portable electrical equipment to remove power. Open a disconnecting device or circuit breaker to de-energize fixed electrical equipment.

5.4: FIRST AID

A victim may require Cardio-Pulmonary Resuscitation (CPR). If the victim is breathing and has a heartbeat, give first aid for injuries and treat for shock. Ensure the victim gets medical care as soon as possible. Provide medical personnel with information on voltage level, shock duration & entry/exit points. The treating/attending physician must have detailed specific information to properly diagnose and care for the victim. The physician must determine whether the victim should be sent to a "Trauma or Burn Center."

Stay with the victim until help arrives (Ralph H. Lee, 1971).

6: CONCLUSION

The overview of electrical and safety tips revealed a level of awareness of electrical hazards and safety measures knowledge among electricity users. From the study, it has become cleared that many users of electricity are not well informed or aware about electricity hazards and safety measures. The implications of these are seen in number of electricity accidents witnessed in homes and offices. To avoid this, everyone both at offices and at homes must help spread this awareness of electrical hazards and safety.

6.1: RECOMMENDATIONS

I. The electricity users should be well informed on the safety measures which will help in protecting lives and property of the users of electricity through safety posters, public lectures amongst others.

II. Hazards and safety practices attribute to each equipment, appliances, and machines should be conspicuously printed on it. This will remind the users when using the appliances, equipment and machines.

III. Electricity users should be well sensitized by Government, NGOs, electrical power providers and manufacturers of electrical products on hazards pose through using television, radio, posters, public lectures and other means of communications.

6.2: FUTURE WORK

Future work on electrical hazards include the biological effect of electrical/electronic devices such as mobile phones, laptop, televisions, power lines, transformers, radio, communication masts, etc., to human health. These poses lots of health treats due to electromagnetic radiations emitted by them.

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