NCMT

ELECTRICAL SAFETY

COURSE MATERIAL

Mussafah 39, Abu Dhabi, UAE | Tel.: +97126721777 | Fax: +97126725511

Email: training@ncmt.ae | Web: www.ncmt.ae

ELECTRICAL

SAFETY

INTRODUCTION

- Because electricity is a familiar part of our lives, it is often not treated with enough caution.
- One worker is electrocuted on the job every day of every year!
- Electrocution is the third leading cause of work related deaths among young Workers.
- Electrocution is the cause of 12% of all workplace deaths among young Workers.

DEFINITION

ELECTRICITY:

A source of Energy Essential to

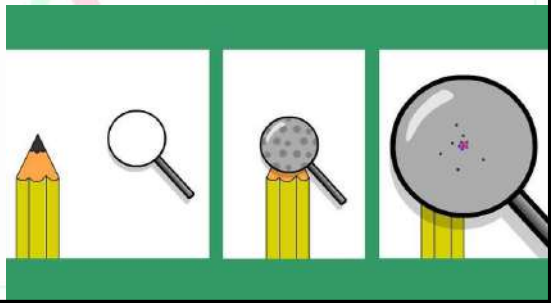
modern life Extremely Dangerous

Cannot be seen or smelt.

A physical agency caused by the motion of electrons, protons, and other charged particles, manifesting itself as an attraction, repulsion, magnetic, luminous, and heating effects, etc.

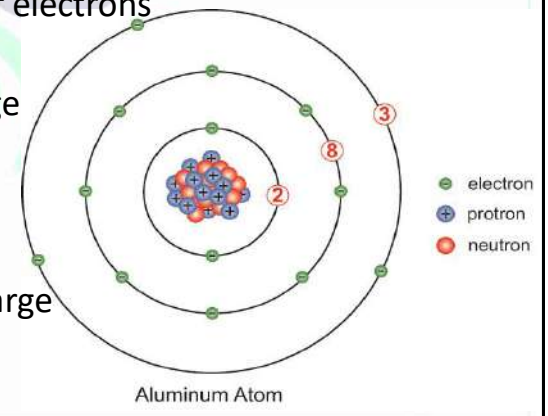
ELEMENTS & ATOMS

- Every known substance – solid, liquid or gas is composed of elements
- An atom is the smallest particle of an element that retains all the properties of that element
- Each element has it's own kind of atom



ATOMS

- Inner part composed of protons & neutrons
- Outer part composed of electrons
- Protons = positive charge
- Neutrons = no charge
- Electrons = negative charge

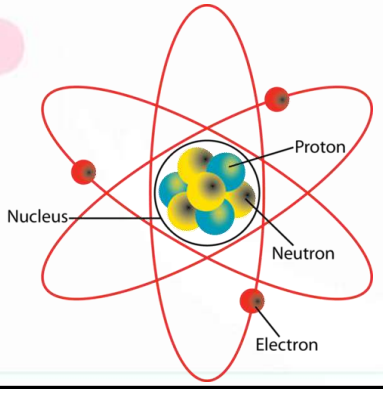


Aluminum Atom

ATOMS

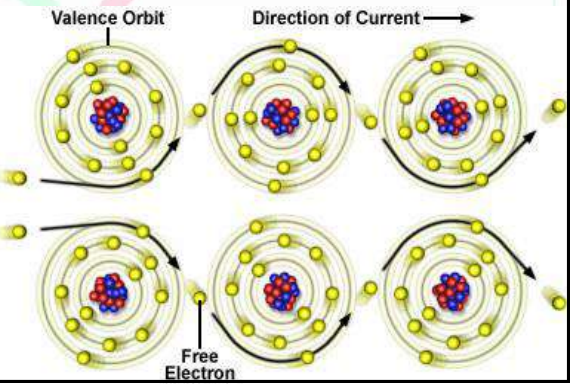
- Each element has a definite number of electrons and the same number of protons
- They are oppositely charged and therefore attract each other.

This tends to hold the electrons in orbit around the atom.



FREE ELECTRONS

- Some electrons are easily moved out of orbit
- The ability to move or flow is the basis of current electricity
- If channeled in a given direction, a flow of electrons occurs. when flowed through a conductor it is dynamic electricity



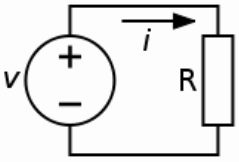
ELECTICAL MATERIALS

- **CONDUCTOR:** contains many free electrons, gold, copper, silver, aluminum etc. allows electrons to flow through it.
- **INSULATOR:** contains few free electrons-Usually non-metallic such as wood, rubber, glass, etc resists the flow of electrons.
- **VOLTAGE (V):** Potential Difference – unit of measurement. The difference in electrical pressure between two points is called the potential difference and is measured in volts.
- **CURRENT:** is the flow of electrons through a conductor.
- **RESISTANCE:** Opposition to movement of electrons. Makes it possible to generate heat, control current flow, & supply correct voltage to devices.

BASIC ELECTRICAL CIRCUITRY

Circuits: consists of:

- A source of electric current
- Conductors
- Equipment powered by the current.

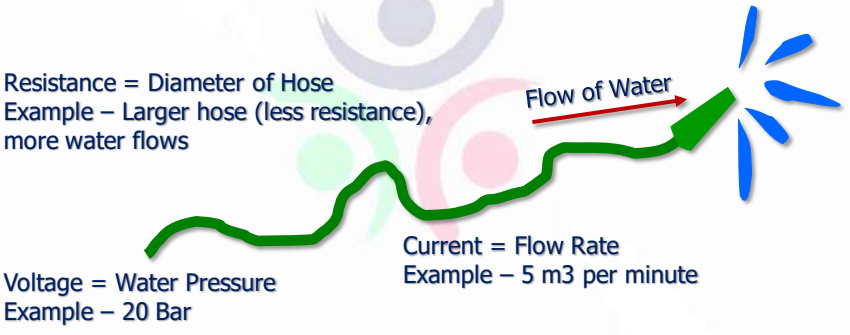


Short Circuits: if a circuit is linked by a conductor to an area of lower electrical potential, the current will flow to the lower potential instead of round the circuit – this is a **short circuit**. The new circuit created by the short circuit is called the **earth fault loop**.

Earthing Principles: the earth conductor in a circuit (protective conductor) is linked to the general mass of earth which at zero potential. By connecting the metal parts to earth, this will prevent them of becoming live if provided by any fault current.

FUNDAMENTALS OF ELECTRICITY

LIKE WATER IN A GARDEN HOSE



ALTERNATING CURRRENT

- More common in electrical work.
- Changes rapidly in both direction and value.
- Power companies produce power cheaper with alternating current.

DIRECT CURRENT

- Always flows in one direction
- Used to charge batteries, run some motors, operate magnetic lifting devices and welding equipment.

OHM'S LAW

- George Simon Ohm
  - Formulated a mathematical relationship between:
    - Current= I
    - Potential Difference (or)Voltage= V
    - Resistance= R

I= V/R Or V= IR where V is the potential difference in volts

Electric power P, is the rate of doing work, measured in **watts**,

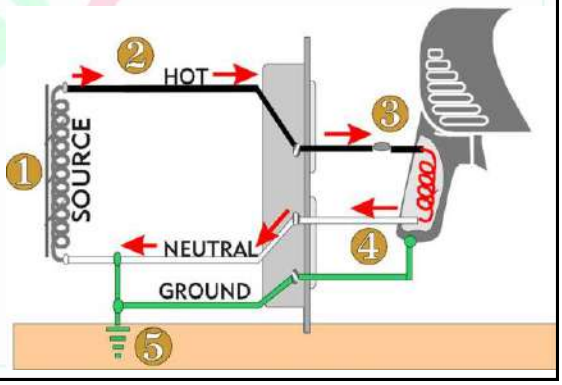
P= V X I = volt X amperes = watts

FUNDAMENTALS OF ELECTRICITY

- Circuits are AC (alternating current) or DC (direct current).
- Current is usually AC.
- AC current has five parts:

(1) Electrical source
(2) HOT wire to the tool.
(3) The tool itself
(4) NEUTRAL wire returns electricity from the tool
(5) GROUND

To Enable current electricity to flow there need to be a complete circuit from, and back to, the source.

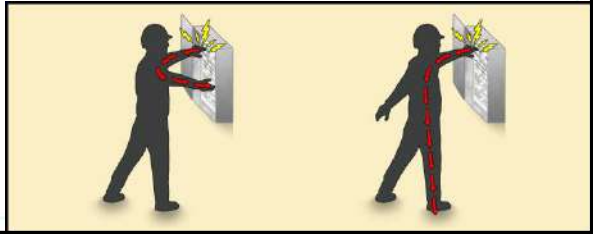


ELECTRICAL HAZARDS

ELECTRIC SHOCK

How Shocks Occur

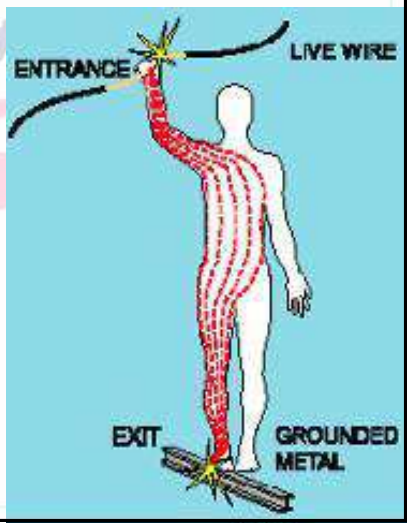
- Current travels in closed circuits through conductors (water, metal, the human body).
- Current enters at one point & leaves at another.
- Electric shock occurs when the body becomes part of the circuit.
- The direct result can be electrocution.
- The indirect result can be a fall or other actions.



Effects On The Body

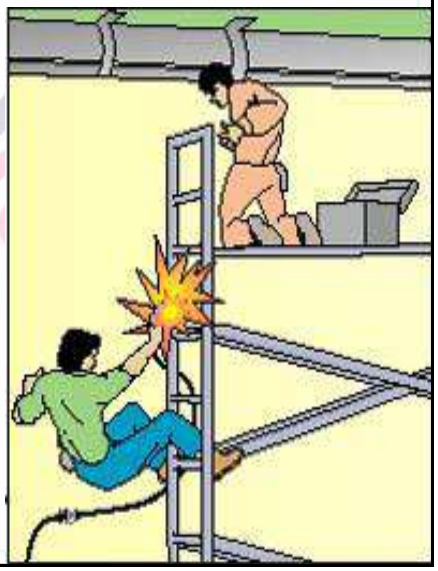
The current may have a number of effects on the body, any of which may prove fatal:

- Pain
- Muscular contraction
- Respiratory failure
- Fibrillation of the heart
- Cardiac arrest
- Internal burns



SECONDARY EFFECTS OF ELECTRIC SHOCK

The involuntary muscular reaction may throw the arm back so violently that the muscles become overstrained or ligaments are torn. The shock may startle the victim and cause momentary lose of control and balance, resulting in falls if working at height.



SEVERITY OF THE SHOCK

Severity of the Shock depends on:

- **Amount of current**
  - Determined by voltage and resistance to flow
- **Path through the body**
- **Duration of flow through the body**
- **Other factors such as general health and individual differences.**

EFFECTS OF CURRENT FLOW

- 0.5 – 2 milliamps (ma): Threshold of perception
- 2 - 10 ma: Painful sensation
- 10 - 25 ma: Inability to let go, danger of asphyxiation
- 25 - 80 ma: loss of consciousness from heart or respiratory failure
- More than 80 ma: Burns at point of contact, death from ventricular fibrillation

let go value: is the value of current that the hand will, if holding the life source, be unable to let go.

EFFECTS OF CURRENT FLOW

Using a 120 volt circuit and resistance for wet & dry skin:

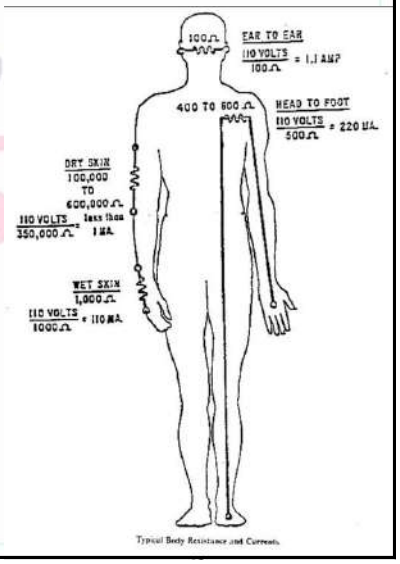
V=IR: Voltage=Current x Resistance
(Volts) (Amps) (Ohms)

So: I=V/R

Dry Skin =120/100,000=.0012 amps
=1.2ma flowing through
body to ground

Wet skin =120/1000=.120 amps
=120ma flowing through
body to ground

Remember: 1 Amp = 1000 milliamps



Typical Body Resistance and Currents.

EFFECTS OF CURRENT FLOW

ELECTRICAL HAZARDS

ELECTRIC BURNS

- **Direct Burns:** caused by the intense heating effect of an electric current as it passes through the body.
- **Indirect Burns:** electric arcing generates large amounts of energy and leads to burns caused be radiation:
  - Infra red, which produces a sensation of heat.
  - Ultraviolet, which can burn the skin and cause "eye flash" which is an eye irritation.

ELECTRICAL HAZARDS

ELECTRIC FIRES

Can be caused in several ways:

- Leakage of current due to poor electrical insulation.
- Overheating of electrical equipment and cables due to overloading of conductors.
- Overheating of flammable materials too close to electrical equipment.
- Ignition of flammable vapour by electrical equipment which is not operating normally.
- Mechanical damage: the overloading of a socket will damage it and can lead arcing between the plugs.

ELECTRICAL HAZARDS

ELECTRIC ARCS

Sometimes called a 'flashover' or 'arc flash', Arcing can occur when the potential in a conductor is great enough to create a conductive path between that conductor and another which is at lower potential.

The arc will be capable of crossing the air gap or insulation which separates the two conductors. Very amounts of energy can be created in a short time, possibly less than one second.

It generates ultraviolet radiation which can burn the skin and the retina of eyes, additional burns may results from radiated heat and form molten/hot metal fragment.

Sever, sometimes fatal, injuries and burns or serious fire may result from an arcing incident.

STATIC ELECTRICITY

Static is produced by build up of electrons on poor conductors of electricity and this affected by:

- –The speed of separation of materials
- –The size of contact area
- –The degree of conductivity

Greater charges are created by:

- – Fast separation
- – Large contact
- – Insulators

Insulators such as plastic, paper and synthetic fabric can create charges of thousands of volts relatively quickly which may be retained for long period.

STATIC ELECTRICITY

The main **hazards** of static electricity is:

The discharge of very high voltage to earth which can ignite flammable atmospheres.

Liquids, solids and gases can build an electrostatic charge either positive or negative, which will discharge into anything of opposite polarity on contact.

if high voltages are involved, flash over, sufficient to ignite a flammable atmosphere may occur.

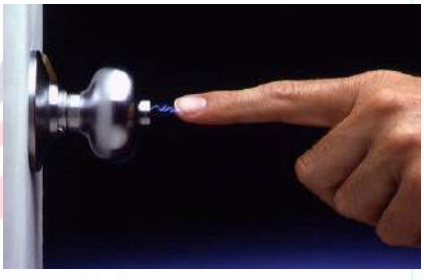
Static may be generated by:

- Conveyor belts
- Chutes
- Paper manufacture
- Mixing solids and loading to drums
- Organic liquids

STATIC ELECTRICITY

The static can occur:

- In pipelines during pumping
- On vessels during filling
- In mixing tanks



Discharge of static through a person is rapid, likely to cause some discomfort, but unlikely to cause burns or a fatality, but it may cause a secondary accident such as "**fall from height**".

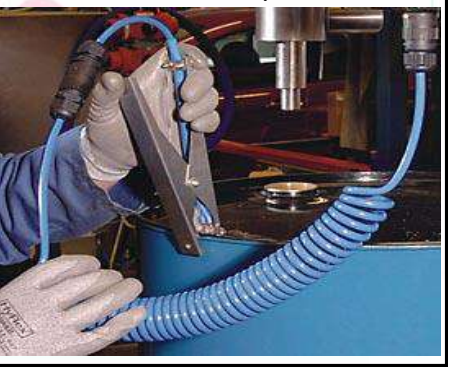
STATIC ELECTRICITY

Precautions

Earthing:

Provision of a conductive path to prevent the build up of charge.
Earthing should follow this sequences:

- Earth connection is made before fluid transfer takes place.
- It is removed after the transfer is complete
- Premature removal of the earth connection could produce a hazardous spark.



STATIC ELECTRICITY

Precautions

Increasing conductivity:

to minimize the build-up of static charge. And this can be achieved by modifications the material:

- –Flammable liquid fuels treated with additives to reduce resistance.
- –Plastic treated with a surfactant chemical.
- –Rubber or plastic conveyor belts containing carbon black

Ionization:

a conductive path can be created by ionizing the air at the surface of the material, to prevent the build–up of static charge.

PLANNING, DESIGN AND INSTALLATION OF ELECTRICAL SAFETY

Electrical systems should be planned, designed and installed in way to prevent danger through:

- –Strength and Capability of Electrical Equipment
- –Insulation, Protection and placing of Conductors
- –Reducing the Risk of Shock
- –Excess Current Protection
  - Fuses
  - Circuit Breakers
- –Cutting off Supply and Isolation
- –Working Space, Access and Lighting

Strength and Capability of Electrical Equipment

- Electrical equipment should not be brought into use if its strength and capability may be exceeded in such way give rise to danger.

  This to insure that :
- Equipment will not subject to electrical stress and,
- It is able to withstand the effects of the electrical current (normal currents, overload currents and faults currents).

Insulation, Protection and placing of Conductors

- The first way to safeguard workers from electrically energized wires is through insulation.
- Rubber and plastic is put on wires to prevent shock, fires, short circuits and for strain relief.
- It is always necessary to check the insulation on equipment and cords before plugging them in.
- Remember, even the smallest defect will allow leakage!

PLANNING, DESIGN AND INSTALLATION OF ELECTRICAL SAFETY

Insulation, Protection and placing of Conductors

Defective Extension Cords

Defective Cord Incident

- Worker attempted to climb scaffold with electric drill.
- Drill's cord was damaged with bare wires showing.
- The bare wire contacted the scaffolding.
- The worker died!

PLANNING, DESIGN AND INSTALLATION OF ELECTRICAL SAFETY

Insulation, Protection and placing of Conductors

Elevating the Conductors

- The second way to safeguard workers from electrically energized wires is by elevating them.
- Wires are often elevated by the power company.
- It is always necessary to check the location of overhead lines before you begin work each day.
- Remember, never allow yourself, your tools, or the materials you are working with to be within *3 meters* of energized lines!

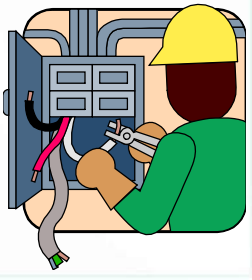
Overhead Line Incident

- A worker was attempting to move mobile scaffold.
- Scaffold made contact with 7200 volt line.
- The worker died.

PLANNING, DESIGN AND INSTALLATION OF ELECTRICAL SAFETY
Insulation, Protection and placing of Conductors

Guarding the Conductors

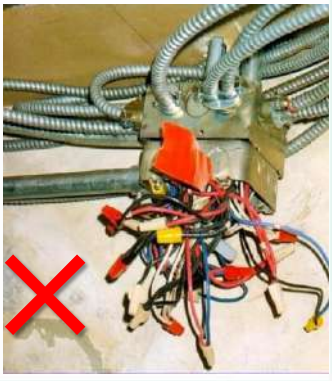
- The third way to safeguard workers from electrically energized wires is by guarding them.
- Covers, boxes, and enclosures are often put around conductors to prevent worker contact.
- It is always necessary to check that electrical boxes and panels are covered and free from missing “knock-outs”.



Insulation, Protection and placing of Conductors

Guarding the Conductors

- Live parts of electric equipment operating at 50 volts or more guarded against accidental contact by approved cabinets, or other forms of approved enclosures, or by any of the following means:



PLANNING, DESIGN AND INSTALLATION OF ELECTRICAL SAFETY

Insulation, Protection and placing of Conductors

Guarding the Conductors

- By location in a room, vault, accessible only to qualified persons.
- By permanent, substantial partitions or screens
- By location on a suitable balcony or platform as to exclude unqualified persons.
- By elevation of 8 feet or more above the floor or other working surface.

Insulation, Protection and placing of Conductors

Guarding the Conductors

Entrances to rooms and other guarded locations containing exposed live parts shall be marked with conspicuous warning signs forbidding unqualified persons to enter

PLANNING, DESIGN AND INSTALLATION OF ELECTRICAL SAFETY

Insulation, Protection and placing of Conductors

Guarding the Conductors

Insulation, Protection and placing of Conductors

Equipment Grounding

- We can be safe by providing a separate, low resistance pathway for electricity when it does not follow normal flow (ground prong).
- Grounding gives the stray current somewhere to go and keeps you from becoming part of the circuit.

PLANNING, DESIGN AND INSTALLATION OF ELECTRICAL SAFETY

Insulation, Protection and placing of Conductors

Can You Rely on Grounding?

- Grounding *will not work* if the electricity can flow through you more easily than the ground. This can happen when:
  - **Your tool doesn't have a ground pin.**
  - **You're working in wet locations.**
  - **You're touching a metal object.**

Insulation, Protection and placing of Conductors

What Must be Grounded?

- All circuits and extension cords.
- All noncurrent carrying metal parts.
- Portable & semi-portable tools and equipment unless double insulated.

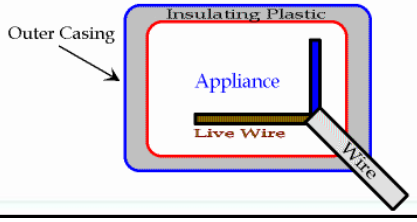
PLANNING, DESIGN AND INSTALLATION OF ELECTRICAL SAFETY

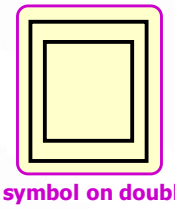
Reducing the Risk of Shock

Reducing the likelihood of a shock occurring by:

Double insulation:

Double insulated appliances have plastic cases, without any wires connected to the case. This means that the case cannot become live, because plastic does not conduct electricity.





symbol on double insulated appliance

Reducing the Risk of Shock

Reducing the likelihood of a shock occurring by:

Training:

Even the most highly qualified and capable people may not be competent to carry out specific types of work without suitable training. Competent workers will be self-disciplined and aware that reckless behavior with electricity can lead to injury and death.

PLANNING, DESIGN AND INSTALLATION OF ELECTRICAL SAFETY

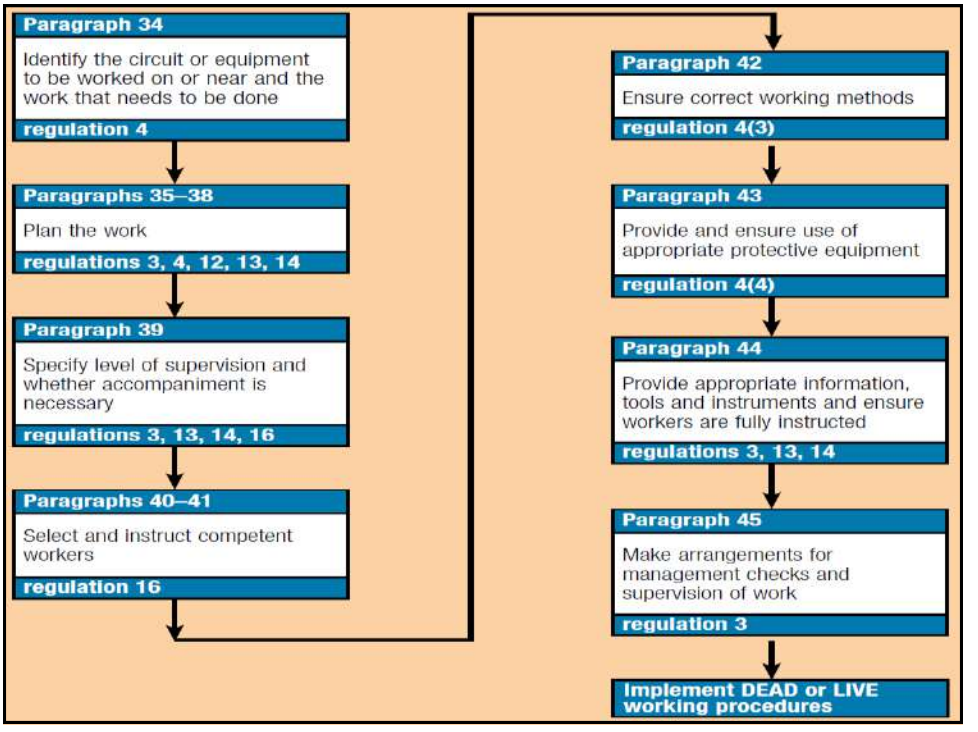
Reducing the Risk of Shock

Reducing the likelihood of a shock occurring by:

Safe System of Work:

procedures to control the Hazards, implement them, train and instruct workers and monitor the compliance.

It will include also Signage, Emergency response plan, the use of permit to work, Risk assessment and others can make the work Safe.



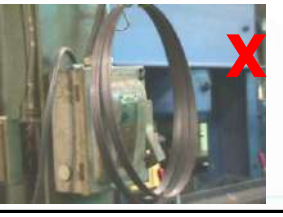
PLANNING, DESIGN AND INSTALLATION OF ELECTRICAL SAFETY

Reducing the Risk of Shock

Reducing the likelihood of a shock occurring by:

Providing Working Space:

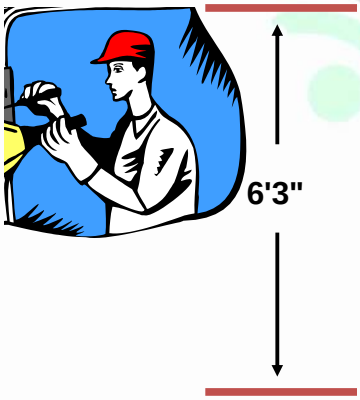
- Sufficient access and working space around all electrical equipment, provided & maintained to provide ready and safe operation and maintenance.
- Not used for storage.
- If located in aisle or general open area, working space shall be suitably guarded.



Reducing the Risk of Shock

Reducing the likelihood of a shock occurring by:

Headroom



- The minimum headroom of working spaces about service equipment, switchboards, panel-boards, or motor control centers shall be 6 feet 3 inches.

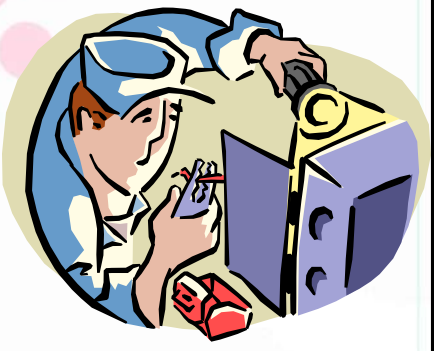
PLANNING, DESIGN AND INSTALLATION OF ELECTRICAL SAFETY

Reducing the Risk of Shock

Reducing the likelihood of a shock occurring by:

Illumination

- Illumination provided for all working spaces about service equipment, switchboards, panel-boards, and motor control centers installed indoors.



Reducing the Risk of Shock

Reducing the likelihood of a shock occurring by:

Illumination

- Adequate illumination for all working spaces about electric equipment.
- The lighting outlets arranged that persons changing lamps or making repairs on the lighting system will not be endangered by live parts or other equipment.

PLANNING, DESIGN AND INSTALLATION OF ELECTRICAL SAFETY

Reducing the Risk of Shock

Reducing the likelihood of a shock occurring by:

Residual Current Devices "GFCI Protection"

We can be safer by automatically shutting off the flow of electricity in the event of leakage, or short circuit.

Residual Current Devices /Ground Fault Circuit Interrupters (GFCI) are circuit protection devices that protect you, the worker.

- Must be wired correctly and tested.

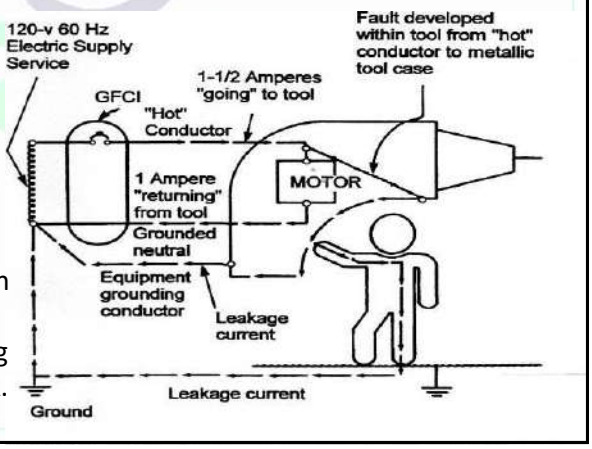
Reducing the Risk of Shock

How a GFCI Works?

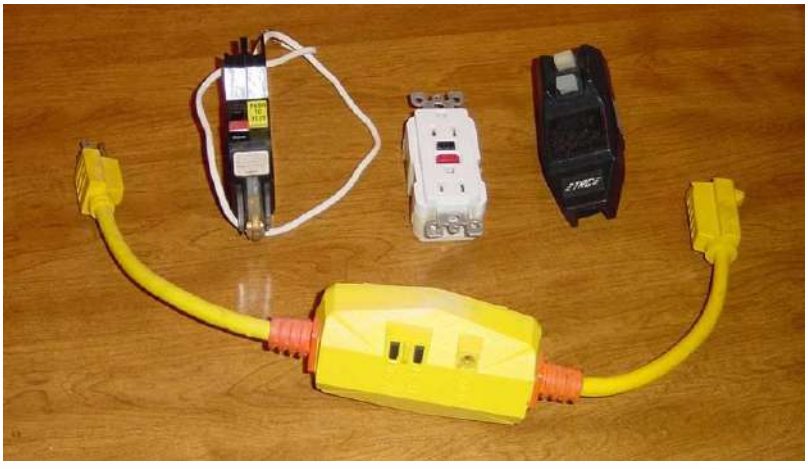
Continually measure the current flowing in the live and neutral lines and trip the circuit if any difference caused by short circuit to earth

The GFCI detects 'leakage' of 30 mA milliamps & opens the circuit in 1/1000 of a second.

Detect human contact with a live conductor resulting in electrical current flow to earth quickly enough to prevent sufficient current flow for long enough to prevent fatal shock.



Types of GFCI Protection



Types of GFCI Protection

A GFCI breaker must be installed to protect workers using 220V masonry saws.

GFCI Testers

Reducing the Risk of Shock

Reduced Voltage Systems

A system in which the nominal line to line voltage does not exceed 110V and the nominal line to earth voltage does not exceed 63.5V". On single phase systems the maximum shock risk to earth is 55V and on three phase systems the maximum shock risk to earth is 63.5V. It is believed that no one has died purely as a result of an electric shock from an Reduced Low Voltage "RLV" supply.

PLANNING, DESIGN AND INSTALLATION OF ELECTRICAL SAFETY

Reducing the Risk of Shock

Reduced Voltage Systems

RLV should be used to feed portable equipment and temporary lighting on construction sites, wet areas and similar installations.

Lower voltage systems (safety extra low voltage, SELV) are those in which the voltage doesn't exceed 50 volts ac. These system represent even less hazard and should be used:

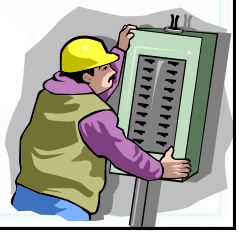
- In vehicle washing areas.
- In the vicinity of swimming pools.
- For hand lamps, and other small hand tools where the risk of shock is high.

Excess Current Protection

Protection to cope with faults and overloads which could give rise to danger includes the use of:

- **Circuit Breakers** and **Fuses**
  - Only protect the building, equipment, and tools from heat build-up!
  - Never depend on circuit breakers or fuses to prevent shocks!

Protection devices disconnect the current flow when excess current is detected.



PLANNING, DESIGN AND INSTALLATION OF ELECTRICAL SAFETY

Excess Current Protection

Fuses

An electrical fuse is a simple device used to interrupt an electrical circuit during over current condition due to short circuit and/or overload. An electrical fuse operates on the principle of heating effect of electric current.

The time required for melting the fuse element depends upon the magnitude of the over current. If, more over current flows through a fuse element, more rapidly it is melted to disconnect the supply.

Fuse

Excess Current Protection

Circuit Breakers

Is a switching device which can be operated manually as well as automatically for controlling and protection of electrical power system respectively.

Trip out when excess current is detected by either temperature increase or increased magnetic field

Can be reset, quickly restoring the electricity supply, but need regular testing.

PLANNING, DESIGN AND INSTALLATION OF ELECTRICAL SAFETY

Cutting off Supply and Isolation

Switching off: refers to depriving the equipment of electric power.

Isolation: refers to depriving it of electric power from any source with the additional step being taken of ensuring that it cannot be inadvertently re-energized.

The means of cutting of the supply must be:

- Capable of operation in normal, abnormal and fault condition
- Suitably located
- Clearly labeled.

Cutting off Supply and Isolation

Isolation should establish an effective barrier between the equipment and the supply and ensure no unauthorized person is able to remove it.

The means of isolation should:

- Establish an air gap or some other barrier
- Include a padlock or lock to prevent the removal of the barrier by unauthorized persons.
- Be accessible, easy to operate and clearly labeled.

PLANNING, DESIGN AND INSTALLATION OF ELECTRICAL SAFETY

Control Measures for Electrical Equipment and System Must Consider:

–Selective and Suitability of Equipment.

–Protective Systems:

- Fuses
- Reduced Voltage System
- Isolation
- Residual Current Devices
- Double Insulation
- Earth Free Zones

Inspection and Maintenance Strategy:

- **User Checks:**

  Visual check for damage, loose parts and other sign.

- **Formal Visual Inspections:**

  By competent person, remove the cover check fuse, terminations and internal intact.

- **Combined Inspection and Tests:**

  Testing and inspection together to check earth integrity, insulation, contamination internally and externally.

PLANNING, DESIGN AND INSTALLATION OF ELECTRICAL SAFETY

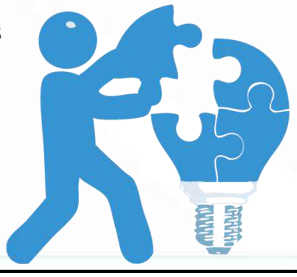
Inspection and Maintenance Strategy:

- **Records of maintenance and tests:**

  Records should be maintained to each equipment (faults and maintenance) and label the equipment indicating that it passed as safe and the next test date.

- **Frequency of Inspection and Testing:**

  Will be related to: type of equipment, manufacture's recommendation, age, working environment, frequency of use, previous previous maintenance record recommendation..



- **Competent Persons:**

  Only competent person will inspect and test.

ADVERSE OR HAZARDOUS ENVIRONMENT

Electrical equipment to be used in hazardous environments should be constructed and protected to prevent danger arising from exposure through:

- Resistance to mechanical damage and solid bodies.
- Protection against dusts, liquids and gas.
- Protection against natural hazards.

ADVERSE OR HAZARDOUS ENVIRONMENT

Principles of Selection of Electrical Equipment for Use in Flammable Atmospheres:

In situation where flammable atmospheres are present or likely to occur on occasions, particular precautions are necessary to prevent electrically caused ignition of the atmosphere.

Hazardous Areas Classification

Explosive gas atmosphere zone classification

Zone 0, Zone 1 & 2

Combustible dusts cloud zone classifications

Zone 20, Zone 21 & 22

Hazardous Area classification:

Hazardous areas are classified into zones based on an assessment of the frequency of the occurrence and duration of an explosive gas atmosphere, as follows:

Zone 0:

An area in which an explosive gas atmosphere is present continuously or for long periods.

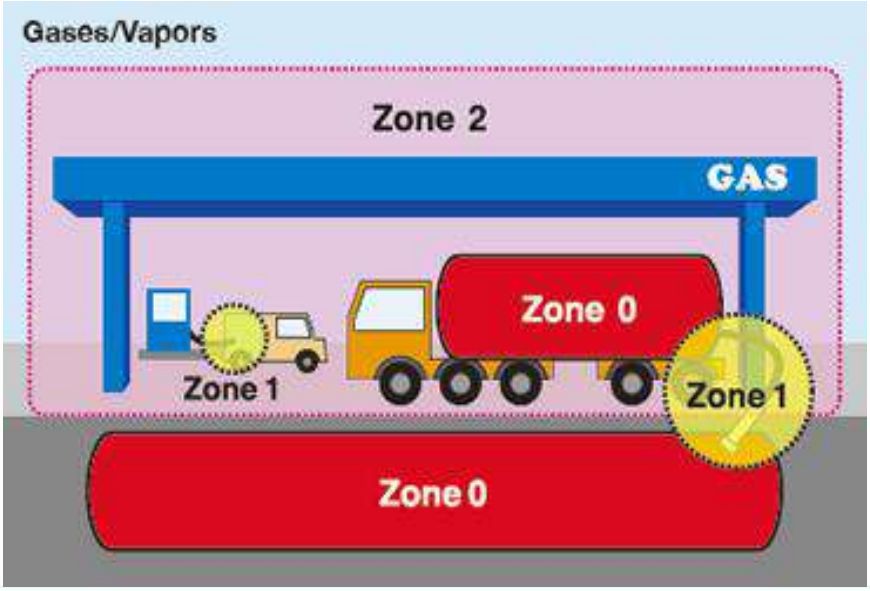
Zone 1:

An area in which an explosive gas atmosphere is likely to occur in normal operation.

Zone 2:

An area in which an explosive gas atmosphere is not likely to occur in normal operation and, if it occurs, will only exist for a short time.

ADVERSE OR HAZARDOUS ENVIRONMENT



Hazardous Area classification:

For Dusts, the zone classifications are:

Zone 20

A place in which an explosive atmosphere in the form of a cloud of combustible dust in air is present continuously, or for long periods or frequently.

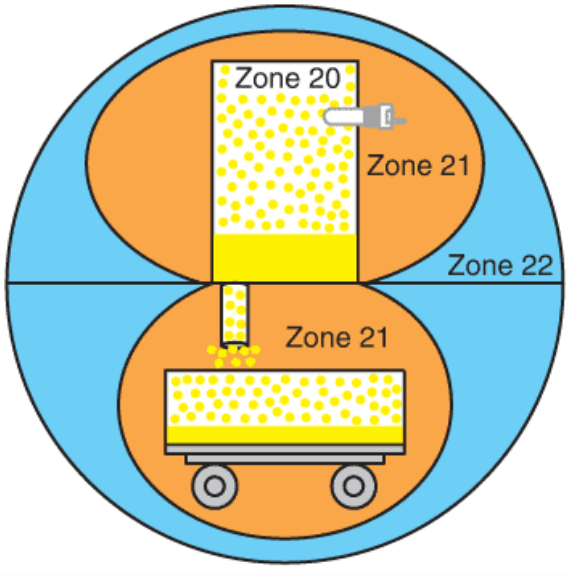
Zone 21

A place in which an explosive atmosphere in the form of a cloud of combustible dust in air is likely to occur in normal operation occasionally.

Zone 22

A place in which an explosive atmosphere in the form of a cloud of combustible dust in air is not likely to occur in normal operation but, if it does occur, will persist for a short period only.

ADVERSE OR HAZARDOUS ENVIRONMENT



Equipment in hazardous areas

Special precautions need to be taken in hazardous areas to prevent equipment from being a source of ignition.
So, reliance is placed on using equipment with a low probability of creating a source of ignition.
Equipment is categorized (1, 2 or 3) depending on the level of zone where it is intended to be used.

ATEX is the name commonly given to the two European Directives for controlling explosive atmospheres. They talk about Equipment and protective systems intended for use in potentially explosive atmospheres and Minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres.

Where necessary, the entry points to areas classified into zones must be marked with a specified '**EX**' sign.

ADVERSE OR HAZARDOUS ENVIRONMENT

Equipment categories and zones

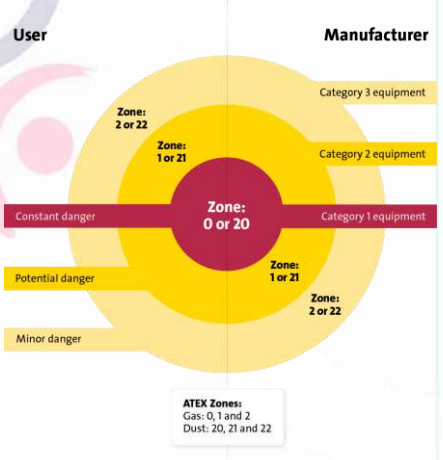
The hazardous area zone classification and corresponding equipment categories are:

Zone 0 or zone 20 - category 1 equipment

Zone 1 or zone 21 - category 2 equipment

Zone 2 or zone 22 - category 3 equipment

Note; Category 1 equipment can also be used in zones 1 and 21 and category 1 and 2 equipment can be used in zones 2 and 22.



Types of Equipment

Intrinsically safe:

The equipment is designed that the electrical energy which can enter explosive environment is so low or restricted in a manner that it cannot ignite a explosive gas air mixture.

Two Categories are there:

ia more stringent and suitable for zone 0

ib less stringent and suitable for 1 & 2

Type 'e' Equipment :

This type of protection is achieved by adopting measures in the design and manufacture of electrical apparatus to ensure security against occurrence of arcs, sparks and excessive temperature.

ADVERSE OR HAZARDOUS ENVIRONMENT

Types of Equipment

Type 'n' Equipment or non sparking type:

Less stringent requirement have to be met by this category of equipment as compared with type 'e' it is intended to for use in zone 2.

Flameproof Equipment:

The enclosure which houses the equipment is designed that the explosion inside the enclosure will not be transmitted to outside hazardous atmosphere.

Example: motor, lighting, and portable hand lamp. Suitable in zone 1&2 but not in zone 0.

SAFE USE, MAINTENANCE AND REPAIR OF ELECTRICAL SYSTEM

Importance of Schemes of Maintenance, Schedule, Plans and Records.

A preventive maintenance "PM" program which include regular inspection, test and repair of equipment is essential to prevent break down and lead to danger.

The PM frequency depends on :

- Manufactures' recommendations.
- Users' experience.
- Nature of the equipment.
- Work to be undertaken.

SAFE USE, MAINTENANCE AND REPAIR OF ELECTRICAL SYSTEM

Safe System of Work and Criteria of Acceptability of **live working**

There are limited circumstances where live working is deemed to be acceptable. It is where:

- Unacceptable in all the circumstances for the live part to be dead.
- Reasonable in all the circumstances for the person to be at work on or near the live part whilst it is live.

Examples of work on near live conductors include:

- Maintenance of electrified railway track.
- Cable jointing in the electricity supply industry.
- Fault testing

Whenever possible, work on live equipment should be carried out form distance by using specially designed insulated tools.

SAFE USE, MAINTENANCE AND REPAIR OF ELECTRICAL SYSTEM

Safe System of Work and Criteria of Acceptability of **live working**

❑**To prevent injury, the following precautions should be taken:**

- Only competent persons should undertake the work.
- Adequate information should be provided:
  - The type of conductors
  - The associated system
  - The foreseeable risks

❑**Suitable tools, equipment and protective clothing should used:**

- Test instruments with insulated probes.
- Insulated gloves, helmets and goggles.
- Insulated screens, mats and stands.

SAFE USE, MAINTENANCE AND REPAIR OF ELECTRICAL SYSTEM

Safe System of Work and Criteria of Acceptability of **live working**

❑**The worker should be accompanied by a person capable of reducing the risk of injury and administrating help in an emergency.**

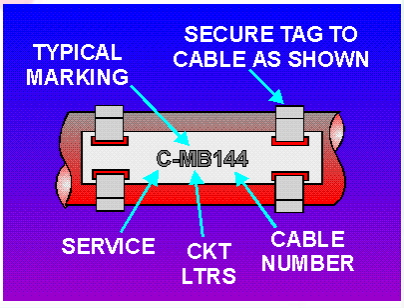
❑**Regular, Routine testing on live uninsulated conductors should be restricted to designated areas where measure are taken to ensure the work can be done in safety in non-conducting environment.**

❑ **Entry to the work area should be restricted to essential personal only.**

Safe Systems of Work on Installation **Made Dead**:

Identification

Adequate information should be supplied to identify equipment correctly. For most circuits and equipment correct labeling is important, but it should never be assumed that labeling is correct and that work can be started without having first proved that the equipment or circuit is dead. In some special cases, e.g. underground cables, cable-locating techniques using specialized instruments may be necessary and it may also be necessary to identify the cable both before and after switching operations and cable spiking.



SAFE USE, MAINTENANCE AND REPAIR OF ELECTRICAL SYSTEM

Safe Systems of Work on Installation **Made Dead:**

Disconnection '**cutting of the supply**'**.**
Disconnect the equipment from every source of electrical energy before working on. ensure stored charge has been safely discharged.

Secure isolation

For adequate isolation, the disconnecting device should have an isolating gap sufficient for the voltage levels present or likely to occur. Switches, should be locked in the OFF position preferably using a 'safety' lock,

Safe Systems of Work on Installation **Made Dead:**

Post notices

You should put a notice or label at the place of disconnection. For example, a 'caution' notice can be used, and 'danger' notices attached to live equipment adjacent to the place of work will indicate that the apparatus is still energized. You should remove labels or notices when they no longer apply so that the system does not fall into disrepute. It is often useful for the 'caution' and 'danger' notices to have a space for the name of the person responsible for the work and for the date.

Safe Systems of Work on Installation **Made Dead**:

Proving dead

Having isolated the circuit or equipment, and before working on it, check that the parts to be worked on or near really are dead.

The instrument to do this should be properly constructed to protect against electric shock.

It will be necessary to test the instrument before and after use.

Where underground cables cannot be positively identified and proved dead at the point of work, it may be necessary to spike the cable using a properly designed, Cable spiking tool.

Cable spiking tool

Safe Systems of Work on Installation **Made Dead:**

Earthing

The risk to people if the above precautions fail can be minimized by securely earthing all the conductors using properly designed earthing devices or earthing leads,

Earthing low-voltage equipment is desirable if there is a risk of re-energisation, e.g. from a generator under someone else's control.

Adjacent parts

The danger from inadvertent contact with other live parts nearby. This should preferably be done by erecting physical barriers and/or the use of temporary insulation and posting 'danger' notices.

SAFE USE, MAINTENANCE AND REPAIR OF ELECTRICAL SYSTEM

The use of Electrical permits-to-work:

An electrical permit-to-work is primarily a statement that a circuit or item of equipment is safe to work on, isolated and, where appropriate, earthed.

It should state which equipment etc. has been made safe, the steps by which this safety has been achieved, and exactly what work is to be done.

If a program of work must be changed, the existing electrical permit-to-work should be cancelled and a new one issued before any variation is made to the work.

SAFE USE, MAINTENANCE AND REPAIR OF ELECTRICAL SYSTEM

The use of Electrical permits-to-work:

An electrical PTW should be issued by only a designated competent person who is familiar with the system and equipment.

The electrical permit-to-work should state clearly:

- the person the permit is addressed to,
- the exact equipment which has been made dead and its location;
- the points of isolation;
- where the conductors are earthed;
- where warning notices are posted and special safety locks fitted;
- the nature of the work to be carried out;
- the presence of any hazard, with cross-reference to other permits;
- further precautions to be taken during the course of the work.

SAFE USE, MAINTENANCE AND REPAIR OF ELECTRICAL SYSTEM

The use of Electrical permits-to-work:

In cases where there may be divided responsibility, roles must be defined to ensure there is no confusion over respective responsibilities, for instance:

At the time the person in immediate charge of the operation accepts the permit they become responsible for ensuring that all the specified safety precautions are followed that:

- only permitted work is done; and
- the work is confined to the area defined in the permit.

SAFE USE, MAINTENANCE AND REPAIR OF ELECTRICAL SYSTEM

The use of Electrical permits-to-work:

the leader of a group, should explain – before the work begins:

- The scope of work and the means by which safety has been achieved.
- No one should issue permit to himself.
- The recipient of an electrical permit-to-work should keep it for reference while the work is in progress and to prevent inadvertent cancellation and re-energisation of the equipment.
- When the work is complete, whoever the permit was issued to should sign it to declare that any additional earths and tools have been removed and people in the group have been withdrawn and instructed not to approach the equipment again.

Safe Working in the Vicinity of High-Voltage Systems

Common High-Voltage Systems and Prevention of Danger

- High-Voltage Systems are often to be in excess of 1000V
- Contact with overhead electric lines can be lethal
- Overhead line consists usually of uninsulated conductors supported via insulators by wooden poles or metal towers
- Work with or near overhead lines has led to many fatal and serious accidents.
- Direct contact with overhead cables is not necessary to cause harm since very high voltage can jump significant air gaps.
- Only **competent** person allowed to work, sign and authorize the work (he should have knowledge, ability, training, experience and know his limit).

Safe Working in the Vicinity of High-Voltage Systems

Safe System of Work and Permit to Work Procedures

PTW should be used to ensure that the defined and limited section of the system to be worked on has been made and will remain safe. A PTW should only be used on system made dead.

Access to High-Voltage Area

Access should be restricted to authorized persons only.

- The importance of isolating systems before gaining access must be stressed.
- Physical barriers should be provided to keep high-voltage systems and people apart:
  - Secure fencing.
  - Locked access.

Safe Working in the Vicinity of High-Voltage Systems

Safe System of Work and Permit to Work Procedures

Additional Precautions

- Portable electrical tools and inspection lamps should operate at voltages no greater than 110V. Other tools should be all-insulated.
- Adequate working space is provided to prevent danger.
- Suitable PPE / clothing should be issued and used.
- No lone working.
- Suitable fire extinguisher equipment should be available nearby.

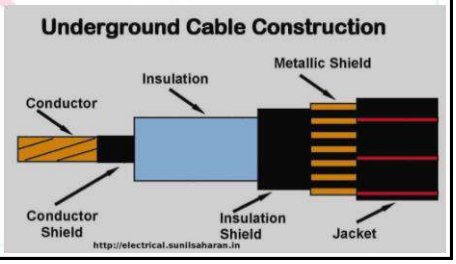
Safe Working Near overhead Power lines and Underground cables – hazards and Precaution

Underground Cables

These are particularly Hazardous because they are:

- Concealed
- Frequently close to the surface
- Sometimes in unexpected location

Damage to cables usually occurs during excavation work. The damage to the live cables often results in arcing currents with associated explosive effects, fire and flames which cause potentially fatal burns to hand, face.



Safe Working in the Vicinity of High-Voltage Systems

Safe Working Near overhead Power lines and Underground cables – hazards and Precaution

Underground Cables

Excavation Plan should assume that cables are present and live.

A safe system of work incorporating the following precautions should be used:

- **Use of cable location plans:** which is not accurate always due to change in soil depth, land marks and by people but still give good information.
- **Cable locating device:**
  - Radio frequency detector
  - Hum detector
  - Transmitter- receiver detector
  - Metal detector


Underground Cables Detector

Underground Cables

- **Safe Digging Practice:**
  Using hand tools by digging trial holes which should expose the cables
  Excavation should be alongside rather than above the cable
  The use of shovels rather than other tools such as picks.
- **Trained Personnel:**
  They should be trained on the hazards and precautions, type of cables, Depths of laying cables, use of plans and locations devices, and actions to be taken in the event of cables damaged (stop the job, put barrier and precautions to keep people away and repair it before continue).

Safe Working in the Vicinity of High-Voltage Systems

Safe Working Near overhead Power lines and Underground cables – hazards and Precaution

Overhead Lines

Normally not insulated and can be accessible to those working on roofs, scaffolding or elevated platform.

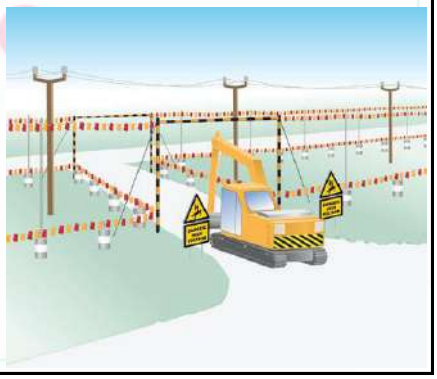
People operating vehicles such as cranes and excavators or handling equipment such as scaffold poles, metal ladders or pipes can also be at risk due to contact with, or flash over from, overhead cables.

Safe Working Near overhead Power lines and Underground cables – hazards and Precaution

Precautions with Work Near Overhead Lines

The priority is to make the line dead, If not possible then:

- No part of vehicle, plant or equipment should approach within:
  - 15 meters of lines suspended from steel towers.
  - 09 meters of lines suspended from wooden poles.
- Restricted Work or Passage of plant beneath lines
- Ground-level barriers



Safe Working in the Vicinity of High-Voltage Systems

Safe Working Near overhead Power lines and Underground cables – hazards and Precaution

Precautions with Work Near Overhead Lines (continue).

- Precautions for passage Beneath Lines.
- Work Carried out Beneath lines should:
  - Keep safe clearance.
  - Prohibit tools can extend to unsafe clearance.
  - Responsible person to supervise job
  - If risk is increased, an earthed steel net should be erected over the work area

Portable Electrical Equipment

Conditions and Practices likely to lead to Accidents:

Nearly a quarter of all reportable accidents involve portable equipment.

Failure to maintain equipment is a major cause of such accidents.

Conditions which may lead to accidents include:

- Incorrectly made connections.
- Damaged or missing insulation, exposing live conductors.
- Insulations failure.
- Servicing equipment without disconnecting supply.
- Misuse of equipment.
- Unauthorized equipment brought into the work environment.

Hazards of Portable Electric Tools

Accidents are typically caused by:

- Use of unsuitable equipment:
  - Flexible cable being dragged through areas where oil, grease or solvents are present.
  - Cable should be selected which has a sheath resistance to this chemicals.
- Use of defective equipment:
  - Badly made joints in flexible cables which can expose conductors.
  - Operators should be instructed:
    - ✓ Never to make their own repairs
    - ✓ Never to use defective equipment
    - ✓ Withdraw defective equipment and not to use unless repaired and checked by competent person.

Portable Electrical Equipment

Hazards of Portable Electric Tools

- Misuse of equipment:
  - Servicing the equipment while it is live.
- Inadequate maintenance:
  - No system of regular inspection “PM”.
  - Regular inspections of portable equipment are important because of the hard use that such equipment often suffers.

Portable Electrical Equipment

Reducing the Risk of Electric Shock with portable Equipment:

Risk of electric shock can be minimized by:

- Earthing all exposed metal parts.
- Using all-insulated casings.
- Using double insulation.
- Using reduced voltage.
- Providing sensitive earth-leakage protection to limit the duration of shock.

Inspection and Testing

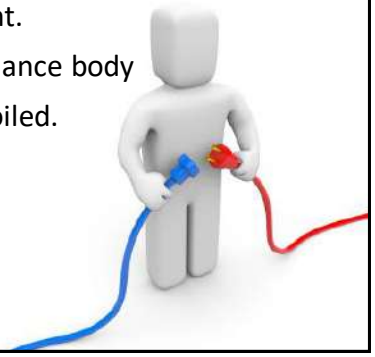
To prevents accidents, the followings are essential:

- All equipments should be recorded in a register, indicating when inspected, the next inspection and marked by that.
- Only competent person to inspect.
- Discourage the use of Unauthorized equipment.
- Inspection could include removal of the plug cover and checking that:
  - The correct fuse is being used.
  - The cord grip is holding the outer part of the cable tightly.
  - The wires, including the earth are attached to the correct terminals.
  - No bare wire is visible.
  - The terminal screws tight.
  - There is no sign of internal damage, i.e. (overheating or entry of liquid dust or dirt).

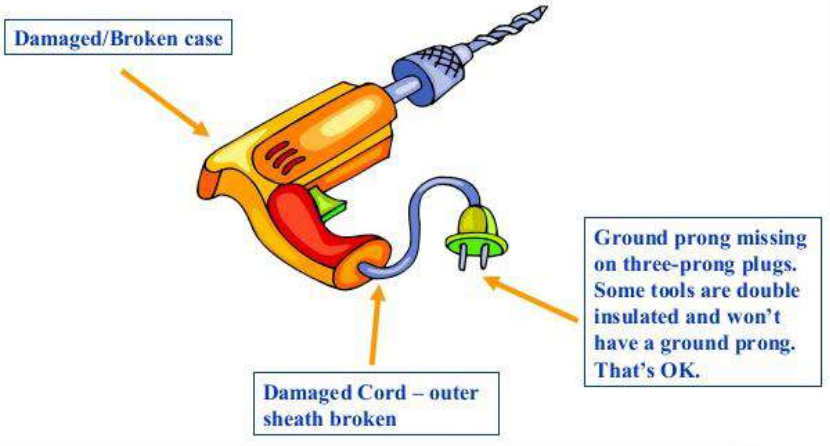
Portable Electrical Equipment

Routine Visual Inspection Checks:

- Body of plug is intact and secure.
- Plug cable clamp appears to be tight.
- Flex appears fully insulated, with no splits or sever pinches.
- Body of appliance is intact.
- Appliance cable clamp appears to be tight.
- No obvious scorch marks to plug or Appliance body
- Plug and appliance are not excessively soiled.
- Plug and appliance are not wet.



Portable Electric Tools - Things to look for:



Safe Work Practices

- Before work begins, the employer must determine where exposed and concealed electrical circuits are located.
- Once found, warning signs/labels must be posted.
- Workers need to know the location, hazards, and protective measures.

Safe Work Practices

- Competent Person determines if performance of work could bring contact with energy.
  - **Distance of the worker to the energy source should be considered first.**
  - **Tools, materials, and processes should also be considered to see if they could potentially shorten the safe separation distance.**
    - **Examples: Metal Ladders, Forklift, Scaffold Frames, etc.**

Safe Work Practices

- No metal ladders for or near electrical work.
- No wet hands when plugging or unplugging cords/equipment.
- No raising or lowering tools by the cord.
- Unless equipment is designed for it, cannot be used in damp and wet locations.

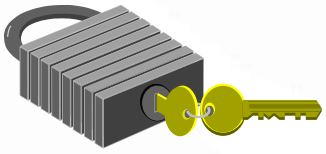
Safe Work Practices

- Must not permit work near electric circuits unless the worker is protected by:
  - **De-energizing the circuit and grounding it.**
  - **Guarding it effectively by insulation.**
  - **Other means (maintaining safe separation)**
- De-energized circuits and equipment must be *locked/tagged out.*

Lockout/Tagout Standard

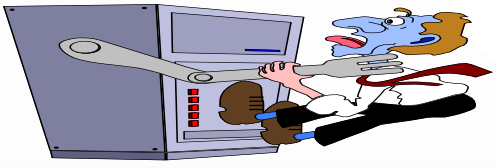
Lockout

- Lockout is a technique used to prevent the release of hazardous energy, or to prevent the hazardous energy from escaping.
- A padlock is placed on the appropriate energy isolating device that is in the off or closed position.



The "Fatal Five" Main Causes of Lockout/Tagout Injuries

- Failure to stop equipment
- Failure to disconnect from power source
- Failure to dissipate (bleed, neutralize) residual energy
- Accidental restarting of equipment
- Failure to clear work areas before restarting



Definitions

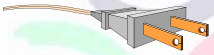
- Authorized Employee - one who locks out machines or equipment in order to perform the servicing or maintenance on that machine or equipment.
- Affected Employee - one whose job requires him/her to operate or use a machine or equipment on which servicing or maintenance is being performed under lockout, or whose job requires him/her to work in an area in which such servicing or maintenance is being performed.

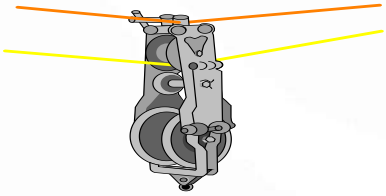
Definitions, cont.

- Energy Isolating Device - A mechanical device that physically prevents the transmission or release of energy.
- Energy Control Procedure - Safety program adopted by the employer that includes energy control procedures plus provisions for inspecting the procedures and training employees for lockout/tagout.

Hazardous Energy Sources Found in the Workplace

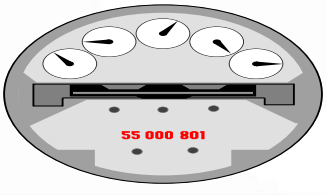
- Electrical
  - Generated
  - Static
- Mechanical
  - Transitional
  - Rotational
- Thermal
  - Machines or Equipment
  - Chemical Reactions
- Potential
  - Pressure
    - Hydraulic
    - Pneumatic
    - Vacuum
  - Springs
  - Gravity





Types of Lockout Devices

- Plug Locks
- Ball Valve Lockout
- Gate Valve Lockout
- Group Lockout Hasp
- Electrical
- Hydraulic, pneumatic, and other pressurized systems



Lockout Procedure

0. *Alert the operator (s) that power is being disconnected.*
1. *Preparation for Shutdown*
2. *Equipment Shutdown*
3. *Equipment Isolation*
4. *Application of Lockout Devices*
5. *Control of Stored Energy*
6. *Equipment Isolation-Verification*

Removal of Lockout

- *Ensure equipment is safe to operate*
- *Safeguard all employees*
- *Remove lockout/tagout devices. Except in emergencies, each device must be **removed by the person who put it on.***
- *Last person to take off lock*
- *Follow checklist*

Temporarily Reactivating Equipment

- *Remove unnecessary tools from the work area and make sure everyone is clear of the equipment*
- *Remove lockout/tagout devices and re-energize the system*
- *As soon as the energy is no longer needed, isolate the equipment and re-apply lockout/tagout, using the six step procedure.*

Special Situations

- *Servicing lasts longer than one shift.*
- *Contractors are performing service or maintenance at your workplace*
- *Worker who applied lock is not available*

Tidbits of Info.

- *Never attempt lockout/tagout procedures unless you have been trained and certified by your employer under an approved Energy Control Program.*
- *Never loan or share your lock, combination, or key with anybody else.*
- *Always be sure all lockout/tagout devices are compatible with the environment in which they will be used i.e. corrosive, humid, etc.*

NCMT

Mussafah 39, Abu Dhabi, UAE | Tel.: +97126721777 | Fax: +97126725511

Email: training@ncmt.ae | Web: www.ncmt.ae