

Construction Hazard and Risk Control

Lecture Title: Electrical Safety on Construction Sites

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**Undergraduate Diploma in
Occupational Health and Safety**

This lecture covers the following learning objectives:

- The principles, hazards and risk associated with the use of electricity in the workplace
- Outline the control measures that should be taken when working with electrical systems or using electrical
- Outline the control measures to be taken when working near or underneath overhead power lines



Differences Between Low and High Voltage

- **High voltage:** this is defined in national and international standards as being in excess of 1000V AC or 1500V DC.
- **Low voltage:** this is defined in national and international standards as any voltage in the range 50–1000V AC or 120–1500V DC and any voltage below 50V is classified as extra low voltage.



Potential Difference (or Voltage)

- For electricity to flow, there needs to be a source. This can be a battery or the socket in your workplace. This provides the voltage (unit - volts, symbol - V) which will push the electricity. The higher the voltage, the harder it will push.
- Whatever the source of electricity, there are a minimum of two terminals; one from which the electricity flows and the other to which it returns.
- On a battery they are the positive and negative terminals; in the wall socket they are the live and neutral connections (the two at the bottom in UK sockets, for example). In certain electrical arrangements, there may be more than two terminals, for example, three-phase systems.



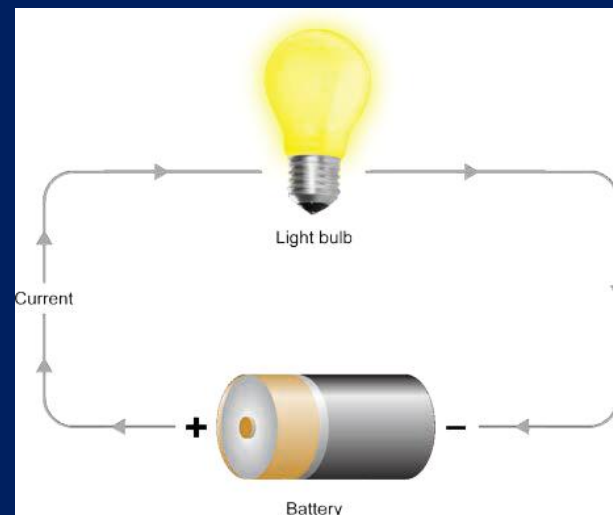
Potential Difference (or Voltage)

- To enable electricity to flow, there needs to be a complete circuit between the two terminals through which it can travel. This is normally made by using wires known as conductors. A good conductor will allow the electricity to flow easily. A typical good conductor is copper and most electrical circuits use copper wire.



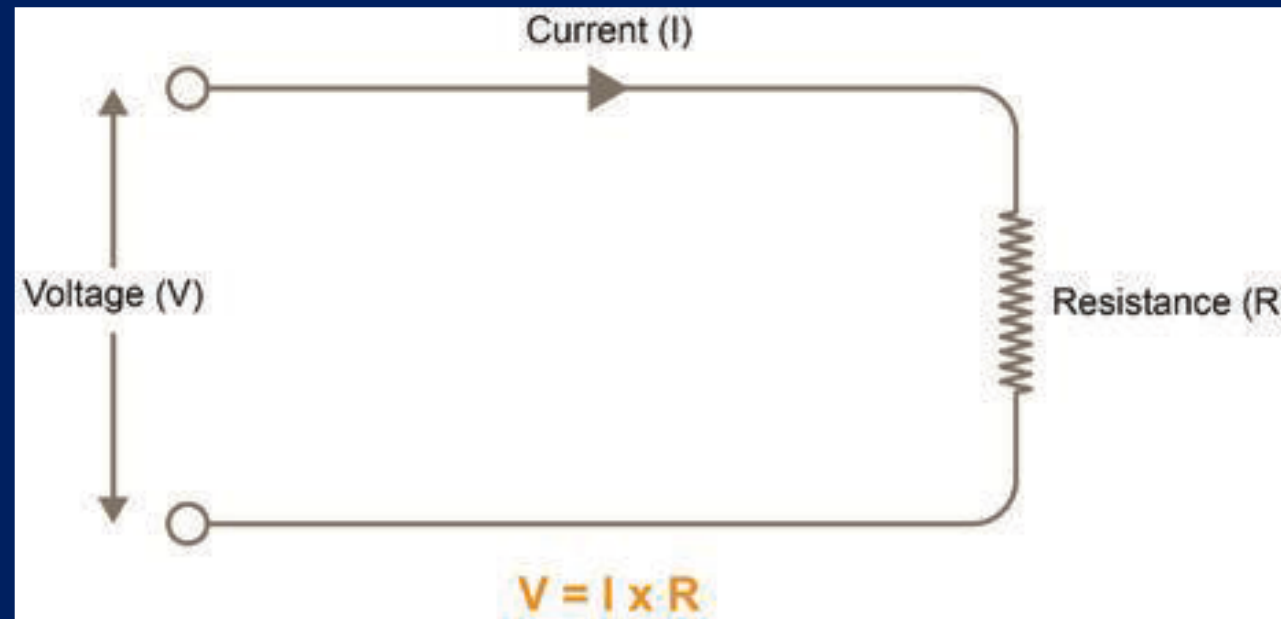
Current

- The flow of electricity through the conductors is known as the current (unit - ampere, symbol - A). The faster the current flows, the more power is generated. Current flow can be increased by using more voltage to push it through quicker.



Resistance and Impedance- $I = V/R$ or $R = V/I$

- To prevent a short circuit and to make the circuit useful, it is necessary to introduce something to slow the current flow. This is known as a resistance (unit - ohm, symbol - Ω). Typical resistances used in everyday life include light bulbs, power tools, hi-fi systems. In fact, everything that relies on electrical power is a resistance.



Circuits

- An electrical circuit consists of a number of components - a **source** of electric current, conductors and equipment powered by the current.
- The current is supplied from a source (e.g. a generator or battery) and applied to electric equipment (known as the **load**) such as a motor, a fire or a refrigerator, via connecting cables (the **conductors**).
- The conductor which supplies the current is the **phase conductor**, or live or **line conductor**. Once the voltage is applied, an electric current will flow. At the point of use, e.g. an electric fire, the electric flow is converted back to energy in the form of heat. The current returns to the source via the neutral or **return conductor**. A simplified circuit is illustrated in the following figure.



Earthing Principles

- The earth conductor in a circuit, sometimes called the protective conductor, is linked to the general mass of earth, which is at zero potential.
- By connecting all exposed metal parts which should not normally carry a current to earth, any fault current is provided with a path to earth so that the exposed metal parts cannot become live.



Electric Shock

- An electric shock results in a convulsive response by the nervous system to the passage of electricity through part of the body.
- No voltage can be considered safe in all circumstances, although low voltages may reduce the risk. We must always assume that an electricity supply of 240 volts is potentially fatal.
- Shock accidents usually occur when a person makes a contact with a live conductor when in simultaneous contact with an earthed object; for example, a person touching a live terminal in a fuse-box whilst standing on a concrete floor.

Electric Shock

- Most electrical supply systems are deliberately connected to earth at some point and, by touching one live terminal, the person automatically completes a circuit through his or her body and feet back to the supply system, through the earth.
- To function, the body needs a certain amount of electricity. The muscles are controlled by a small current in the order of 4 microamps acting on the central nervous system. In order for us to grasp an object, a signal is sent down to the nervous system which causes an increase of current in the muscles. An increase to about 4 milliamps (4/1000ths of an amp) causes the muscles to contract.



Electric shock

- The effect of an electric shock can vary from a slight tingling sensation to death.
- The severity of the shock depends on the size of the current and voltage.
- Low-voltage shocks, below 110 V, are seldom fatal.
- Electric shock can also produce burn

Battery-powered electrical tools will not give the user an electric shock

<https://youtu.be/jYrOxOW71Xc>

Electric Shock- how it happens

Pain arising from the sensation of electricity passing through the body and also from the associated burns. Internal burns caused by the heating effect of current passing through the body, which damages tissue and muscles.

Muscular contractions, which may cause the person to grip and be unable to release from the current source.

Respiratory failure caused by current passing through the chest and the resulting spasm preventing respiratory movement and causing asphyxia.

Fibrillation of the heart, which is a vibration of the heart muscle that disrupts the normal rhythm of the heart and stops effective blood circulation.

Cardiac arrest caused by current passing through the chest and heart and the resulting spasm.



Treatment of electric shock

- Raise the alarm
- Switch off the power – if not possible, use insulating material to move victim from contact with the power supply
- Call for an ambulance
- If breathing, place victim in recovery position
- If not breathing, apply mouth-to-mouth resuscitation
- Treat any burns
- If person regains consciousness, treat for normal shock
- Remain with person until help arrives.

If high voltages are involved, inform police and electrical supply company but do not approach the victim

Electrical fires and explosions

Twenty-five per cent of all fires have an electrical origin.

Causes:

- short circuits
- overheating of cables and equipment
- ignition of flammable gases and vapours
- ignition of combustible substances by static electrical discharges
- electric arcing
- static electricity – lightning strikes



Portable electrical equipment

Twenty-five per cent of all electrical accidents are caused by portable electrical equipment.

Hazards:

- faulty cables, extension leads, plugs and sockets
- inadequate maintenance
- use in flammable or damp atmospheres
- misuse of equipment.

The safest position for an extension cable while in use is above head height



Sources of high risks associated with the use of electricity

- working with poorly maintained electrical equipment;
- using electrical equipment in adverse or hazardous environments such as wet, flammable or explosive atmospheres;
- working on mains electricity supplies;
- contact with underground cables during excavation work; and
- contact with live overhead power lines



Control measures

The main control measures are given in the Electricity at Work Regulations, which cover the following topics:

- the design, construction and maintenance of electrical systems, work activities and protective equipment;
- the strength and capability of electrical equipment;
- the protection of equipment against adverse and hazardous environments;
- the insulation, protection and placing of electrical conductors

Control measures

- the earthing of conductors and other suitable precautions;
- the integrity of referenced conductors;
- the suitability of joints and connections used in electrical systems;
- means for protection from excess current;
- means for cutting off the supply and for isolation;
- the precautions to be taken for work on equipment made dead

Control measures

- working on or near live conductors;
- adequate working space, access and lighting; and
- the competence requirements for persons working on electrical equipment to prevent danger and injury

Specific controls for electrical hazards

- A management system that ensures safe installation, operation and maintenance
- Training at all levels – induction, supervisory and technical
- Safe systems of work include permits to work on live electricity



Specific controls for electrical hazards

Selection of suitable equipment for the work and environment by considering the following:

- atmosphere (flammable, damp)
- weather conditions
- high or low temperatures
- dirty or corrosive conditions
- standard of installation
- rated operating conditions



Specific controls for electrical hazards

- Protective systems:
 - Fuse (and circuit breaker)
 - Insulation
 - Isolation
 - Reduced low-voltage systems
 - Residual current devices
 - Double insulation.



Protection against contact with live buried power lines

- Check for any obvious signs of underground services, for example valve covers or patching of the road surface.
- Ensure that the excavation supervisor has the necessary service plans and is competent to use them to locate underground services.
- Ensure that all excavation workers are trained in safe digging practices and emergency procedures
- Use locators to trace any services and mark the ground accordingly. A series of trial holes should be dug by hand to confirm the position of the pipes or cables. This is particularly important in the case of plastic pipes, which cannot be detected by normal locating equipment



Protection against contact with live buried power lines

In areas where underground services may be present, only hand digging should be used with insulated tools. Spades and shovels should be used rather than picks and forks, which are more likely to pierce cables.

Assume that all cables are 'live' unless it is known otherwise.

Hand-held power tools should not be used within 0.5 m of the marked position of an electricity cable. Collars should be fitted to the tools so that initial penetration of the surface is restricted

Protection against contact with live buried power lines

- Any suspected damage to cables must be reported to the service providers and the health and safety enforcement authority.
- All exposed cables should be backfilled with fine material such as dry sand or small gravel.
- The service plans must be updated when the new cables have been laid

Emergency procedures

Following an electrical incident, the emergency procedures are:

- The isolation of the electrical device that has caused the emergency by switching off and disconnecting the supply.
- If electric shock or fire is the main emergency, appropriate procedures should be activated.
- If there is a fire as a result of electrical equipment malfunction, the fire procedures should be activated.
- If the emergency could affect hazardous equipment or processes, emergency plant shutdown and isolation should be put into action.
- Work must not resume after an emergency until a competent person has checked and declared that all electrical equipment affected by the emergency is safe.
- Following the incident, an investigation should take place, a report produced and, if appropriate send it to OHSA



Inspection and maintenance strategies

The particular areas of interest for inspection and maintenance are:

- the competence of the inspection and maintenance team
- the cleanliness of insulator and conductor surfaces
- the mechanical and electrical integrity of all joints and connections
- the integrity of mechanical mechanisms, such as switches and relays
- the calibration, condition and operation of all protection equipment, such as circuit breakers, RCDs and switches
- isolation procedures
- inspection and maintenance records
- permits to work for work on live electricity

Inspection strategies

Any strategy for the inspection of electrical equipment, particularly portable appliances, should involve the following considerations:

- a means of identifying the equipment to be tested
- the number and type of appliances to be tested
- the competence of those who will undertake the testing (whether in-house or bought-in)
- the legal requirements for portable appliance testing (PAT) and other electrical equipment testing and the guidance available

Inspection strategies

- organisational duties of those with responsibilities for PAT and other electrical equipment testing
- test equipment selection and recalibration
- the development of a recording, monitoring and review system
- the development of any training requirements resulting from the test programme



Portable electrical appliance testing

General points:

- user checks – at least once a week
- formal visual inspection – by a trained person
- combined testing and inspection – by a competent person using testing equipment
- the frequency of inspection and testing depends on usage rate and conditions – normally determined by a risk assessment
- records of inspection and testing require

Advantages of portable appliance testing	Limitations of portable appliance testing
<ul style="list-style-type: none">▶ early indication of serious faults▶ discovery of incorrect equipment or electrical supply▶ incorrect fuses found▶ reduction in the number of electrical accidents▶ monitoring misuse of portable appliances▶ check on selection procedures▶ increase awareness of hazards▶ introduction of a more regular maintenance regime	<ul style="list-style-type: none">▶ too frequent testing of fixed equipment can lead to excessive costs▶ some unauthorised equipment never tested because of lack of records▶ equipment misused or overused between tests▶ the inclusion of trivial faults leads to long lists and the overlooking of significant faults▶ the level of competence of tester▶ the use of incorrectly calibrated test equipment

Control measures for working near overhead power line

- No vehicles, plant or equipment should be brought closer than:
- 15 m of overhead lines suspended from steel towers
- 9 m of overhead lines supported on wooden poles.

Control measures for working near overhead power line

If a closer approach required, lines should be made dead and a permit to work used.

If vehicles need to move beneath power lines:

- the roadway should be covered by goalposts covered with warning tape;
- bunting should be suspended, level with the top of the goalposts and just above ground level between poles across the site along the length of the power line;
- suitable warning signs should be placed on either side of the roadway on each side of the power line to warn of the overhead power line; and
- reach of vehicles/equipment should be restricted



Control measures for working near overhead power line

- At the tender stage, the existence of any overhead lines across the site must be noted and contact made with both the power supply company and the local authority.
- For work at or near overhead power lines, the following hierarchy of risk control should be considered:
 1. avoid working under or near overhead lines; if this is not possible,
 2. divert all overhead lines clear of the work area or, if it is not feasible,
 3. make lines dead while the work is in progress or, if this is not feasible,
 4. work around the live overhead lines using the precautions outlined below

Precautions

The precautions depend on the nature of the work at the site but the following recommendations should be possible for most work:

1. Clearance – the safe clearance required beneath the overhead lines should be ascertained from the owner of the line;
2. Exclusion – plant, equipment or hand tools that could reach beyond the safe clearance limit should not be taken under the line;
3. Modifications – plant such as cranes and excavators should be modified by the addition of suitable physical restraints so that it cannot reach beyond the safe clearance limit;
4. Additions – cranes with telescopic or fly jibs may need additional restraining devices to prevent alteration in length of jib or angle of fly jib; and
5. Supervision – access for plant and materials should be under the direct supervision of a suitable person





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