ELEMENT 5 – ELECTRICAL SAFETY

5.1 Outline the principles, hazards and risks associated with the use of electricity in the workplace.

5.2 Outline the control measures that should be taken when working with electrical systems or using electrical equipment in all workplace conditions.

5.1 ELECTRICAL PRINCIPLES

Electricity has become a vital part of modern day lives; it powers our homes and workplaces and is one of the most versatile energy forms because it can be converted into a variety of other energy forms e.g. light, microwaves, radio waves, heat and sound.

Current

This is the flow of electricity through a material such as copper and aluminium. Electricity will flow from the conductor with the greatest potential (live wire) to the lowest (neutral wire). The flow of electricity is called the current and is measured in amperes or 'amps'.

Electricity

Water

- Waits for tap to turn
- Need more - increase pressure
- Widen pipes
- Lost pressure because of kinks and leaks
- Flows to earth (gravity)
- Takes easiest route
- Water stops after potential energy is used

Electricity

- Waiting for something to be switched on
- Increase volts
- Use wider cable
- Damaged wire = leaks
- Flows to earth
- Takes easiest route
- Energy dissipates after flow through circuit – potential lost

Voltage

The force of electrical current is measured in volts. In domestic systems in the UK this is 230-240 volts.

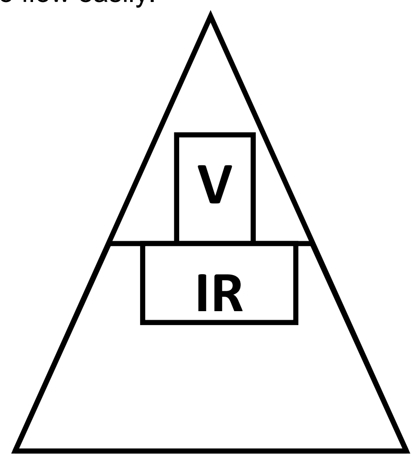
Resistance

Every different material has a different resistance to electricity, some allow it to flow readily e.g. metals and others stop it flowing completely e.g. rubber. Metals have little resistance and allow electricity to flow easily. The resistance of a circuit will limit the flow of electricity. Resistance is measured in Ohms. Materials which resist the flow of electricity well are known as insulators e.g. the plastic sheathing around power cables.

Conductor

Any solid, liquid or gas that conducts electricity is classed as an electrical conductor. Metals are good conductors but plastics are not, these are known as insulators. Metals have a low resistance to the passage of electricity i.e. they allow it to flow easily.

Ohms law
This is the relationship between Voltage, Current and Resistance.

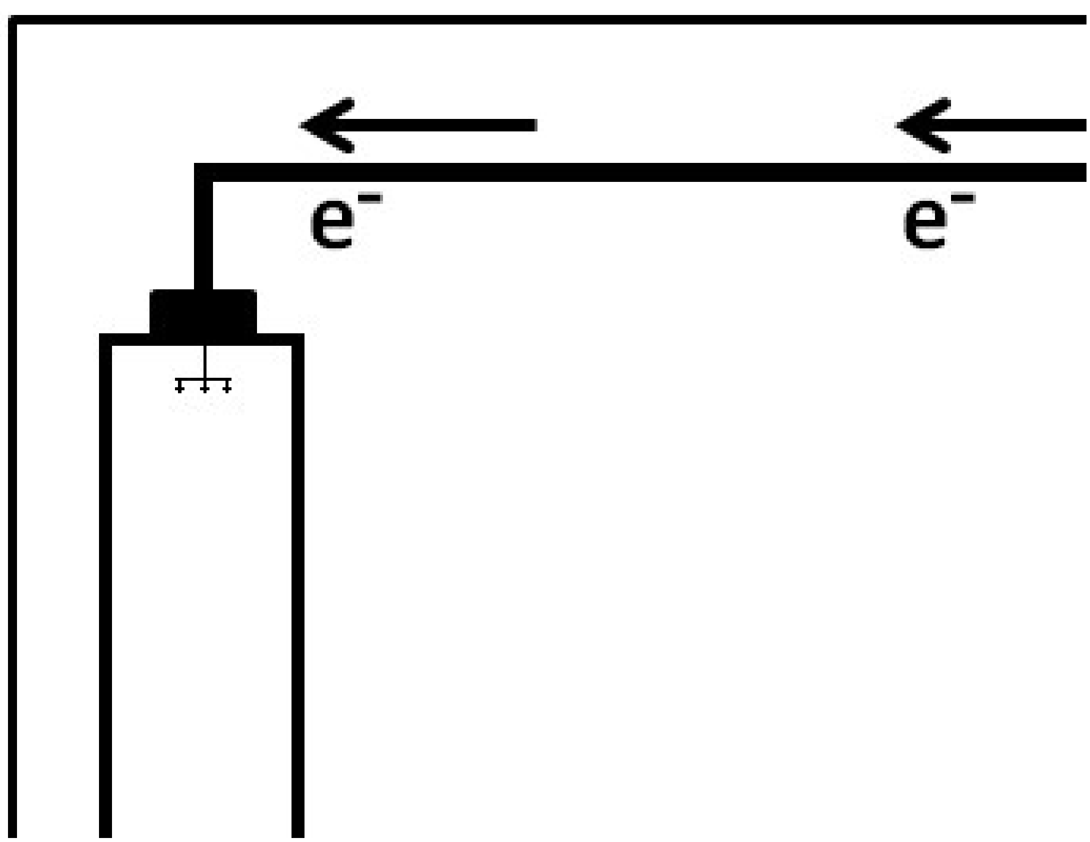


Current = voltage / resistance

V= Electro motive force measured in Volts
I = Current (amps)
R = Resistance (ohms)

By rearranging the V= I x R each component can be calculated
I = V / R
V = I x R
If any two of the above factors are known then the third can be calculated.

Normal senses will not detect electricity but touching a small supply can be lethal. Very few electrical accidents are actually recorded however their severity is much higher than for other accident categories.



5.2 THE EFFECTS OF ELECTRICITY (RISKS)

Electric shock is the general term given when someone comes into contact with live electricity, shock can result in a number of different specific injuries. This can include burns (entry and exit point and along route of flow), muscle spasms, loss of consciousness, cardiac arrest & heart fibrillation (rapid irregular heart beat).

Other risks

- Arcing can lead to fires and explosions as well as electric shock.
- Electric sparks can lead to explosions.
- Electrocution – this is when the person receives a fatal electric shock.
- Being thrown leading to impact injuries – this is a high risk if the person is working at height.

Our own bodies produce very small micro amps of electricity. If we come into contact with an electrical source an electric shock occurs. This can overwhelm the body's natural electrical signals causing nerve damage, it can also stop the heart and lungs. The heart's natural rhythm may also be altered causing a rapid fibrillation of the heart muscles. Muscle spasms can result, which may mean the person cannot let go of the exposed surface or wire.

What different factors could affect the severity of the outcome of an accident involving electric shock?

The severity of injuries received is determined by a range of factors including the flow of the current, the voltage, the resistance of the human body, the part of the body exposed, the clothes worn, temperature, amount of contact time and moisture levels etc.

5.3 WHAT HAZARDS DO YOU ASSOCIATE WITH THE USE OF ELECTRICITY?

- Damaged covers / insulation
- Damaged or poorly joined cables
- Unsafe working (covers removed from electrical equipment)
- Over-current protection breaks down (e.g. insulation on cables melts due to heat or mechanical damage).
- Inadequate earthing
- Over-heating and blocked air vents
- Loose contacts between cables or in plugs
- Use of multi point adapters
- Leaving equipment switched on when it is not in use.
- Using unsuitable equipment – unsuitable for the specific work environment
- Inadequate rating of fuse or cable used

- Poor maintenance & testing of the fixed installation and equipment
- Trailing cables
- Broken sockets

5.4 ELECTRICITY AT WORK REGULATIONS 1989 - KEY POINTS

These regulations aim to prevent injury and minimise danger where people are working on the electrical system or using electrical equipment. They set some specific standards which apply to all workplaces.

- All electrical systems shall be constructed and maintained to avoid danger
- Those who work on the electrical system must be trained and competent
- There must be a way of isolating the electrical system and equipment connected to it.
- The system must be adequately earthed to allow electricity to flow away if there is a fault condition
- Written systems & PPE for those working on the live system
- Duty holder: this includes the employee, electrician and manager who are all responsible for the areas within their control.

5.5 CONTROL MEASURES

HOW CAN WE REDUCE THE RISK OF INJURY WITHIN THE WORKPLACE FROM ELECTRICITY ?

- ASSESS THE DANGER (RISK ASSESSMENT)
- SUITABLE EQUIPMENT – Correctly rated for the working environment e.g. intrinsically safe for use in flammable atmospheres.
- SUITABLE EARTHING
- DOUBLE INSULATED TOOLS – These have two separate layers of insulation within their casing to protect the outer casing from becoming live. These tools do not have an earth cable.
- ISOLATION – This is where the electrical circuit is disconnected, usually by a non conductor or by physical gap, the isolator must be locked off rather than just being switched off.
- SAFE SYSTEMS OF WORK – for use of equipment and when working on the fixed installation.
- INSULATION - Cable sheathing or rubber mats when working on live electricity.
- FUSES – These are a weak link in the system, they are a thin piece of metal which allows a certain amount of electricity to flow. If this is exceeded the electricity generates heat which will melt the fuse and break the circuit. Fuses have different amp ratings and melt at different current flows, they limit damage to the equipment but there is a time delay before they break the circuit (see also over current protection).
- CIRCUIT BREAKERS – these are often mechanical devices which detect excess current flow and cut off supply.
- EMERGENCY STOPS – Easily accessible
- USE RECHARGEABLE TOOLS TO REDUCE ISSUES ASSOCIATED WITH TRAILING CABLES
- REDUCE THE VOLTAGE – 110V centre tapped earth.

- PROTECT CABLES AND SOCKETS FROM PHYSICAL SURROUNDINGS
- MAINTENANCE OF THE ELECTRICAL SYSTEM ITSELF (This is recommended every 5 years for industrial premises)
- VISUAL INSPECTIONS BY USER (HSG107)
- FORMAL INSPECTIONS BY A NOMINATED PERSON (HSG107)
- COMBINED INSPECTION AND TEST ((Portable Appliance Testing (PAT)) HSG (107)
- SIGNAGE
- PURCHASING POLICIES – to ensure equipment of the suitable rating is selected

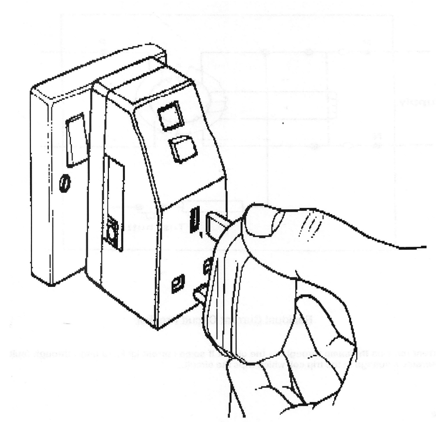
Earthing

This means the metal work on an appliance is connected to earth, as electricity always flows where the resistance is least, this gives the electricity an alternative route of exit if it comes into contact with a person. Earthing allows the electricity to flow to earth, protecting the individual and the loss of current should cause any trip devices or circuit breakers to trigger and cut the circuit.

Over-current Protection

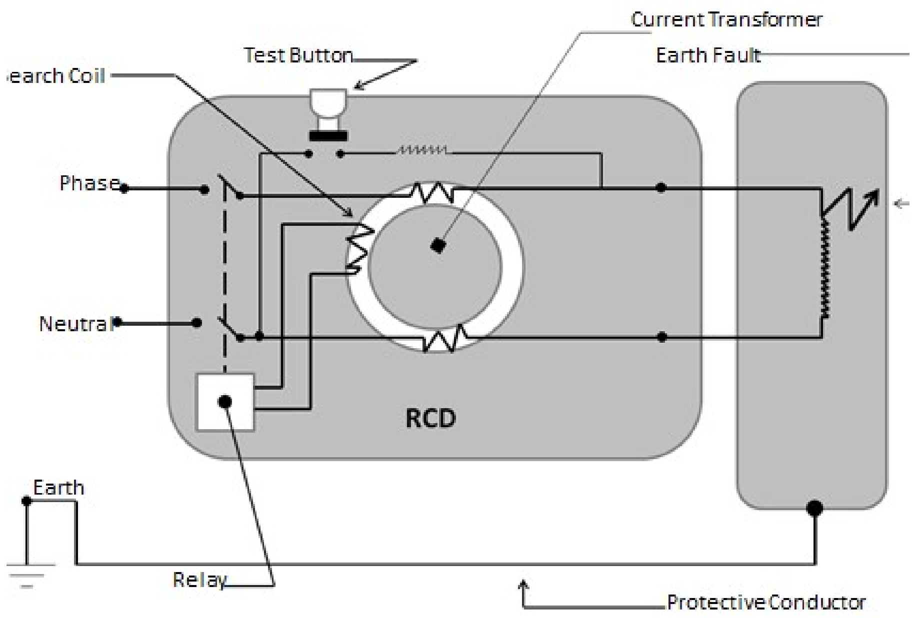
The flow of electrical current can be limited by inserting a weak link, this is normally a fuse or trip switch. If too much current flows the rise in temperature can cause a fire, this can occur when sockets are over loaded. A fuse will heat up and break to prevent over-current. A fuse of the correct amperage or a circuit breaker must be fitted. Paper clips, bullets or nails should never be used in place of fuses.

Residual Current Device (RCD)



RCD's are designed to detect even very small amounts of earth leakage, variations of milliamps are sufficient to trip the device and break the current in milli seconds. The advantages of these devices are that they are very sensitive and will disconnect the supply before the current flow reaches a harmful level.

The flow of electricity in amps is measured as it flows to the appliance, the flow back from the appliance along the neutral is also monitored. If there is any difference between these two figures the RCD trips and cuts the circuit immediately. These devices help to protect the users of equipment against electric shock.



Principle Components of an RCD

Reduce Voltage (110v) Appliances using a centre tapped transformer or **BATTERY TOOLS.**

For 110v tools the mains system is normally stepped down via a transformer giving 55 volts via a centre tapped transformer. The voltage is reduced to 55V via a centre tapped earth. No one has been recorded as receiving a fatal electric shock from a 100V system of this type. SELV – Separated Extra Low Voltage are those normally under 55V and can be used where there is a greater risk of electric shock or explosion e.g. swimming pool, construction site etc.

WHO CAN TEST / EXAMINE / INSTALL ELECTRICAL CIRCUITS AND APPARATUS?

Technical Capability - Trained, experienced people, with knowledge of the particular system being worked on and the technical skills required.

Inspections can include a **visual check** by the operator, a **formal visual check** by a more skilled individual or a **full combined inspection and test** normally referred to as a ***PAT test.***

5.6 LIVE WORKING

Working on an electrical system when the power is still switched on is known as live working. This should only be undertaken when there is no reasonable alternative - it should not be undertaken ordinarily. Because the system is live any hazard will present a higher risk in this situation. A trailing cable is always a hazard but in this situation if the electrician trips and touches a live connector the risk would be high.

Typical hazards which increase the risk when working with live electricity

- Lack of space

- Lack of lighting
- Lack of training
- Incorrect tools used e.g. not insulated
- Work at heights
- No permit to work
- Inadequate PPE
- Obstructions

Live working must only be undertaken under a permit to work system, by trained and competent employees. They need to have insulated tools, be wearing non conducting footwear and other personal protective equipment. Adequate lighting needs to be in place and the area where they are working needs to be free from obstructions - barriers and signage should be erected to stop unauthorised personnel interfering with the tasks being undertaken.

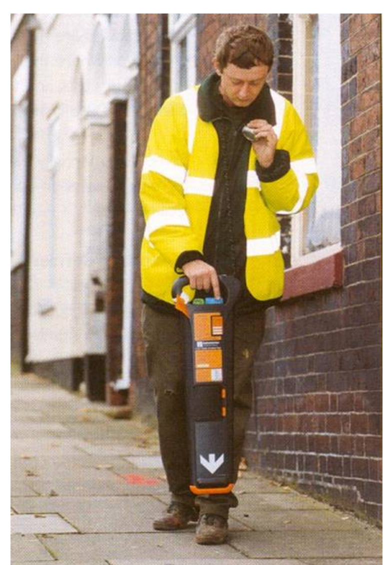
5.7 AVOIDING DANGER FROM UNDERGROUND AND OVERHEAD POWER LINES

Underground and overhead power lines exist at various voltages from 240V to 400,000V and are the cause of many accidents every year. The majority of underground cable accidents result in burns and a few fatalities; the majority of overhead line accidents result in electrocutions.

Underground Cables

Underground cables are particularly hazardous because they are widespread, concealed, frequently close to the surface, sometimes occur in unexpected locations and are often poorly protected. Damage to cables usually occurs during excavation work and is caused by the crushing or penetrating effects of hand or machine tools such as pneumatic drills and mechanical excavators. A tool may penetrate the sheath of a cable and the cable insulation or crush the cable and cause contact between the conductors or between the sheathing and one of the conductors. Damage to live cables often results in arcing currents with associated explosive effects, fire and flames which usually cause severe, potentially fatal bums to the hands, face and torso. Direct electric shock is rare.

Cable Plans



Before work commences, cable plans or other information should be sought in an attempt to locate the position of all cables in the area in which the excavation is to take place. Where available, the information should be obtained from the owners of the cables such as the local Electricity Board, the Local Authority, private land owners etc.

Most plans will give useful information on the location, number and configuration of cables and will help in the use of cable detectors. However, they cannot be relied upon to give precise information.

Cable locating devices

The location of cables shown on plans should be checked as accurately as possible using a cable locating device. Where no plans have been obtained, the use of the cable detector is additionally important. As cables are located with the device, their routes should be marked on the surface of the ground with waterproof crayon, chalk, paint or wooden pegs as appropriate. Various cable locating devices are available.

Locating devices should only be used by trained operators, within the manufacturers' guidelines and should be maintained in good working order.

Safe digging practice

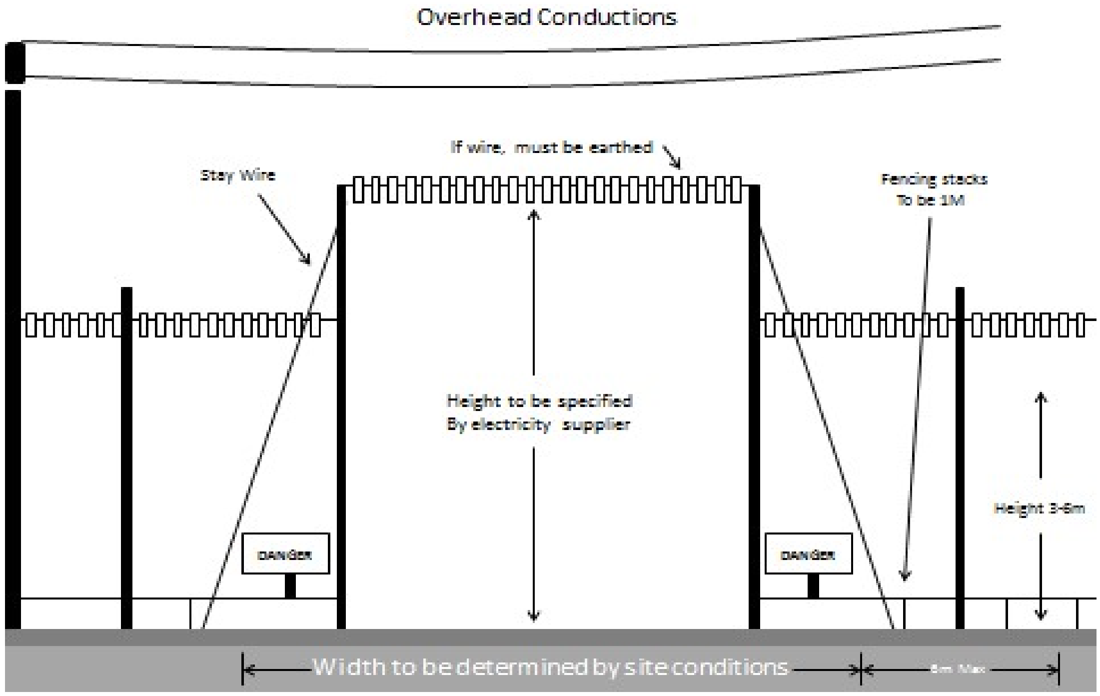
Once the location of cables has been ascertained using plans and detectors, the routes should be confirmed by digging trial holes which should expose the cables. Hand tools should be used and particular care should be taken above or close to the route of the cable. It is preferable that excavations should be alongside rather than above the cable and that final exposure should be by horizontal digging which is easier to control. Incorrectly used hand tools cause many accidents every year. Such accidents may be minimised by the use of spades and shovels rather than other tools such as picks, avoiding spiking or throwing tools into the ground, or by using compressed air tools such as air-knifes which can expose cables safely. Hand held power tools and mechanical excavators are a major source of danger and should not be used too close to underground cables.

Trained personnel

All personnel who are involved in excavation work where underground cables may be present should be adequately trained in the dangers and the precautions which should be taken. Training should include details on how the hazards occur, types of cables, use of plans and location devices, action to be taken in the event of cable damage etc. If a cable is damaged, all work in the vicinity of the damage should stop. Temporary barriers and warning notices should be erected to keep people away.

SAFETY WHEN WORKING NEAR OVERHEAD LINES

Although out of reach under normal circumstances overhead lines, which are not normally insulated, can become accessible to those working on roofs, scaffolding, elevated platforms etc. People operating vehicles such as cranes and excavators or handling equipment such as scaffold poles, metal ladders, pipes etc can also be at risk due to



contact with or flashover from overhead lines. Approximately a third of accidents involving overhead lines are fatal.

Planning the Work

Precautions must be taken to avoid contact or near contact with overhead lines. At the planning stage of any work in an area where overhead lines could be a hazard, the owner/operator of the lines should be requested to divert the lines or make them dead. If neither of these options is possible, other precautions, which guarantee safe clearance distances from the lines, must be taken.

In situations where the owner/operator of the cables has not been consulted for advice, no part of a vehicle, plant or equipment etc should approach or work in a position where it is liable to be within:

15 metres of lines suspended from steel towers
9 metres of lines suspended from wooden poles.

The owner should be consulted as soon as possible in order that realistic and safe clearance distances may be set.

Danger can virtually be eliminated if appropriate precautions and procedures of work are followed in liaison with the owners/operators of the lines. Three broad categories of work should be considered:

- no work or passage of plant beneath lines
- passage of plant beneath lines
- work carried out beneath lines.

Barriers should be as distinctive as possible, parallel to and at least 6 metres from the lines. However, if mobile plant such as cranes could encroach within this space, the distance between the barriers and the lines should be extended to 6 metres plus at least the jib length of the crane. If site conditions will not permit the extra clearance allowance, additional warning of the 6 metre distance should be given. This should be in the form of bunting or flags which are suspended above the barrier and at a distance of 3-6 metres above the ground.

Where plant will pass beneath lines, the width of the passageway should be restricted to no more than 10 metres and preferably be at right angles to the lines. In addition, the number of passageways should be kept to a minimum.

Near each set of goalposts, warning signs should be erected giving cross-bar clearance height and instructions to drivers to lower jibs to below that height. Safe clearance distances between the ground and the cables should not be reduced by uneven surfaces. Surfaces should be level, firm and well maintained.

Work carried out beneath lines

Barriers, goal-posts and warning notices must be erected. As these precautions will not prevent danger from upward movement of plant and structures and those working on them, the following precautions are necessary:

- safe clearance distance should be obtained from the line owner/operator
- plant, equipment or hand tools which could extend beyond the safe clearance distance should not be used. Plant such as cranes can be modified by the use of physical restraints which prevent extension into the danger area
- the work should be under the direct supervision of a responsible person who ensures that the safety precautions are observed
- where there is increased risk due to work in close proximity to the lines e.g. in the case of a structure being erected under the lines, a horizontal barrier of insulating material should be erected to form a roof over the work area. Alternatively, an earthed steel net may be used.

In all situations where safe clearance distances are necessary, it should be ensured that they are not reduced by the dumping/tipping of waste material, landscaping operations or the creation of unplanned storage areas.

Controlled passageways