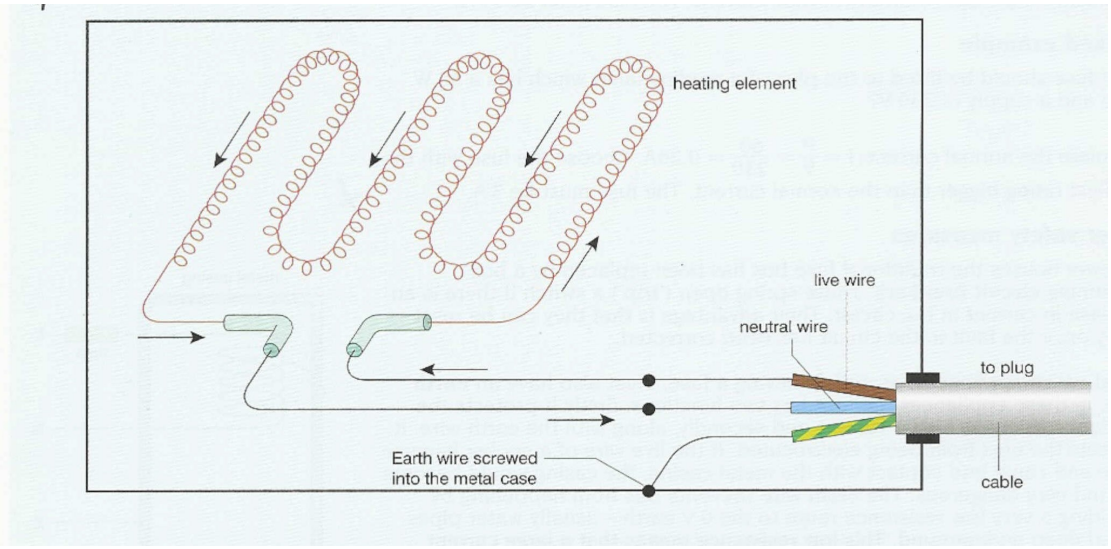
ELEMENT 6 ELECTRICAL SAFETY



Learning outcomes

- Outline the principles, hazards and risks 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 equipment
- Outline the control measures to be taken when working near or underneath overhead power lines

6.1 INTRODUCTION

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.

Unlike manual handling, the actual number of electrical accidents is small. However, the severity of injury through such accidents is very much higher than with other causes.

EFFECT ON BODY OR WORKPLACE

Shock – leading to Burns, muscle spasms, heart stopping, cardiac arrest & heart fibrillation.
Arcing can lead to fires and explosions as well as electric shock.
Electric sparks can lead to explosions.

Our own bodies produce very small micro amps of electricity. Electric shock overwhelms the body's natural electrical signals, 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. Other injuries associated with falls and being thrown could also result from electric shock. The severity of injuries will depend on the flow, the part of the body exposed, the clothes worn, temperature, amount of contact time and moisture levels etc.

6.2 KEY TERMS

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'.

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

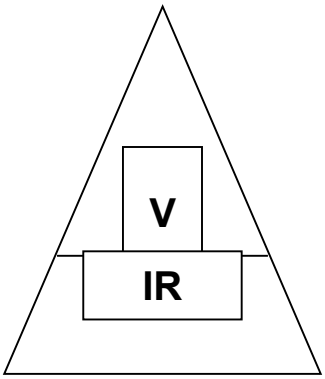
This is the relationship between Voltage, Current and Resistance.

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
R=V/I



If any two of the above factors are known then the third can be calculated.

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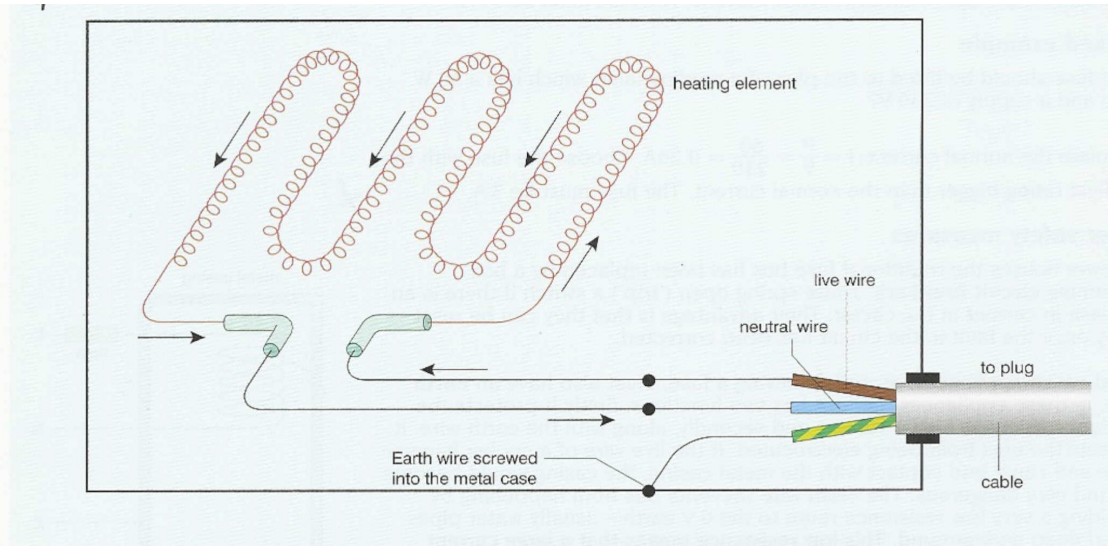


Electricity

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

6.3 THE HAZARDS AND RISKS ASSOCIATED WITH ELECTRICITY

Electricity can be a killer on site, people may suffer electric shock and burns which can be fatal. Additionally workers may fall from ladders and scaffolding as the result of receiving an electric shock. Faulty equipment can put not only users at risk but all those on site, overhead and underground cables may also present a risk.

Electrical issues need to be understood and communicated in both minor and major construction projects, for major projects notifable under CDM electrical issues should appear in both the pre-tender information and the construction phase safety plan. At the end of the project plans, wiring diagrams and installation specifications should be included in the H&S file for the new building or structure. Duties are placed on employers, clients, employees, contractors and the self employed to ensure they do not put themselves or others at risk from electrical hazards.

Looking around a typical construction site what electrical hazards might you spot?

- Damaged covers / insulation
- Damaged or poorly joined cables
- Trailing cables where they could be damaged by moving plant
- Electrical cables in wet and damp areas
- Unsafe working (cover removed from junction boxes)
- Over-current protection breaks down
- Inadequate earthing
- Over-heating of electrical appliances
- Loose contacts
- Inadequate rating / fuse
- Poor maintenance & testing – damaged equipment
- Trailing cables from scaffolding above – stretched cables
- Broken sockets
- Temporary site supplies
- Underground cables
- Over head cables
- Packaging tape around damaged cables

6.4 WHAT FACTORS CAN AFFECT THE SEVERITY OF AN ELECTRIC SHOCK?

- Voltage - shocks
- Resistance
- Current (kills)
- Current path through the body
- Duration of contact
- Ac (frequency) /Dc
- Wet environment
- Availability of earthing
- Body temperature
- Health of person
- Clothing worn

6.5 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 including construction sites.

- 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.

6.6 HOW CAN WE REDUCE THE RISK OF INJURY?

We should consider firstly the usual hierarchy of control via design and planning is it possible to eliminate the possible contact with live electricity. The remaining residual risks need to be evaluated and then action taken to reduce the risk. Is it possible to

combat the risk at source e.g. insulate or shroud the cables to protect them from damage.

- ASSESS THE DANGER (RISK ASSESSMENT)
- ISOLATION – This is where the electrical circuit is disconnected, usually by a non conductor or by a physical gap, the isolator must be locked off rather than just being switched off.
- SAFE SYSTEMS OF WORK
- INSULATION - Cable sheathing, rubber mats
- FUSES - Melt at different current flows limiting damage but there is a time delay (see over current protection)
- CIRCUIT BREAKERS - detect excess current flow and cut off supply
- EMERGENCY STOPS – Easily accessible
- PROTECT CABLE AND SOCKETS FROM PHYSICAL SURROUNDINGS
- MAINTENANCE OF THE ELECTRICAL SYSTEM ITSELF
- VISUAL INSPECTIONS BY USER OF PORTABLE APPLIANCES
- FORMAL INSPECTIONS BY A NOMINATED PERSON
- COMBINED INSPECTION AND TEST ((Portable Appliance Testing (PAT))
- SIGNAGE
- IN WET CONDITIONS USE CORDLESS OR AIR POWERED TOOLS
- PROVIDE SUITABLE TRANSFORMERS AND GENERATORS
- ENSURE SWITCHGEAR AND METERS ARE ALWAYS ACCESSIBLE
- 110v and 240V plugs must not be interchangeable
- POSITION CABLES WHERE THEY ARE LESS LIKELY TO BE DAMAGED BY MECHANICAL EQUIPMENT (I.E. AT HEIGHT)
- PROTECT CABLES INSIDE CONDUIT
- SELECT TOOLS FOR TRADE USE – NO ARGOS SPECIALS!

Earthing

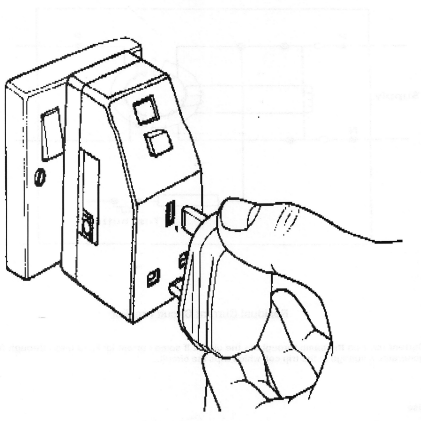
This means the metal work on an appliance is connected to earth, as electricity always flows where the resistance is least, this gives the electricity an alternative route of exit if it comes into contact with a person. Earthing allows the electricity to flow to earth protecting the individual and the 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. These should be installed in weather proof



enclosures, protected against mechanical damage, checked daily, formally inspected weekly and tested at least every three months.

RCDs are not always suitable for site use as they are so sensitive and can trigger due to minor problems and then cut off the entire site

Reduce Voltage (110v) Appliances using a centre tapped transformer or **BATTERY TOOLS.** The 240V system is normally stepped down via a transformer giving 55 volts via a centre tapped transformer (Centre tapped earth). The voltage is reduced to 55V via a centre tapped earth. No one has been recorded as receiving a fatal electric shock from a 110V system of this type. SLEV - Super Low Electrical Voltages are those normally under 55V and can be used where there is a greater risk of electric shock or explosion.

Setting up a installation

Obtain drawings even though these may not be accurate, review the results of any surveys. Suitable voltages may be needed for the different applications on site:-

Portable hand lamps for confined spaces or damp 25V single phase
Portable lamps 50V
Site lighting – 110V
Portable hand tool – 110V
Installations to site offices - 230V single phase
Fixed or mobile plant – 400V three phase

The site distribution systems must be protected from harsh weather even if they are deigned to be temporary, the correct fuses and circuit breakers must be in place. Makeshift arrangements of unprotected wiring, taped, twisted cable joints must not be allowed. These issues are covered by a number of BS standards including BS 7375, 4363, 60439-4.

All fixed distribution cables carrying 400V or 230V should be sheathed or armored and be effectively earthed.

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

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

6.7 PORTABLE APPLIANCES

- Class 1 – earthed
- Class 2 – double insulated
- Class 3 – low voltage
- Battery operated
- SELV – Safety extra low voltage (SLV) (Max 50V)

HSG 107

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.

a. User Checks (Visual)

What would you look at when inspecting a piece of portable apparatus prior to using it?

- Lead
- Connections
- Plug & lead into plug
- Mains switch
- Casing (Earth resistance test / high voltage insulation test)
- Fuse
- Switches

b. Formal Visual Inspections

- By Trained person
- Dangerous faults
- Monitor user checks
- Remove plug cover
  - Check fuse
  - Check cord grip
  - Check cable terminals
- Does not involve taking equipment apart
- Written guidance
- Regular intervals

c. Combined Inspection and Tests (PAT testing)

- Formal Visual Inspection plus :
- Correct polarity, check correct fuse
- Check termination of cables
- Check suitability of equipment
- Testing
- Diagnostic Test
- Impedance, earth continuity, insulation deterioration, contamination of internal or external surfaces
- (Earth resistance test / high voltage insulation test)
- Level of competency of tester

Equipment	**User**	**Formal**	**Combined**
Hire		**Before/after**	**Before use**

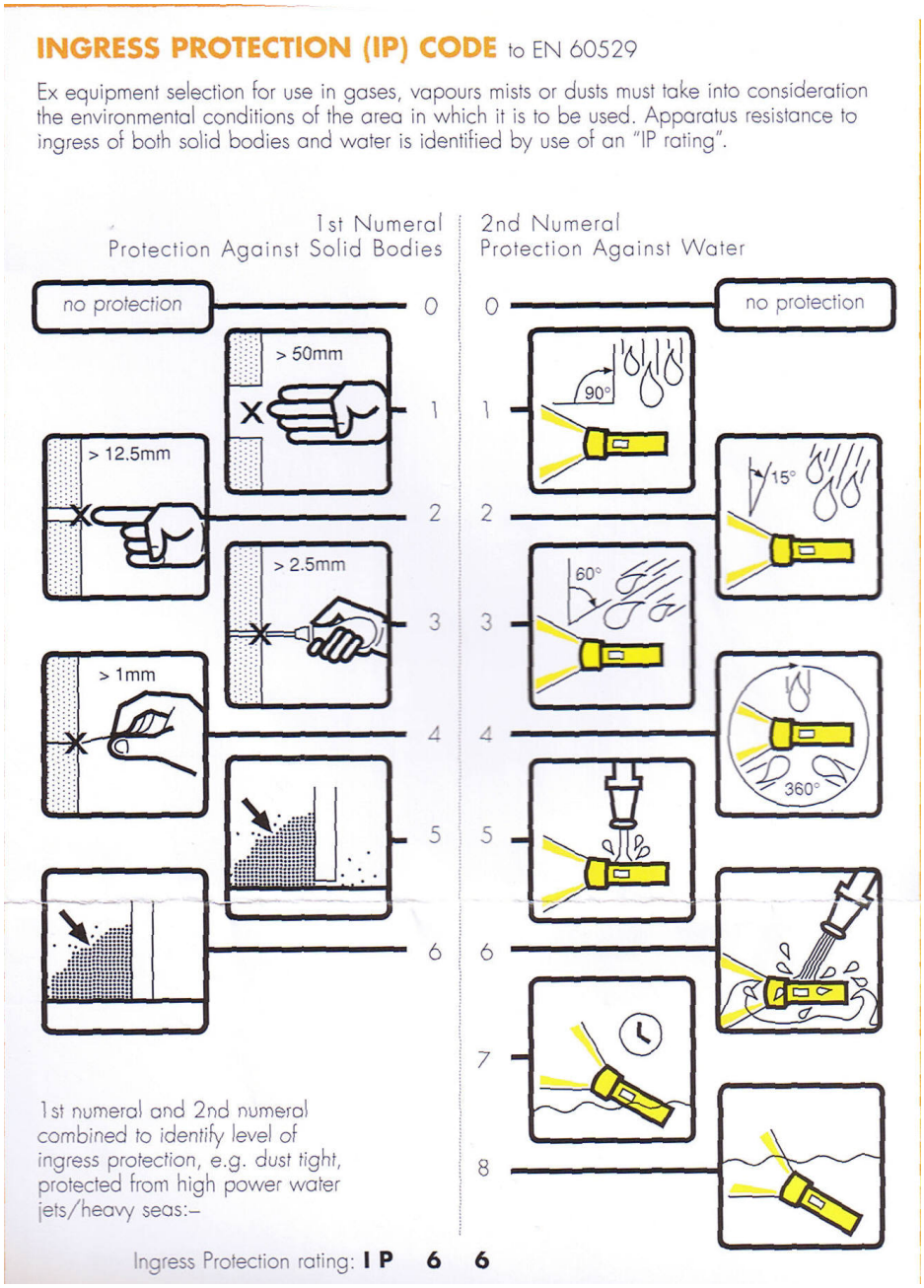
Construction	**110V weekly Mains daily**	**110V monthly**	**110v before/3 monthly**
Office equipment	**No**	**1 – 2 years**	**No**
Hand held double insulated eqt Class II	**Yes**	**6 month/year**	**No**
Cables and extension leads	**Yes**	**3 months**	**2 years**
Class I earthed eqpt i.e. kettles	**Yes**	**6 months – year**	**1 – 2 years**

HSE Construction site guidance HSG 141

Equipment	Voltage	User	Formal Visual	Combined inspection and test
Battery operated	Less than 25V	No	No	No
25V Portable hand lamp	25V	No	No	No
50V portable hand lamps	25V winding centre to earth	No	No	Yearly
110V Portable hand tools **Extension leads** **Switch gear**	55V Centre tapped earth	Weekly	Monthly	Before first use 3 monthly
230V Portable hand held tools **extension leads** **Portable flood lights**	230 V 30mA RCD	Daily/every shift	Weekly	Before first use Monthly
RCDs fixed	230 V Supply fuses MCBs	Daily/every shift	Weekly	Before first use Monthly
Equipment in site offices	230V	Monthly	6 Monthly	Before first use Annually

d. Portable appliances used in adverse environments

- Electrical equipment which could be exposed to –
  - Mechanical damage
  - The effects of weather, natural hazards, temperature or pressure
  - The effects of wet, dirty, dusty, or corrosive conditions
  - Any flammable or explosive substance including dusts, vapours & gases
- Electrical equipment shall be so constructed and protected so that it should prevent danger
- Intrinsically safe – will not cause a spark or heat (E Ex ia or E Ex ib)
- Flameproof – will contain any explosion if dust or flammable vapour enters. (E Ex d)



6.8 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 of working with live electricity

- Lack of space
- Lack of lighting
- Lack of training

- Incorrect Tools
- 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.

- No person shall work so near a live (uninsulated) conductor that danger may arise unless –
  - It is unreasonable for it to be dead
  - It is reasonable in the circumstances (i.e. segregated parts of equipment, safe distance, special tools)
  - Precautions are taken to prevent injury

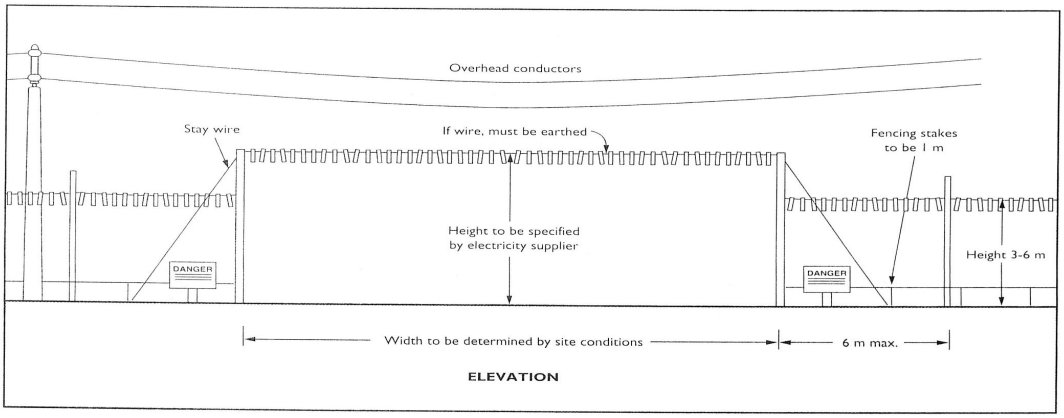
Example Questions

Outline the effects on the human body of a severe electric shock (5)

Outline the emergency action to be taken if a person suffers a severe electric shock. (This question does not assume you are a trained first aider) (5)

Outline the practical measures to reduce the risk of electric shock when using portable electrical appliances. (5)

6.9 OVERHEAD ELECTRIC CABLES



Overhead service can be of the same type and be transported by the same means as those listed in buried services but instead of being laid underground will be carried overhead. They can be mounted within the voids or on the walls of buildings either on show or within boxings/casings for aesthetic purposes. Telephone wires can be found suspended from wooden or metal poles, as to can electric cables although these will be carrying voltages from ranging from 240 up to 400,000 volts, with the higher voltage power lines being carried by pylons.

GS 6 HSE guidance – linked to Reg 4 & Reg 14 EAW

- Contact the owner
- Can work be avoided?
- Divert OH lines
- Make dead
- Planning – info from service provider
- Ground barriers – 6m min
- Bunting 3-6m from ground
- No carrying metal ladders/scaffold poles
- Make barriers visible
- Safe passageway routes
- Goal posts
- Notices – lighting
- Level floor surface
- Limit access to high plant/restraining devices
- Supervision
- Insulation
- Prevent flying fragments
- Training
- Limit work in adverse weather

Telephone and electric cables can be found either insulated or un-insulated depending on their height and when they were erected.

- All overhead power lines must be considered live until confirmed otherwise by the owner.

- Is it possible to avoid working near or going under cables

- Before any work near power lines starts, the local electric company must be consulted and a safe system of work devised and implemented. Where possible the lines should be made dead.

- Where this is not possible the owner of the line may be able to insulate them, if not then suitable barriers must be in place to deny access to plant at the distances.

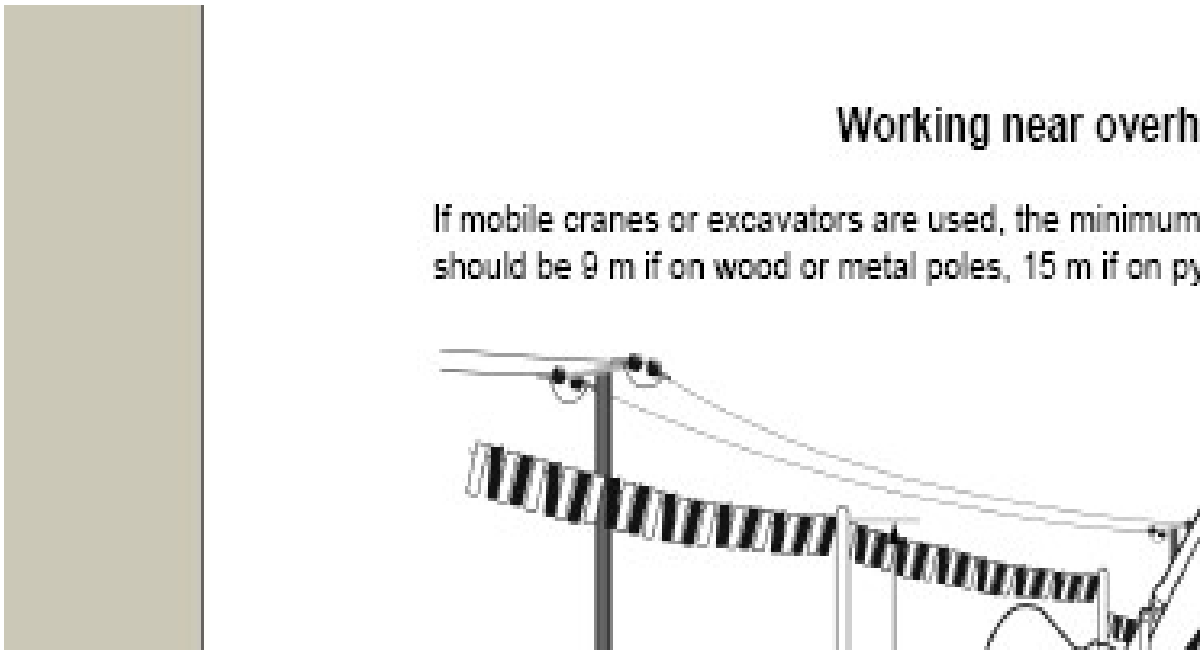
- If there are persons carrying conductive materials such as scaffold tubes, ladders, etc, a physical barrier such as timber rails should also be erected.

- If mobile cranes or excavators are used, the minimum distance from the ground level barrier to the line should be 9 m if on wooden or metal poles, 15m if on pylons plus the length of the boom or jib.

- Electronic proximity warning devices may be fitted to crane jibs, booms, etc.

- Where works are carried out during hours of darkness the barriers must be adequately illuminated.

- Where there is a requirement to pass beneath power lines, then suitable barriers must be in place at the distances.



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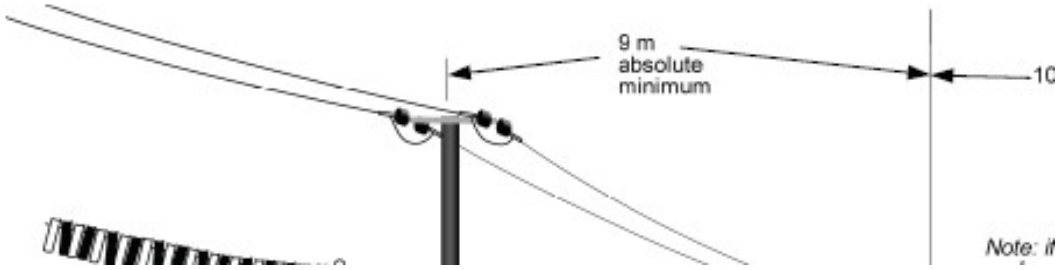
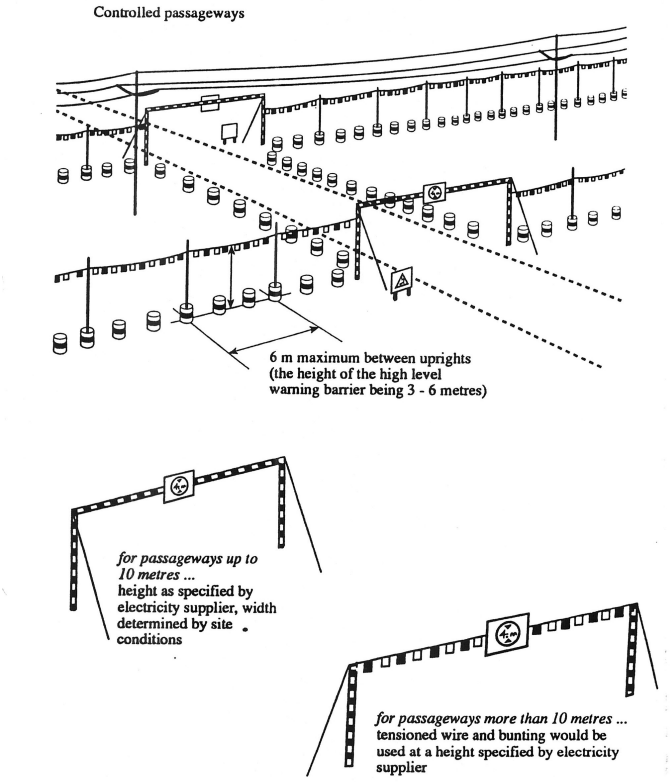
Traffic passing beneath overhea





Site Control Standards