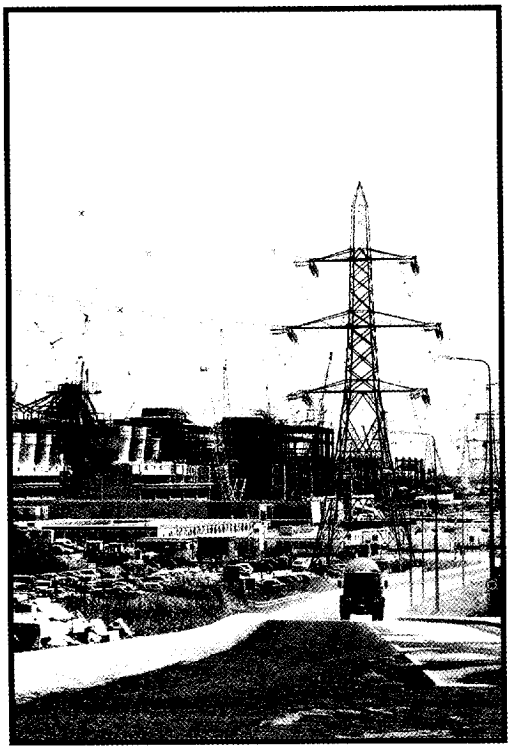
ELECTRICAL SAFETY ON CONSTRUCTION SITES



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This guidance is issued by the Health and Safety Executive. Following the guidance is not compulsory and you are free to take other action. But if you do follow the guidance you will normally be doing enough to comply with the law. Health and safety inspectors seek to secure compliance with the law and may refer to this guidance as illustrating good practice.

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CONTENTS

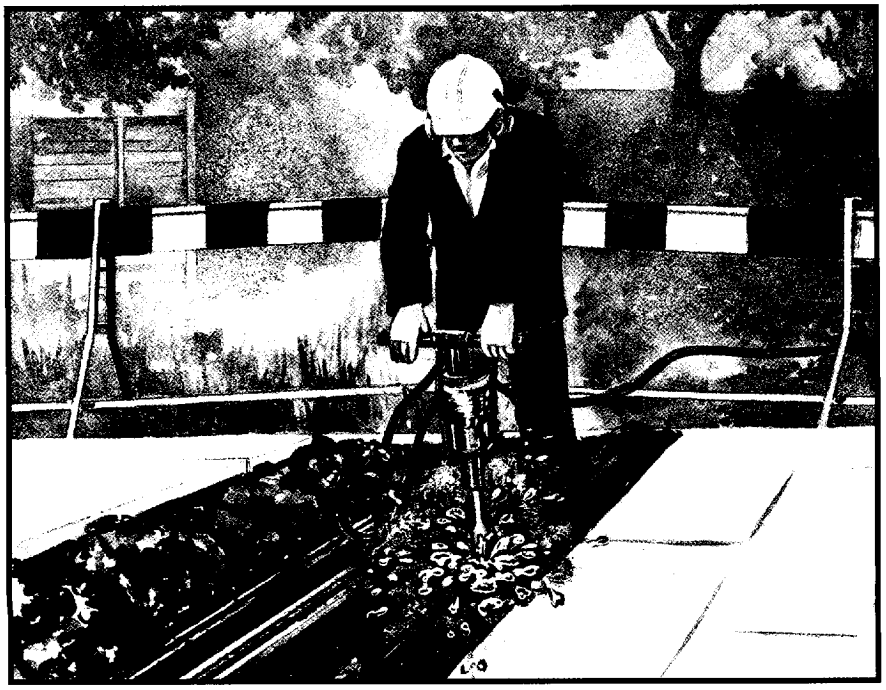
INTRODUCTION

1 Electricity can kill. Every year, the use of electricity on construction sites results in a number of accidents. People suffer electric shocks and burns which can in themselves cause serious and sometimes fatal injury. People may also fall from ladders, scaffolds and other equipment as a consequence of the shock, which can result in further injury. Also, those using the electricity may not be the only ones at risk, for example faulty equipment may lead to a scaffold becoming live or short circuits can result in fires.

2 This guidance book gives advice on precautions that can be taken to reduce the risk of accidents during the construction phase. It covers the:

- installation and use of the temporary site distribution system (designed to distribute and supply electricity to plant, work equipment, site offices and site huts etc);

Contact with underground cables can kill



- use of electrical equipment, including portable equipment, supplied by the temporary site distribution system;
- commissioning and use of the new permanently fixed electrical installation in the building or structure under construction;
- use of an existing fixed electrical installation in a building undergoing substantial modifications, together with the equipment connected to it;
- existing electrical installations in buildings or structures about to be demolished.

It does not cover the use of existing or new fixed electrical installations after the construction phase has been completed.

3 This publication is aimed at those responsible for site planning and management, and those who control the installation and use of electrical systems and equipment on construction sites (including subcontractors). Practical information is given to help people understand what the requirements of the relevant legislation may mean in practice. This includes, in particular, the Construction (Design and Management) Regulations 1994[1] (CDM Regulations), regulation 6 of the Electricity at Work Regulations 1989[2] (equipment used in adverse or hazardous environments) and regulation 5 of the Provision and Use of Work Equipment Regulations 1992[3] (selection of suitable work equipment).

4 The guidance does not address in detail the use of 3 phase 400 volt (V) installations such as supplies to tower cranes or other fixed plant. Electric arc welding is also outside the scope of this guidance (see BS 638 *Arc welding power sources, equipment and accessories*[4] and HSE's guidance HS(G)118 *Electrical safety in arc welding*[5]).

5 References are numbered in the text. At the back of this publication there is a section which lists the references and provides information on further reading.

Legislation

6 Modern law provides a framework for the consideration of hazards and sets objectives for the elimination and control of risks at work. It places duties on all those who can contribute to health and safety including employers, employees and the self-employed.

7 These duties are set out in the Health and Safety at Work etc Act 1974[6], and in more detail in Regulations made under this Act. A summary of the main relevant legal provisions is given in Appendix 1. The legislation is designed to protect the health, safety and welfare of:

- employees and self-employed people who work on the construction site;
- other people who may visit the site during the course of their work, eg delivery drivers, service engineers etc;
- other people including members of the public who may be affected by the work activity.

8 Some regulations give detailed requirements for the construction industry, for example the CDM Regulations[1]. These Regulations place duties on:

- clients;
- designers;
- those planning and co-ordinating the work (planning supervisor and principal contractor);
- contractors who carry out the work.

Other regulations set out requirements which apply across all industries, for example the Electricity at Work Regulations 1989[2], and the Provision and Use of Work Equipment Regulations 1992[3].

9 Those who have duties under health and safety legislation should be aware of the hierarchy of risk control which underlies the modern approach to health and safety management. Some of the main principles of this hierarchy are:

- where possible, avoid risks altogether (eg, change the design, work method, equipment or working environment);
- assess the extent of any risks which remain;
- reduce these risks to an acceptable level, preferably by using solutions which combat the risk at source;
- replace the dangerous by the non-dangerous or less dangerous (eg, use pneumatic power tools in a wet environment);
- give priority to controls which will protect all workers rather than a number of individuals. For example, a reduced low voltage, site distribution system such as one which is 110V centre tapped to earth (110V CTE), will ensure that if distribution cables are damaged the risk of fatal shock to anyone in the vicinity is virtually eliminated;
- provide information, training and instruction to combat any risk which remains.

The risk

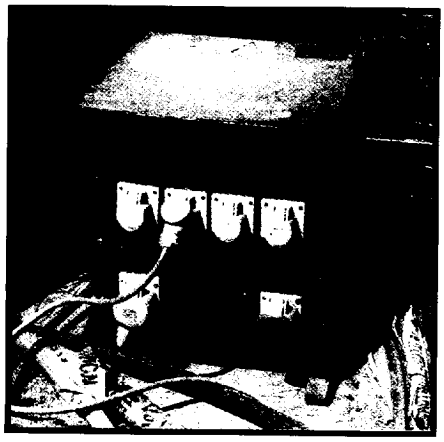
10 Each year, people are killed or seriously injured by electricity in the construction industry. Most of these accidents could be avoided.

11 Construction sites present one of the most challenging environments to the safe use of electricity. Much of the work is done outdoors in all weathers - damp and wet conditions increase the risk and potential severity of shock. Sites are constantly changing as the work progresses, so there is always a temptation to improvise supply systems. Excavations, demolition work and routine construction activities may all result in damage to both the temporary site distribution system and/or the existing fixed installation.

12 Cables and equipment are likely to be damaged by the movement of heavy plant and materials. During installation work sites are often congested, which makes the control of risk more difficult. There may also be confusion as to which parts of the temporary, existing or new installations are live, and which have been made dead.

13 The temporary site distribution system may be used by a wide range of people who often work for different contractors and who will have various needs and expectations. Contractors may provide their own tools and equipment, or use equipment provided by others. Effective management is necessary to ensure that all the equipment is suitable for use and is properly maintained.

Site distribution unit



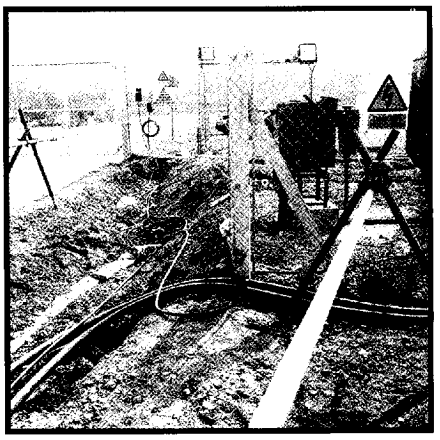
PLANNING THE WORK

14 Many of the risks can be avoided by careful planning before the work starts. The CDM Regulations[1] provide a framework for the management of these risks. Even where these Regulations do not apply, the advice in the following paragraphs will help contractors and others to comply with their general duties under other health and safety legislation.

15 Where the CDM Regulations apply, the client will need to first appoint someone to plan the work (the planning supervisor). Clients should then provide them with information relevant to health and safety. This includes information about present or previous use of existing buildings, land or plant etc at the site where the construction work is to be carried out.

16 Information such as drawings and wiring diagrams for the existing electrical installation, plans showing the location of electrical services, or previous surveys of the land and structures may be to hand, for example in an existing health and safety file. If not, the client (or someone acting on the client's behalf) will need to make reasonable enquiries to obtain this information which will be needed by both the designers and the contractors. This might mean commissioning a survey of existing premises to determine, for example, which electrical services will remain live while the work is carried out, or to obtain information from the utilities on the location of underground services.

Location of electrical services



17 Designers should use this and other relevant information when deciding how best to control risk. They should:

- first consider if the risk can be avoided, eg arrange for overhead lines to be moved or site the structure away from them;
- specify the use of particular equipment such as air powered, or cordless tools for those locations where the work will be in wet or confined conditions;

- combat the risks at source, if risks cannot be eliminated, eg by programming and controlling the work to ensure that parts of a new permanent electrical system are not commissioned until all work on the installation has been completed;

- give priority to risk control measures that will protect all workers.

18 Depending on the type of project, the design and planning decisions will be made at different stages. Some decisions may be made by architects (eg, the location of the structure in relation to overhead lines), some will be made or influenced by specialist equipment suppliers (who may also be designers), and other decisions might only be finalised when detailed planning is done by the main or principal contractor. It is therefore important for those planning the work to make sure that there is co-operation between the various parties. This will achieve a co-ordinated and comprehensive approach to the control of electrical risk. Depending on the stage of the project, this duty may fall to either the person planning the work, or the main contractor (planning supervisor or principal contractor on sites where the CDM Regulations apply).

19 At the design and planning stage, and as the project develops, issues which will need to be considered or reviewed will include the following:

- the need to alert the electricity supplier to the nature, duration and likely start date for the work;

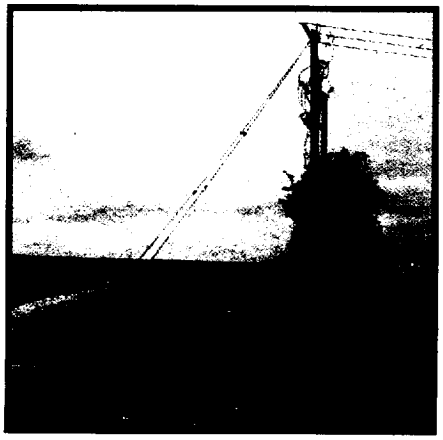
- the location of overhead lines and buried cables;

- environmental considerations, eg the season in which the work is to take place (often wet in winter), ground conditions such as waterlogging, (which increases the risk of serious injury from electric shock);

- the supply voltages to be used for offices, plant, equipment etc;

- the need to use generators to provide all or part of the site supply;

Overhead line

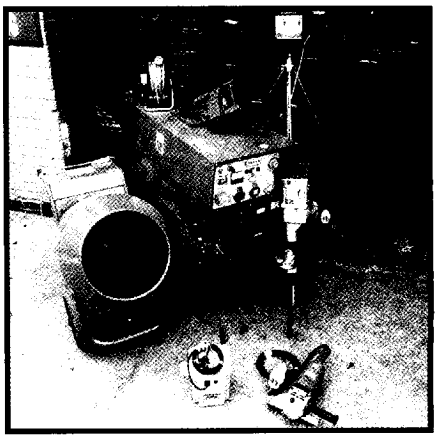


- earthing requirements or earthing system to be used;
- the supply to and siting of heavy duty equipment, eg tower cranes;
- the installation and commissioning of the temporary site distribution system, in particular the siting and protection of metering equipment and switchgear, distribution boards and supply cables;
- the way in which the system will be modified or extended as the work progresses;
- operation of the temporary site distribution system (who will control, operate, and maintain the electrical distribution systems and how this can be done safely);
- use of plant and equipment connected to the distribution system (consider who will use the plant and equipment, and how such use will be controlled. Who will be responsible for plant and equipment maintenance?);
- provision of lockable switches and means of isolation;
- use of existing permanent systems as a supply for plant and equipment;
- if refurbishment works are to be carried out, identification of parts of the system which are live;
- commissioning and handover arrangements for completed buildings or installations.

Most of these issues are covered in later paragraphs.

20 Where the CDM Regulations apply, a planning supervisor should be appointed and a pre-tender stage health and safety plan should be prepared. The plan should include details of health and safety risks (including electrical risks) and other relevant

Typical equipment



information which the principal contractor is likely to need to manage those risks. The principal contractor should then develop a plan which sets out how these risks will be managed and controlled during the construction phase. This should include any unusual risks or risks requiring particular attention.

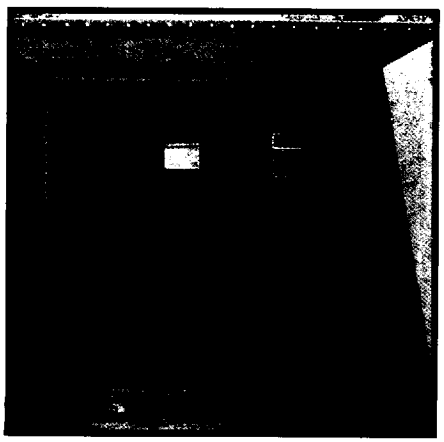
21 Contractors coming to site should be provided with information about relevant risks. The principal contractor may make site rules (eg, specifying acceptable types of equipment; the maximum voltage for portable tools which may be used on site; working procedures; commissioning procedures). Contractors should co-operate with the principal contractor to ensure that any rules or agreed methods of working are put into practice.

Advice from the electricity supplier

22 Early contact with the electricity supplier is strongly recommended. While this is normally carried out during the planning stage, discussions between the electrical system designers, or the contractors who will carry out the work and the electricity supplier are also recommended. Many of the issues raised in paragraph 19 will be relevant to these discussions, in particular the:

- correct rating of fuses and switchgear at the point of supply;
- use of generators in addition to the public supply (see paragraph 44);
- earthing requirements or earthing systems to be used;
- likely use of very heavy plant (eg, tower cranes) needing a high voltage supply (close liaison with the electricity supplier is essential and specialist advice may be necessary);
- location of metering equipment and switchgear (which will need to be accessible at all times in case of emergency).

Location of metering equipment - point of supply



Overhead lines and underground cables

23 If there are existing overhead lines or cables on site, they should, where possible, be made dead or re-routed before work starts. The owners of the overhead lines or cables will need to agree to this. They may be:

- the site owner;
- the developer;
- the local authority;
- the local electricity supplier;
- the railway line owner where the site is near an electrified railway line.

24 Early contact with the owners is recommended so that this work can be completed before construction work begins. If the overhead lines and cables cannot be made dead or re-routed, precautions should be put in place to ensure that they are not approached or disturbed. The owners may also have detailed requirements for work in the vicinity of their equipment.

25 Further information is given in HSE's guidance note GS 6 *Avoidance of danger from overhead electrical lines* [7].

26 The location of any underground cables should be confirmed and the route marked as recommended in HSE's booklet HS(G)47 *Avoiding danger from underground services*[8]. Danger will be avoided if the precautions recommended in that document are followed. Similar precautions should be taken for cables that are subsequently installed as either part of the temporary site supply or as part of the permanent installation. Also see paragraph 60.

Worker using a cable avoidance tool

The supply voltage

27 When planning and installing the site supply, the following need to be taken into account:

230/110 volt transformer

- the principles of risk control outlined in paragraph 9;
- the characteristics of the system selected;
- the voltage requirements of the plant and equipment to be used.

28 Most electric shocks are between a live part and earth as a result of a fault or damage to plugs, cables or equipment. Long experience in the UK has shown that the use of reduced low voltage portable electrical tools and equipment (eg, 110V CTE) on building sites will effectively eliminate the risk of death and greatly reduce the degree of injury in the event of an electrical fault (see paragraph 29). Therefore the best way to reduce such risk is to keep the supply voltage to the lowest which is necessary for the job to be done. This combats the risk at source, and helps ensure the protection of all workers on site.

29 When deciding on the site supply to work areas, remember that:

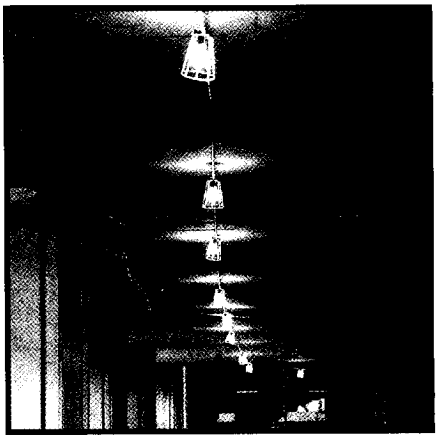
- where risks are particularly high, eg on a waterlogged site or in confined spaces, the use of pneumatically powered tools will eliminate electrical risks;
- where electrically powered tools are used, battery-operated tools are the safest;
- a SELV system (sometimes called a safety extra low voltage system) which is separated from earth and which limits the voltage supplied to a maximum of 50V, can be used for lighting and some power tools, (however this may be impractical for motor driven equipment fed by long leads);
- a reduced low voltage system, which delivers 110V to the equipment, designed so that the maximum voltage to earth is only 55V in a single phase system (65V in a 3 phase system), is safer than using 230V;
- where mains voltage (230V) is used to supply site

Battery-operated drill

offices and welfare facilities, it is recommended that the system is protected with a residual current device;

- if, having considered the hierarchy of risk control, a mains voltage (230V) supply is selected for portable tools and equipment, additional precautions must be provided to reduce the risk to an acceptable level (see paragraph 70).

Technical details of the reduced low voltage systems commonly used in the UK, and the safety benefits arising from their use are given in Appendix 2.



Festoon lighting

30 Many construction sites will require supplies at several voltages. The following are the recommended maximum voltages for particular applications:

- portable hand lamps for use in confined or damp situations: 25V single phase;
- other portable hand lamps: 50V;
- site lighting other than fixed floodlighting: 110V reduced low voltage single phase;
- portable and hand-held tools and transportable equipment up to about 3.7kW (5hp): 110V reduced low voltage, single or 3 phase;
- installations in site offices, huts, other buildings and fixed floodlighting: 230V single phase;
- fixed or moveable heavy duty plant (eg, tower cranes etc): 400V 3 phase;

Note: Some specialist equipment (eg, submersible pumps) may not be available in a range of voltages.

31 Further guidance on the standards for electrical installations on construction sites is contained in the British Standards BS 7375 *Code of practice for distribution of electricity on construction and building sites*[9] and BS 4363 *Specification for distribution assemblies for electricity supplies for construction and building sites*[10].

Main distribution assembly

Selection of equipment for the temporary site distribution system

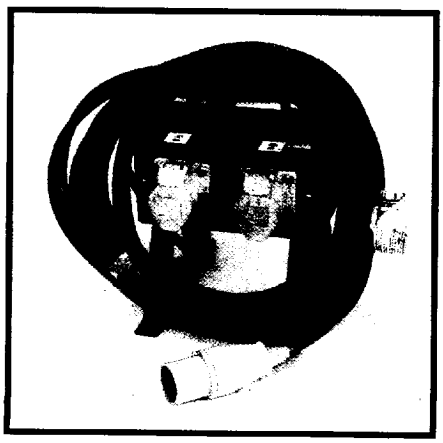
32 Equipment which is designed to withstand conditions on a construction site should be selected. Particular attention should be paid to any restrictions on use specified by the manufacturer.

33 Site distribution units should be designed and manufactured to a suitable standard, eg BS EN 60439-4, *Particular requirements for assemblies for construction sites (ACS)*[11]. Units having the following features will generally be suitable:

- flexibility in application for repeated use on various contracts;
- design for ease of transport and storage;
- robust construction that will resist damage;
- provision of lockable switches and means of isolation.

34 Socket outlets should be suitable for use on construction sites, eg those specified in BS 4343 (BS EN 60309-2) *Plugs, socket-outlets and couplers for industrial purposes*[12]. Sockets for domestic use (eg, BS 1363[13]) are not designed for site use.

Plugs/sockets



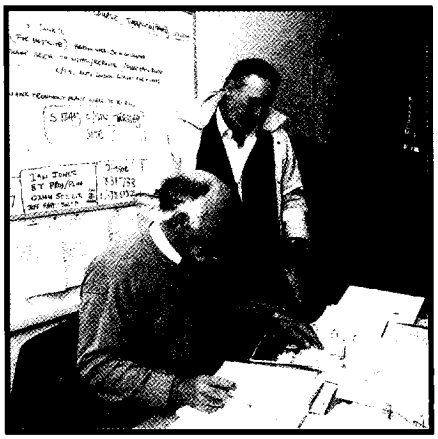
Staff appointments

35 Before starting work the principal or main contractor should appoint people responsible for site safety. It will help if their responsibilities are set out clearly in writing. Where the CDM Regulations apply, anyone appointing or engaging a designer to carry out design work, or a contractor to carry out or manage construction work, should be satisfied that those they intend to appoint are competent and adequately resourced for health and safety purposes.

36 All staff will need to be competent to carry out the tasks for which they will be responsible. When deciding

whether or not people are competent, the following are important:

- training and instruction;
- experience;
- knowledge of the risks involved;
- an understanding of the work and an ability to carry it out safely.



37 Having given people specific responsibility for safety matters, it is important that both the individuals concerned and others working on the site are aware of the extent and limitations of these responsibilities, and what arrangements there are to cover the absence of these staff (eg, during holidays). A good way of making these matters clear is to issue written instructions setting out individual responsibilities and how the safety arrangements will work in practice. Instructions and rules may form part of the relevant health and safety plans.

THE SAFETY OF THE ELECTRICAL INSTALLATION

Generators

38 A supply from an electricity supply company is not always available. In these instances the electricity supply for the site can be provided by an ac generating set. Care is needed to ensure that the generator is installed safely, and expert advice may be needed, particularly on earthing.

39 For small scale work, or in locations remote from the site supply, portable generators (with outputs of up to 10 kVA) are often used. For short time work (eg, less than one day), these generators need not be earthed provided that they are only used with Class II (double insulated or all-insulated) tools or equipment.

40 The smaller, single phase generators used for 110V supplies, (ie those with ratings up to about 5 kVA) need not be earthed, if all the equipment in use is double insulated, or if it supplies only one item of 'earthed' equipment. However, the equipment should be bonded with the frame of the generator. (Bonding involves connecting items of metalwork together in a way that is electrically continuous.)

Small generators

41 In all other circumstances, a suitable earth should be provided.

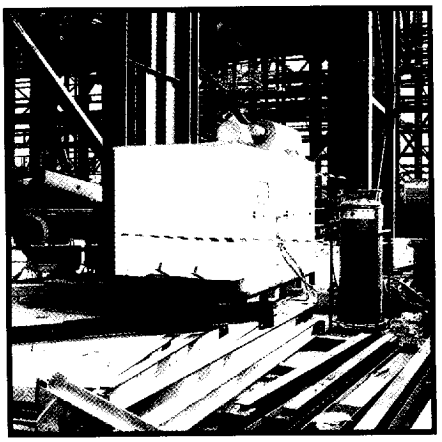
42 When larger generators are used (output in excess of 10 kVA), the generating set may be either single or 3 phase. Particular care is needed to ensure that the system is installed safely and this may require specialist advice. Matters to consider include the following:

- generators need to be earthed, by bonding the neutral to the frame and connecting the frame to earth;
- the impedance of the bonding needs to be low enough to ensure correct operation of protective

devices (fuses, circuit breakers etc). See paragraph 51;

- sensitive earth fault protection may be necessary if earthing conditions are difficult.

43 Further guidance on earthing and bonding of generator systems can be obtained from the supplier of the equipment, and detailed advice can be found in BS 7375 *Code of practice for distribution of electricity on construction and building sites*[9] and BS 7430 *Code of practice for earthing*[14].



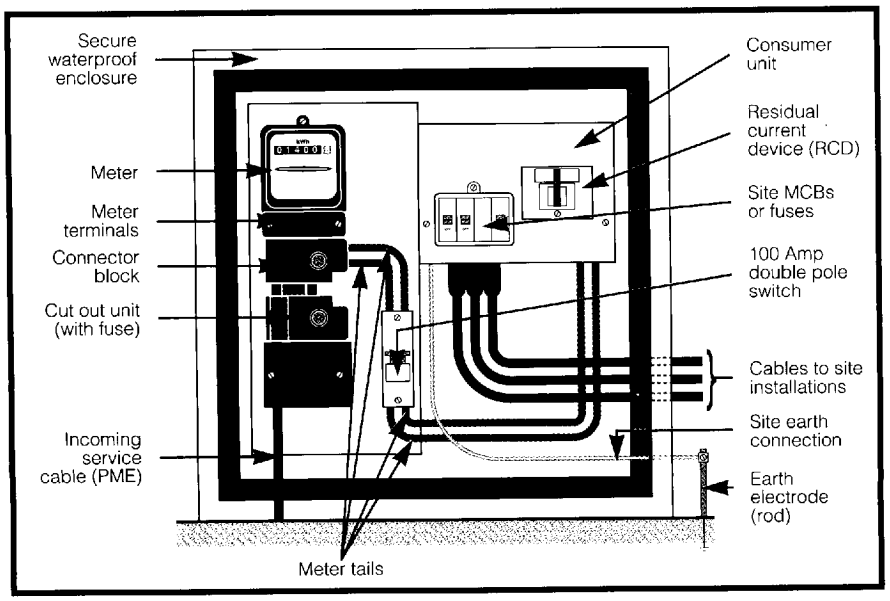
Large generator

44 Generators should be connected and operated so that they are separate from the public supply system unless agreement has already been obtained in writing from the electricity supplier. (See the Electricity Association's recommendation G 59-1[15].)

Earthing the site supply

45 Electrical safety often depends upon the existence of effective earthing. The responsibility for ensuring that the electrical earthing is effective rests with the person in charge of the site, not with the electricity supplier.

Typical PME mains service intake position and equipment showing earth electrode (rod)



***Note: No connection between incoming PME earth and site installation earth**

Earth electrode

46 Many electricity suppliers' systems use protective multiple earthing (PME). (In these systems neutral and earth are combined.) Where a PME system is used all metalwork, including structural metalwork, must be bonded together (connected together in a way that is electrically continuous). This is generally difficult to achieve on a construction site for a variety of reasons, particularly where steelwork is being added in the course of the work, where steelwork has been treated against corrosion, or where individual metal framed portable buildings or cabins are used. Therefore most electricity suppliers will not connect the site electrical system unless there is an adequate alternative earth. The use of an earth from a PME system is not allowed for the electrical supply to site caravans.

47 There are several alternative methods of providing a secure and effective earth. On a construction site a system that uses earth electrodes is most commonly used and will ensure that fuses etc will operate if there is a fault. Where necessary, specialist advice should be sought to ensure that there is adequate electrical protection. Detailed advice on earthing is contained in British Standard 7430 *Code of practice for earthing*[14].

48 If the work involves extending an existing site or structure, the existing electrical installation may be supplied from a PME system. In these circumstances it is strongly recommended that temporary site distribution systems which, for their effective earthing, depend on the provision of their own earthing electrodes, are kept separate from the PME system.

49 Fixed cable armouring and metal conduit can be used as a protective (earthing) conductor. Flexible metallic conduit should not be used as the only earthing conductor; it needs to be bonded (metalwork connected together in a way that is electrically continuous) and a separate protective (earth) conductor will be necessary.

50 The effective operation of any electrical protection depends on a low resistance earth path in the event of a fault. Joints in the earth path are particularly vulnerable to damage so there should be good electrical connection between the various components, eg between conduit, cable glands, and the equipment.

Additional electrical connections between the various metal parts may be necessary to provide this low resistance path, ensuring reliable operation of fuses etc.

Bonded conduit, cable gland and equipment

51 Guidance on earth impedance values is contained in BS 7671 *Requirements for electrical installations* [16]. Specialist advice on appropriate values may be necessary. (**Note:** The values in the British Standard are based on a nominal voltage to earth of 240V. For different voltages to earth, eg reduced low voltage, the impedance values will need to be adjusted accordingly). Earthing should always be tested after an item of equipment has been installed, paying particular attention to the continuity of protective (earthing) conductors, as well as to the polarity and to insulation resistance. See BS 7671[16] and paragraphs 76 to 78 on testing.

Earthing equipment connected to the supply

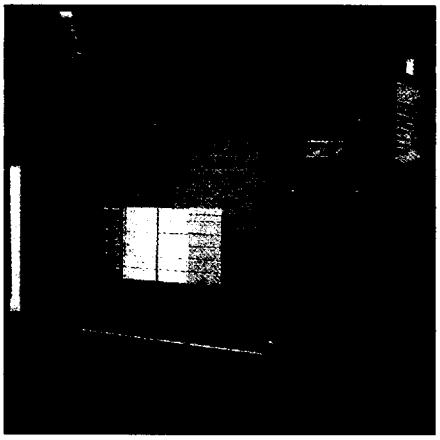
52 Equipment that is either double insulated, (constructed with two layers of insulation to provide electrical protection in case of damage to the outer insulation) or all insulated, (constructed with reinforced insulation) does not need, and will not be fitted with a means of connection to earth. Double insulated equipment is marked with this symbol:

and will therefore be supplied with a two core cable. Equipment which is not double insulated or all insulated must be earthed. A three core cable will be needed.

53 If extension leads are used, it is strongly recommended that these are always of three core construction having a separate protective (earth) conductor. This will ensure that the supply to tools which are not double insulated always includes an earth.

The temporary site distribution system

54 This is the cabling system and equipment installed to distribute and supply electricity to points of use at the



Distribution assembly with circuit breakers

various locations on the site during the construction phase. The temporary site distribution system is always removed when site work is completed as it is then no longer required. Removal may begin on completion and commissioning of all or part of the permanent, fixed installation.

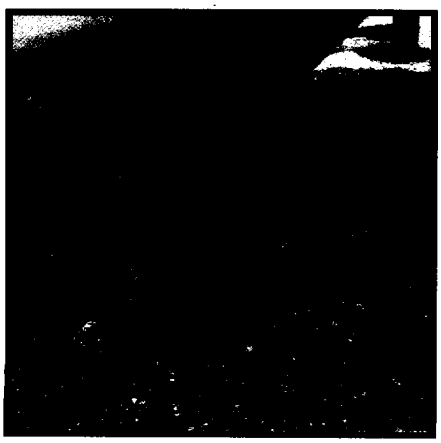
55 Although the site distribution system may be only temporary, the harsh conditions on site require that it is to a high standard. Equipment must be adequately protected against damage and contamination.

56 Switchgear and metering equipment should be provided with secure accommodation, and protected from adverse environmental conditions. It should preferably be located at a place where it is less likely to be damaged. Make sure that switchgear, and in particular the means of turning off the supply, is accessible at all times in case of emergency.

57 The use of correctly rated fuses and/or circuit breakers is essential for all the supplies on site.

58 Makeshift arrangements, such as unprotected wiring, taped and twisted cable joints, are often dangerous and should not be permitted. All wiring on site should be installed to appropriate standards, eg see BS 7671 *Requirements for electrical installations*[16] and BS 7375 *Code of practice for distribution of electricity on construction and building sites*[9].

Underground cable marker



59 Construction site distribution units such as those specified in BS 7375[9], BS 4363[10] and BS EN 60439-4[11], have the facility for plugging in further extensions. Such systems should only be installed or altered by people with the necessary knowledge and experience of the use of such systems. All other site installations which are not designed as plug-in systems need to be installed by a competent electrician. After installation, tests should be carried out to verify that the system is safe. Detailed advice is given in BS 7671[16] and the associated guidance.

60 Distribution cables should be located where they are not likely to be damaged by site activities. They should be kept clear of passageways, ladders and other

services. If they need to cross a site roadway or walkway they can be put into ducts with a marker at each end of the duct. If the roadway is used by vehicles the duct should be at least 0.5 m below the surface. A record of the location of any underground cables, using maps or plans showing the line and depth of such cables will be invaluable in avoiding damage as the work progresses. Alternatively cables properly protected can be carried at a suitable height above the roadway or footway. A goalpost type system may be required - see HSE's guidance note GS 6 *Avoidance of danger from overhead electrical lines*[7].

61 All fixed distribution cables which carry 400V or 230V on a construction site are recommended to be of a type which has metal sheath and/or armour which is continuous and effectively earthed. The metal sheath and/or armour should be protected against corrosion.

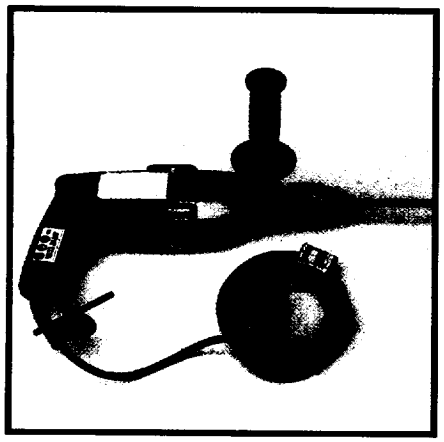
62 Site offices and fixed floodlighting will generally require 230V supplies. Installations within site offices and other buildings should be to a suitable standard - see BS 7671 *Requirements for electrical installations*[16]. The equipment selected and installed should be suitable for the environment in which it is used.

63 It is strongly recommended that, on larger sites, any existing or new permanent fixed supply is not used to supply contractors' equipment during the construction work. This will minimise unauthorised interference with the permanent fixed installation.

Moveable plant

64 Plant such as lifts and hoists which may be relocated occasionally during the work is recommended to be supplied by armoured cable. If, in the course of the construction operations, the plant is to be relocated, a safe method of work must be adopted. This will include turning off the supply and disconnecting the cable before the plant and cable are moved. Plant which is moved frequently (eg, a cement mixer) should be connected to the supply by a flexible cable with protective braid and abrasion-resistant sheath. Cables will need to be suitably located and adequately protected so that they will not be damaged.

65 If equipment has a high current requirement (current ratings greater than 16 amps), arcing can occur if the plug and socket are separated under load, causing burns or other injuries. Ways of isolating the supply should be provided to ensure that the supply is switched off before the plug and socket are separated. Examples of suitable equipment can be found in BS 4343 (BS EN 60309-2) *Plugs, socket-outlets and couplers for industrial purposes*[12], which allows for such plugs to be interlocked so that they cannot be withdrawn unless the supply is switched off at the socket.



Portable drill

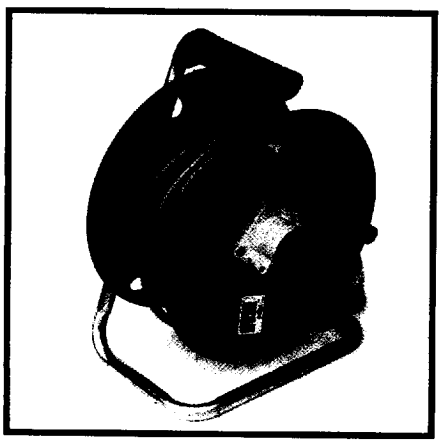
Portable equipment

66 Portable equipment and its leads face harsh conditions and rough use. Equipment is likely to be damaged and may become dangerous. Modern double insulated tools are well protected, but their leads and plugs are still vulnerable to damage and should be regularly checked. See the table on page 27. It is essential that the type of equipment selected is suitable for use on a construction site, and that any restrictions on use given by the manufacturer are followed.

67 The site supply voltage will often influence the choice of equipment. Where the supply is 230V or above, contractors can themselves eliminate or reduce the risks by selecting cordless tools or tools which operate from a reduced low voltage supply, (eg, 110V systems which are centre tapped to earth). For lighting, lower voltages can be used and are even safer.

68 There have been fatal accidents where 110V equipment fitted with plugs designed for a 230V system or damaged BS 4343 (BS 60309-2)[12] 110V plugs have been plugged into 230V supplies. To avoid danger, plugs and sockets used on the reduced low voltage system should not be interchangeable with 230V (mains) plugs and sockets. Plugs and sockets to the standard BS 4343 (BS EN 60309-2) *Plugs, socket-outlets and couplers for industrial purposes*[12], are non-interchangeable and are colour coded to indicate voltage (violet for 25V, white for 50V, yellow for 110V, blue for 230V, red for 400V). These industrial plugs and sockets are more robust than domestic (BS 1363[13]) 13 amp type equipment which is not designed for use on construction sites.

Extension lead



69 Cables with solid conductors (non-stranded) are designed for use in fixed installations. The conductors inside are brittle and liable to break if bent, so they should not be used as either extension leads or replacement cables for portable equipment.

Use of mains voltage equipment

70 When mains voltage equipment is used on construction sites, the risk of injury or death arising from the use of damaged or faulty equipment, leads or plugs is unacceptably high unless special precautions are taken. The precautions must reduce the risk to an acceptable level, taking into account the constraints regarding RCDs mentioned in paragraphs 71 to 75. Reasonably practicable precautions include:

(a) protecting people who may receive an electric shock by fitting non-adjustable residual current devices (RCDs) with a rated tripping current of 30 mA. RCDs should be installed either at the distribution board* which feeds the mains supply sockets or at the fixed mains supply socket. In either of these positions they will provide protection for both the cable and tool. RCDs fitted close to the tool only protect the tool. RCDs should be:

- installed in a dustproof and weatherproof enclosure (see the manufacturer's instructions) or designed for use in dusty and outdoor environments;
- protected against mechanical damage and vibration;
- checked daily by operating the test button;
- inspected weekly together with the equipment it is supplying during the formal visual inspection;
- tested every three months by an electrician using appropriate electrical test equipment. **Note:** The tests should not be carried out on RCDs at a time when loss of power may adversely affect other work activities.

*Note: See paragraph 75 on unwanted tripping

(b) reducing the risk of flexible supply leads being damaged by:

Extension lead with RCD

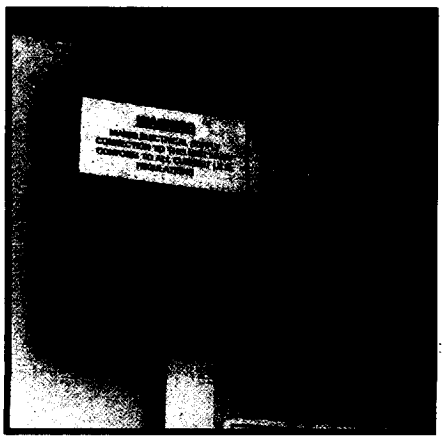
- positioning them where they are less likely to be damaged, (eg, run them at ceiling height inside a building); and/or
- protecting them inside impact resistant conduit where appropriate; or
- using special abrasion resistant or armoured flexible supply leads where appropriate.

(c) selecting tools that are designed for trade and work use. Double insulated equipment is strongly recommended where it is necessary to use a mains voltage supply, because the tools themselves are less likely to give rise to danger. (Danger can still arise, however, if the cables, plugs or equipment casing are damaged). Any restrictions on use set out in the manufacturer's instructions should be observed.

(d) regular maintenance checks which should be made of all electrical equipment. These should include:

- checks by the user each time the tool is used;
- formal visual checks by a trained person on a regular basis (see paragraphs 80 to 82 and the table on page 27);
- combined inspection and testing by a trained person at suitable intervals depending on the risk of damage and the potential for injury. (See paragraphs 84 to 85 and the table on page 27.)

A distribution board with an RCD

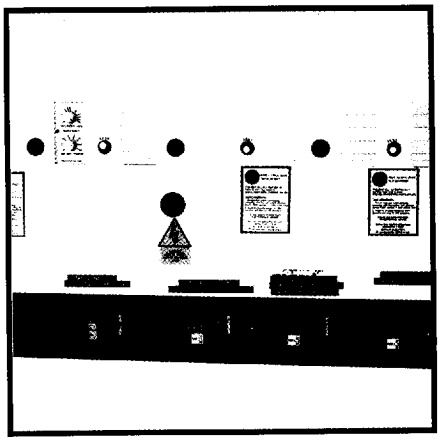


Residual current devices (RCDs)

71 Due to the delicate nature of an RCD, it is not ideal for use in the rough environment of a construction site. It may not be possible to ensure that the housing for the RCD is maintained to the quality required in these locations, and control over the number of times the test button is operated may be difficult. The manufacturers of RCDs do not generally recommend them to be fitted on portable apparatus which may receive mechanical shock or on equipment which might vibrate.

72 An RCD does not guarantee safety. If an RCD fails to operate, or is faulty, this will not be indicated and the worker may remain unaware of the danger. They only protect against earth faults, and will not operate when there is no connection to earth, ie if current is passing from live to neutral. So it is possible to suffer an electric shock and injury even though the RCD is operating correctly.

73 It is therefore not possible to place total or near total reliance for personal safety on RCDs. In contrast, the use of passive systems, such as reduced low voltage, can give reliable protection against fatal electric shock.



Mains distribution assembly with RCDs

74 The installation of an RCD will not make a system safe if it has been poorly designed or installed. An RCD is no substitute for a properly installed and protected electrical system with an efficient earth. RCDs for protecting people have a rated tripping current (sensitivity) of not more than 30 mA (and a non-adjustable rated operating time of 200 milliseconds (ms) at a test current of 30 mA, and 40 ms at 150 mA). See the appropriate British Standard, BS 4293[17] (General), BS 7071[18] (portable) and BS 7288[19] (incorporated in socket outlet).

75 On sites with a larger temporary distribution system, if a 30 mA RCD was fitted at the point at which electricity is supplied to the site, this could lead to unwanted tripping. (Each fault or other earth leakage within the site distribution system could cause the RCD to trip, therefore turning off the supply to the whole site.) Such tripping can also occur when RCDs are fitted to an intermediate distribution system. To reduce the possibility of unwanted tripping, the non-adjustable 30 mA RCDs should be fitted to individual circuits.

Maintaining the electrical installation

76 It is strongly recommended that temporary site distribution systems, new permanent installations and extensions or alterations to an existing system should be tested on completion. Also, a certificate of adequacy needs to be issued by the person carrying out the test. It is also recommended that copies of these certificates

are kept on site. (See BS 7671[16] and associated guidance for details of the appropriate tests.)

77 Electrical distribution systems on construction sites (excluding those within site offices) should be re-tested every three months or more often as experience dictates. This applies to the temporary fixed installation and to any pre-existing or new permanently fixed installation which may be used for the construction activities. On many sites it is often found necessary to inspect the installation much more frequently. Circuits or apparatus which are not satisfactory should be removed from service without delay and remedial action taken before they are used again. Installations in site offices experience more harsh conditions than office installations in a non-construction environment. They should be tested regularly - a period of no more than 12 months is recommended, as well as each time the office is moved.

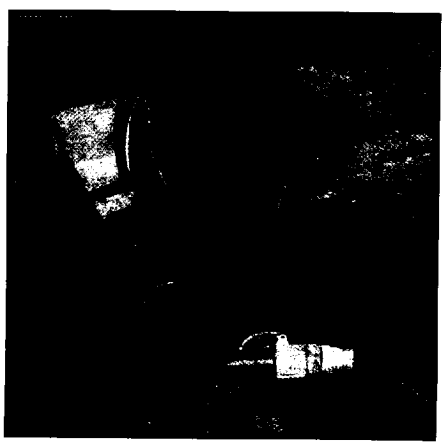
78 Routine testing of the installation and repair of defects should normally be carried out by electricians other than those doing the construction work. This is because the pressures that are often placed upon site workers to meet installation deadlines may be such that the routine testing and repair is not given its proper priority.

Maintaining portable electrical equipment

79 On construction sites, the risks from damaged or faulty portable electrical equipment are high, and need to be managed and controlled by setting up an appropriate maintenance system. HSE's booklet HS(G)107 *Maintaining portable and transportable electrical equipment*[20] gives detailed general advice on the electrical safety aspects of maintaining portable apparatus. The maintenance system will need to include:

- formal visual inspections on a regular basis;
- checks by the user;
- combined inspection and electrical testing where necessary.

Typical equipment



80 The most important precaution is the formal visual inspection because this can detect about 95% of faults or damage. Site management should ensure that regular visual inspections are carried out by sensible (competent) members of staff (see paragraph 36). Such staff should be given sufficient training to enable them to detect signs of faults or damage. These inspections could be included as part of the routine site safety checks carried out by site managers and site supervisors. Allocate time to enable them to carry out the inspections.

81 Those using electrical equipment should be given basic training so that they know how to visually check the equipment they are using. It is recommended that they look at 230V portable equipment and RCDs every day or at the start of every shift (if the site is in use 24 hours a day). They should be instructed to report any faults immediately so that the equipment can be taken out of use and repaired.

82 The following can be seen easily and will normally be picked up during the formal visual inspections and the checks by the user. Make sure that:

- bare wires are not visible;
- the cable covering is not damaged and is free from cuts and abrasions (apart from light scuffing);
- the plug is in good condition, ie the casing is not cracked, the pins are not bent or the key way (socket) is not blocked with loose material;
- there are no taped or other non-standard joints in the cable;
- the outer covering (sheath) of the cable is gripped where it enters the plug or equipment. The coloured insulation of the internal wires should not be visible;
- the outer casing of the equipment is not damaged or loose and all screws are in place;
- there are no overheating or burn marks on the plug, cable or the equipment;
- RCDs are working effectively (the test button should be pressed daily).

83 It is important that electrical equipment is regularly serviced in line with the manufacturer's instructions. If tools and equipment are hired, such maintenance will normally be carried out by the owner of the equipment. In such cases arrangements should be made to return the equipment, or make it available for maintenance, in line with the owner's schedule.

84 Testing can detect faults such as loss of earth continuity, deterioration of the insulation and internal or external contamination by dust, water etc. All of these faults are likely to happen on a construction site, because of the arduous environment, and they may not be picked up by user checks or formal visual inspections. It is therefore important that testing is carried out by a person trained to do so at a frequency appropriate to the type of equipment and the risks.

85 In addition to routine testing as part of the planned maintenance programme, combined inspection and testing is also recommended:

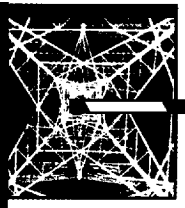
- if there is reason to suspect the equipment may be faulty, damaged or contaminated but this cannot be confirmed by visual inspection; and
- after any repair, modification or similar work to the equipment, when its integrity needs to be established.

86 The following table gives guidance on the suggested frequencies of user checks, planned formal visual inspections and combined visual inspection and testing of portable electrical equipment. It is based on practical experience and is designed to assist those setting up a maintenance regime for the first time. The frequencies should be appropriate to the risks on site. They should be reviewed occasionally, using the results of previous inspections and tests to see whether the frequency can be decreased or should be increased.

SUGGESTED INSPECTION AND TEST FREQUENCIES FOR ELECTRICAL EQUIPMENT ON A CONSTRUCTION SITE

Equipment/ application	Voltage	User check	Formal visual inspection	Combined inspection and test
Battery-operated power tools and torches	Less than 25 volts	No	No	No
25V Portable hand lamps (confined or damp situations)	25 volt Secondary winding from transformer	No	No	No
50V Portable hand lamps	Secondary winding centre tapped to earth (25 volt)	No	No	Yearly
110V Portable and hand-held tools, extension leads, site lighting, moveable wiring systems and associated switchgear	Secondary winding centre tapped to earth (55 volt)	Weekly	Monthly	Before first use on site and then 3 monthly
230V Portable and hand-held tools, extension leads and portable floodlighting	230 volt mains supply through 30mA RCD	Daily/every shift	Weekly	Before first use on site and then monthly
230V Equipment such as lifts, hoists and fixed floodlighting	230V Supply fuses or MCBs	Weekly	Monthly	Before first use on site and then 3 monthly
RCDs Fixed**		Daily/every shift	Weekly	*Before first use on site and then 3 monthly
Equipment in site offices	230 volt Office equipment	Monthly	6 Monthly	Before first use on site and then yearly

* **Note:** RCDs need a different range of tests to other portable equipment, and equipment designed to carry out appropriate tests on RCDs will need to be used.
** It is recommended that portable RCDs are tested monthly



87 Higher risk equipment (230V or above) needs to be checked, inspected and tested more often than lower risk equipment (110V or less).

88 Damaged equipment should be taken out of service immediately and clearly labelled as defective. Users should not attempt makeshift repairs. Repairs should be carried out by competent electricians.

DEMOLITION

89 If the demolition process itself requires a supply of electricity, the supply should be independent of any existing electrical installations in the building being demolished.

90 It is important to locate existing services at the planning stage of a demolition project. Danger will be avoided if all electricity supplies are cut off before demolition begins and proved dead by an electrically competent person, eg electrician or electrical engineer. Demolition plans need to be discussed with the owners of cables in case either they are intending to re-use these cables in later redevelopment or the cables supply an area other than the demolition site. See paragraphs 23 to 26.

BUILDING ALTERATION AND REFURBISHMENT

91 When buildings are altered or extended, risks can arise from the use of, or contact with the existing electrical installation and plant or equipment connected to it. Even for small jobs it is recommended that before work starts the existing wiring is surveyed to ensure that it is safe and the relevant circuits have been identified. Particular care is needed to avoid damage to cables or equipment that may be energised, or might subsequently be made live. The potential for confusion and danger will be avoided if old wiring and equipment no longer required is removed as early in the project as practicable.

92 If the work comprises light refurbishment, shopfitting etc, where only lighting and hand tools are to be used and the possibility of damage to their leads is low, the existing electrical installation may be used as a supply. This is providing that suitable means of connection are available. In these circumstances either the voltage should be reduced to a safe level, eg 110V CTE or the system should be protected using RCDs (see paragraph 70(a)).

HANDOVER AND COMMISSIONING WORK

93 This section deals with the permanent, fixed installation in the building or structure under construction. As parts of the installation are completed, they may be progressively commissioned and brought into use. Risks will arise unless subcontractors and their employees are kept up to date about the state of the job, namely whether electrical systems have been energised, whether they are capable of being energised or whether plant is still safe to work on.

94 These risks will be avoided if the main contractor prepares in good time an agreed plant commissioning programme. The plan can then be monitored by ensuring that:

- the programme is brought to the attention of all mechanical and electrical subcontractors;
- regular (eg, weekly) commissioning meetings are attended by all subcontractors, to record past progress, to arrange for the following week's work, and to manage any programme divergencies;
- key information notes are issued immediately after each meeting;
- subcontractors' written plant commissioning procedures are checked where applicable;
- access to the site by plant suppliers' specialist staff is controlled and information regarding newly commissioned plant is passed on;
- checks are made to ensure that the required work has in fact been completed;
- secure means of isolation exist for each part of the installation on which work is being carried out. All padlocks and keys used should be clearly

Isolator in locked off position

identified and held by either the main contractor or a subcontractor's designated supervisor;

- the use of temporary electrical supplies is minimised during plant commissioning;

- adequate supervision is taking place, and agreed procedures are being followed.

95 Systems should not be made live until all enclosures are complete in all respects. It is strongly recommended that newly commissioned equipment which may be mistaken for non-commissioned equipment is identified as live by a prominent temporary warning notice. This notice should show the commissioning contractor's name, site telephone number and date when it was first made live.

96 It is strongly recommended that circuits which are not in use are locked off and the keys held in safe keeping by a responsible person. Doors to switchrooms and covers to fuse and miniature circuit breaker (MCB) boards should also be locked shut, and the keys held by a responsible person.

SAFE WORKING PRACTICES

97 Safe systems of work should be followed when working on an electrical installation. Guidance is given in HSE's booklet HS(G)85 *Electricity at work:safe working practices*[21].

98 Electricians working on high voltage systems should be specially trained. Depending on the complexity of the system and the voltages in use, permit-to-work systems may need to be used, together with the provision of lockable switches and other means of secure isolation.

TREATMENT OF ELECTRIC SHOCK VICTIMS

99 The Management of Health and Safety at Work Regulations 1992[22] require emergency procedures to be planned for. These should include:

- adequate provisions being made for calling the emergency services;

- workers who are expected to help in the event of an accident being instructed on the procedure to follow to isolate the supply;
- some of the workers on site being given practical training in techniques for treatment in the event of electric shock;
- notices being posted in prominent places to advise on such treatment.

See Appendix 3.

APPENDIX 1: LEGISLATION

1 The following summary outlines the main legal requirements which apply to the use of electricity on construction sites. The list is not complete and does not give a definitive interpretation of the law. It summarises the main issues to be borne in mind when carrying out such work. Full details of the legislation can be found in the documents referred to at the end of this guidance.

The Health and Safety at Work etc Act 1974

2 The Health and Safety at Work etc Act 1974[6] places duties on employers, employees and the self-employed to ensure, so far as is reasonably practicable, the safety of people involved in work activities, and those who may be affected by work activities.

The Management of Health and Safety at Work Regulations 1992

3 The Management of Health and Safety at Work Regulations 1992[22] require employers and the self-employed to assess the risks arising from work activities. They should do this with a view to identifying the measures which need to be taken to comply with relevant health and safety legislation, therefore eliminating risks where possible and controlling those which remain.

The Construction (Design and Management) Regulations 1994

4 The Construction (Design and Management) Regulations 1994[1] apply to many construction projects and set out requirements in relation to their design and management. They place responsibilities on all those who can contribute to improving health and safety including clients, designers and contractors. Hazards should be identified, and risks eliminated, or where this is not possible, reduced by action during the design, planning and execution phases of the project.

5 The Regulations create the two key functions of **planning supervisor** and **principal contractor** to co-ordinate health and safety during the design and construction phases. The Regulations also provide for **health and safety plans** which draw together the health and safety issues in relation to the project. The pre-tender stage health and safety plan should set out what has been done to eliminate or reduce risks (including electrical risks) during the design phase and provide relevant information for the principal contractor. The construction phase health and safety plan prepared by the principal contractor should set out how the construction work will be managed to eliminate and reduce risks.

The Electricity at Work Regulations 1989

6 The Electricity at Work (EAW) Regulations 1989[2] require those in control of part or all of an electrical system to ensure that the system is safe when provided, safe to use, and that it is maintained in a safe condition.

7 The EAW Regulations should not be confused with BS 7671[16] (formally known as the IEE Wiring Regulations) which is a non-statutory code issued jointly by the Institution of Electrical Engineers and the British Standards Institution. BS 7671[16] deals in detail with the safety of electrical installations.

The Provision and Use of Work Equipment Regulations 1992

8 The Provision and Use of Work Equipment Regulations 1992[3] place duties on employers and the self-employed, to ensure the provision of safe and suitable work equipment, and to ensure its safe use. Selection of suitable work equipment involves taking into account the risks that can arise from the place where it will be used, and the purpose for which it will be used.

APPENDIX 2: TECHNICAL NOTES ON RESIDUAL CURRENT DEVICES AND REDUCED LOW VOLTAGE SYSTEMS

Residual current devices (RCDs)

1 An RCD is an electro-mechanical device which may be likened to a current balance. It compares the current flowing into the system with the current flowing out of the system. When the system is fault free, these values are the same, and the RCD continues to allow the current to flow. When the levels differ by a pre-set value (the rated tripping current value of the device) or more, the RCD will open rapidly, therefore interrupting the electrical supply.

2 The RCD is sensitive to very small losses of current. It does not limit the current flowing in the event of shock, it limits the time for which that current flows, therefore minimising injury. If an RCD fails to operate the current will continue flowing, possibly dangerously.

3 RCDs can also be subject to unwanted tripping. This is where the RCD trips frequently in the absence of a detectable fault. The cause may, for example, be due to 'leakage' currents from items such as information technology equipment. The resulting loss of supply causes inconvenience to users of the system, and increases the likelihood of the device being defeated in some way, so rendering the system without protection.

Reduced low voltage systems

4 These are electrical supply systems in which the maximum voltage to earth that can occur in the event of a fault or damage to the system is reliably limited to a value which is unlikely to cause danger to people. Unlike residual current devices (RCDs), reduced low voltage systems are passive systems as they do not rely on the operation of a sensitive electro-mechanical device to ensure safety.

5 Cordless (battery-operated) hand-held tools are one example of reduced low voltage equipment, but these have limitations on power output and duration of operation.

6 A SELV system (sometimes called a safety extra low voltage system) limits the voltage available to a maximum of 50V. These systems are often used for lighting circuits or similar low power requirement situations, but the low voltages make the system less useful for use with power tools and more general application.

7 The reduced low voltage system in most common use on UK building sites for general applications is that which is 110V centre tapped to earth. In this system the source of the electrical supply is usually a double wound transformer with an earthed screen between the primary and secondary windings of the transformer. In addition, the star point or neutral of a 3 phase transformer is connected to earth, and the centre point of a single phase or two pole winding is connected to earth (See figures 1 and 2.) It is possible to use generators to supply these systems and these should be configured to provide the same features.

8 The phase-to-phase (for 3 phase supplies) and the pole-to-pole (for single phase supplies) voltages on the secondary output do not exceed 110V. The corresponding phase-to-earth and pole-to-earth voltages will then not exceed 63.5V and 55V respectively at the transformer output terminals.

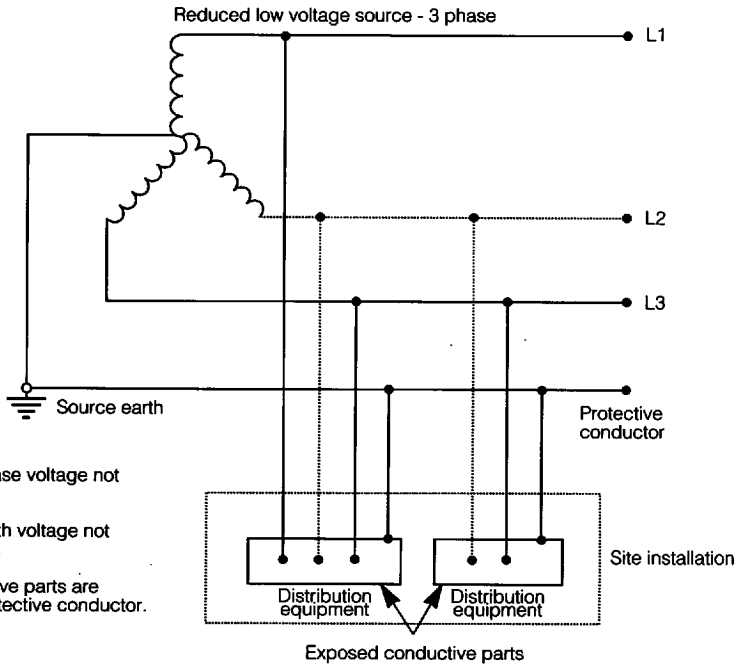
9 In this way, the system is able to supply 110V to tools or equipment in use on the site, while technical investigation has shown that the maximum indirect contact touch voltage to earth from one of these systems does not exceed 40V. This can be a steady state condition and it does not exceed the limits for electric shock protection set out in the protection curves for normal human body impedance, as shown in IEC publications 479-1 and 2[23].

10 These systems have been in widespread use for more than 50 years under the rigours of construction and demolition sites and there is no record of any fatal accidents which have occurred during that time. They achieve a high standard of safety compared to other systems of protection, and the need for maintenance is less.

Reduced low voltage

A system in which the nominal phase-to-earth voltage does not exceed 63.5V and the nominal phase-to-phase voltage does not exceed 110V.

3 phase



RLV

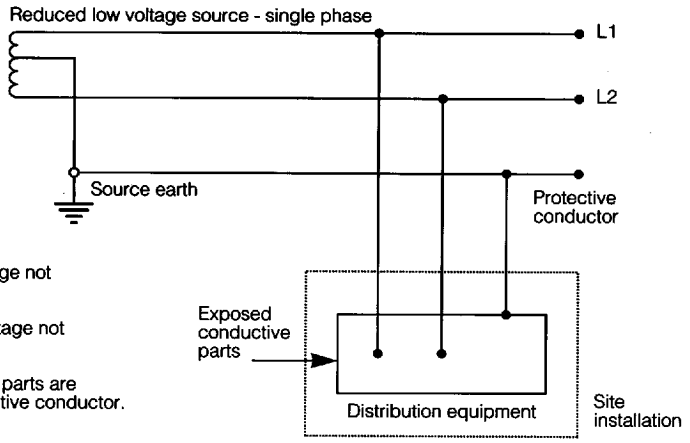
System phase-to-phase voltage not exceeding 110 volts.

System phase-to-earth voltage not exceeding 63.5 volts.

All exposed conductive parts are connected to the protective conductor.

Figure 1

Single phase



RLV

System line-to-line voltage not exceeding 110 volts.

System line-to-earth voltage not exceeding 55 volts.

All exposed conductive parts are connected to the protective conductor.

Figure 2

APPENDIX 3: EMERGENCY PROCEDURES FOR AN ELECTRIC SHOCK CASUALTY

Safety

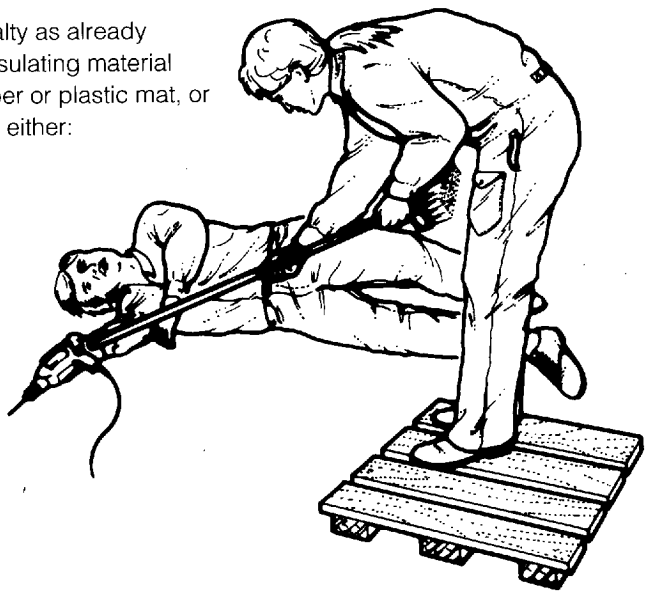
The first priority for the rescuer is to avoid becoming a casualty and making the situation worse for other rescuers. It is essential to make sure it is safe to approach and to check if the casualty is still connected to the electrical current in any way directly (to a faulty machine, apparatus or to a bare wire), or indirectly (lying on an electrically conductive surface).

Procedure

DO NOT touch the casualty with your unprotected hands. Break the contact by switching off the current, removing the plug or wrenching the cable free.

If you are unable to isolate the casualty as already described, you must stand on dry insulating material such as a wooden box, a clean rubber or plastic mat, or a thick pile of dry newspapers. Then either:

- use a wooden or plastic implement to free the casualty from contact with the electrical source; or



- wear rubber or plastic insulating gloves, if available, to pull the casualty free; or
- if rope is available, without touching the casualty, loop it around the feet or under the arms and pull the casualty free.

Ensure there is no more danger. If the casualty seems unharmed, rest and reassure them and refer to a doctor or a nurse. However, if the casualty is unconscious, check breathing and pulse. Send for help immediately. Resuscitation may be needed.

First aid action

Step A

Open the **airway** by:

- turning the casualty on his/her back;
- lifting the jaw and tilting the head back to open the airway;
- carefully removing any obvious debris from inside the mouth.

Step A

Step B

Check **breathing** by:

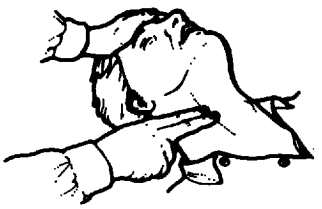
- looking to see if the chest rises and falls;
- listening for breaths;
- feeling breaths on your cheek.

Step B

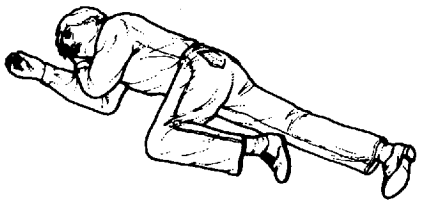
Step C

Check **circulation** (pulse):

- find the pulse by placing your fingers to the side of the voice box and pressing down gently.



Step C



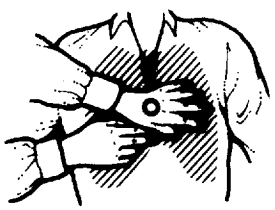
The unconscious casualty, who is breathing and has a pulse, should be placed in the recovery position and monitored until medical assistance arrives.

Mouth-to-mouth ventilation

If there is a pulse but the casualty is not breathing, begin mouth-to-mouth ventilation as follows:

- Kneel beside the casualty. While keeping the head tilted backwards, open their mouth and pinch their nose (Step A).
- Open your mouth and take a deep breath. Seal their mouth with yours and breathe firmly into it. The casualty's chest should rise.
- Remove your mouth and let the casualty's chest fall (Step B). If the casualty's chest does not rise and fall, check that:
  - their head is tilted back sufficiently;
  - you have a firm seal around their mouth;
  - their nostrils are closed completely;
  - their airway is not obstructed.
- Continue breathing into the casualty's mouth at a rate of 12-16 times a minute until they are breathing by themselves. Then place the casualty in the recovery position. **If the casualty is not breathing AND there is no pulse, Cardio-Pulmonary Resuscitation (CPR) must be carried out.** CPR is mouth-to-mouth ventilation combined with chest compression.

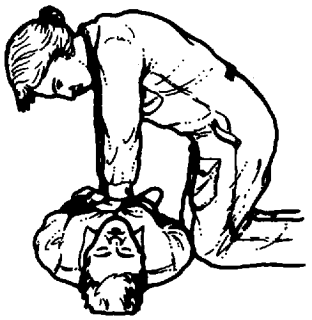
Cardio-Pulmonary Resuscitation (CPR)



- Give two breaths.
- Find the bottom of the breast bone.
- Two fingers' breadth above this, place the heel of one hand along the breast bone. Cover this hand with the other hand, interlocking your fingers.

- Keep your arms straight and press down 4-5 cms, 15 times at a quicker rate than once a second.

- Repeat mouth-to-mouth and continue the cycle at the rate of two breaths to 15 compressions, with 4 cycles per minute.



There should be no pause between the cycles. Two inflations should take approximately 5 seconds and 15 compressions should take approximately 10 seconds. Continue until the casualty has been successfully resuscitated, place in the recovery position if necessary, or until more expert help arrives. Treat other injuries as required.

To be competent at resuscitating effectively, it is advisable to receive emergency first aid training.

REFERENCES AND FURTHER READING

1 HSE *Managing construction for health and safety* Construction (Design and Management) Regulations 1994 Approved Code of Practice L54 HSE Books 1995 ISBN 0 7176 0792 5

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3 HSE *Work equipment* Provision and Use of Work Equipment Regulations 1992 Guidance on Regulations L22 HSE Books 1992 ISBN 0 7176 0414 4

4 British Standards Institution *Arc welding power sources, equipment and accessories* BS 638

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6 Health and Safety at Work etc Act 1974 Chapter 37 HMSO ISBN 0 10 543774 3

7 HSE *Avoidance of danger from overhead electrical lines* GS 6 HSE Books 1991 ISBN 0 11 885668 5

8 HSE *Avoiding danger from underground services* HS(G)47 HSE Books 1989 ISBN 0 7176 0435 7

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BS 4343 *Plugs, socket-outlets and couplers for industrial purposes* 1992
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23 International Electrotechnical Commission
Effects of current passing through the human body
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Part 2: *Special aspects* (IEC 479-2) 1987

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ISBN 0 11 883583 1

British Standards Institution *Code of practice for selection, installation and maintenance of electrical apparatus for use in potentially explosive atmospheres (other than mining applications or explosive processing and manufacture)*
BS 5345 (8 parts)

Building Employers Confederation *Construction safety manual* Section 10 *Electricity* Building Employers Confederation, 82 New Cavendish Street, London W1M 8AD

HSE *Health and safety for small construction sites* HS(G)130 HSE Books 1995 ISBN 0 7176 0806 9

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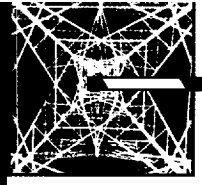

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