BS 7375:2010

BSI Standards Publication

Distribution of electricity on construction and demolition sites – Code of practice

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Contents

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This document comprises a front cover, an inside front cover, pages i to ii, pages 1 to 26, an inside back cover and a back cover.

Foreword

Publishing information

This British Standard is published by BSI and came into effect on 30 April 2010. It was prepared by Subcommittee PEL/17/3, *Low voltage switchgear and controlgear assemblies*, under the authority of Technical Committee PEL/17, *Switchgear, controlgear and HV-LV co-ordination*. A list of organizations represented on this committee can be obtained on request to its secretary.

Supersession

This British Standard supersedes BS 7375:1996, which is withdrawn.

Information about this document

This British Standard is intended to be read in conjunction with the relevant clauses of BS 7671.

This is a full revision of the standard, and introduces the following principal changes:

- updating of references to BS 7671 to take into account the publication of the Seventeenth Edition;
- updating of all other standards references;
- updating of style and structure to conform to current BSI drafting rules.

The use of reduced low voltage systems as recommended in this British Standard has made a major contribution to electrical safety on construction and demolition sites. However, for some site installations, by reason of their siting in relation to the available electricity supply, it might be necessary to use supplies at higher voltage.

Use of this document

As a code of practice, this British Standard takes the form of guidance and recommendations. It should not be quoted as if it were a specification and particular care should be taken to ensure that claims of compliance are not misleading.

Any user claiming compliance with this British Standard is expected to be able to justify any course of action that deviates from its recommendations.

It has been assumed in the preparation of this British Standard that the execution of its provisions will be entrusted to appropriately qualified and experienced people, for whose use it has been produced.

Presentational conventions

The provisions in this standard are presented in roman (i.e. upright) type. Its recommendations are expressed in sentences in which the principal auxiliary verb is "should".

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

1 Scope

This British Standard gives recommendations for the distribution of electricity on construction and demolition sites, and gives guidance on the application of the requirements of BS 7671 on such sites. It is intended for use by builders, contractors, engineers and others concerned with the provision of electrical installation equipment suitable for individual site conditions.

This British Standard is limited to those supply systems operating at nominal voltages not exceeding 440 V a.c. between conductors, or 250 V a.c. between conductors and earth.

The following are outside the scope of this British Standard:

a) high voltage incoming supplies and equipment;

NOTE 1 For some site installations, supplies at a higher voltage, e.g. 11 kV a.c. and 33 kV a.c., are used.

b) underground mining operations;

c) current-using equipment;

d) output circuits of frequency changers (see Note 2).

NOTE 2 Where high frequency power tools are used, a frequency changer is necessary for their connection to a source of supply. This British Standard is applicable only to the input circuits of such devices.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

Standards publications

BS 4363, *Specification for distribution assemblies for reduced low voltage electricity supplies for construction and building sites*

BS 5378-2, *Safety signs and colours – Part 2: Specification for colorimetric and photometric properties of materials*

BS 5499-1:2002, *Graphical symbols and signs – Safety signs, including fire safety signs – Part 1: Specification for geometric shapes, colours and layout*

BS 5467, *Electric cables – Thermosetting insulated, armoured cables for voltages of 600/1000 V and 1900/3300 V*

BS 6708, *Flexible cables for use at mines and quarries*

BS 6724, *Electric cables – Thermosetting insulated, armoured cables for voltages of 600/1000 V and 1900/3300 V, having low emission of smoke and corrosive gases when affected by fire*

BS 7430, *Code of practice for earthing*

BS 7671:2008, *Requirements for electrical installations – IEE Wiring Regulations – Seventeenth edition*

BS 7919:2001, *Electric cables – Flexible cables rated up to 450/750V, for use with appliances and equipment intended for industrial and similar environments*

BS EN 60079-14, *Explosive atmospheres – Part 14: Electrical installations design, selection and erection*

BS EN 60309-2, *Plugs, socket-outlets and couplers for industrial purposes – Part 2: Dimensional interchangeability requirements for pin and contact-tube accessories*

BS EN 60439-4, *Low-voltage switchgear and controlgear assemblies – Part 4: Particular requirements for assemblies for construction sites (ACS)*

BS EN 60529:1992, *Specification for degrees of protection provided by enclosures (IP code)*

BS EN 60947-2:2006, *Low-voltage switchgear and controlgear – Part 2: Circuit breakers*

BS EN 61008-1, *Residual current operated circuit-breakers without integral overcurrent protection for household and similar uses (RCCBs) – Part 1: General rules*

BS EN 61009 (all parts), *Specification for residual current operated circuit-breakers with integral overcurrent protection for household and similar uses (RCBOs)*

BS EN 61140:2002+A1:2006, *Protection against electric shock – Common aspects for installation and equipment*

BS EN 61558-2-6, *Safety of transformers, reactors, power supply units and similar products for supply voltages up to 1100 V – Part 2-6: Particular requirements and tests for safety isolating transformers and power supply units incorporating safety isolating transformers*

BS EN 61558-2-23, *Safety of power transformers, power supply units and similar – Part 2-23: Particular requirements for transformers for construction sites*

BS EN 62305 (all parts), *Protection against lightning*

Other publications

HEALTH AND SAFETY EXECUTIVE. *Avoiding danger from underground services*. HSG47. Revised edition. Sudbury: HSE Books, 2000.

HEALTH AND SAFETY EXECUTIVE. *Avoidance of danger from overhead electric lines*. GS6. Sudbury: HSE Books, 1997.

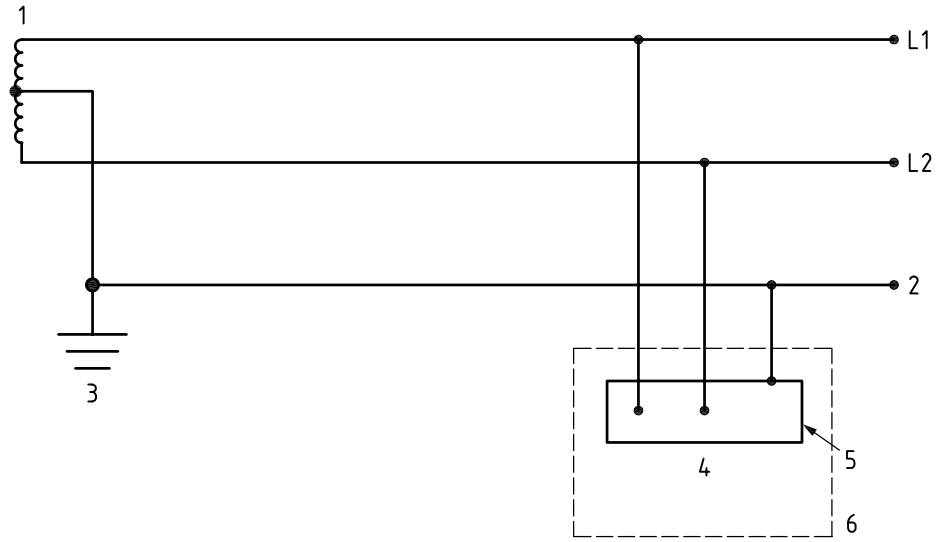
3 Terms and definitions

For the purposes of this British Standard, the terms and definitions given in BS 7671 and the following apply.

NOTE 1 Most of the system types are illustrated in BS 7671, apart from reduced low voltage systems, which are illustrated in Figure 1 of this British Standard.

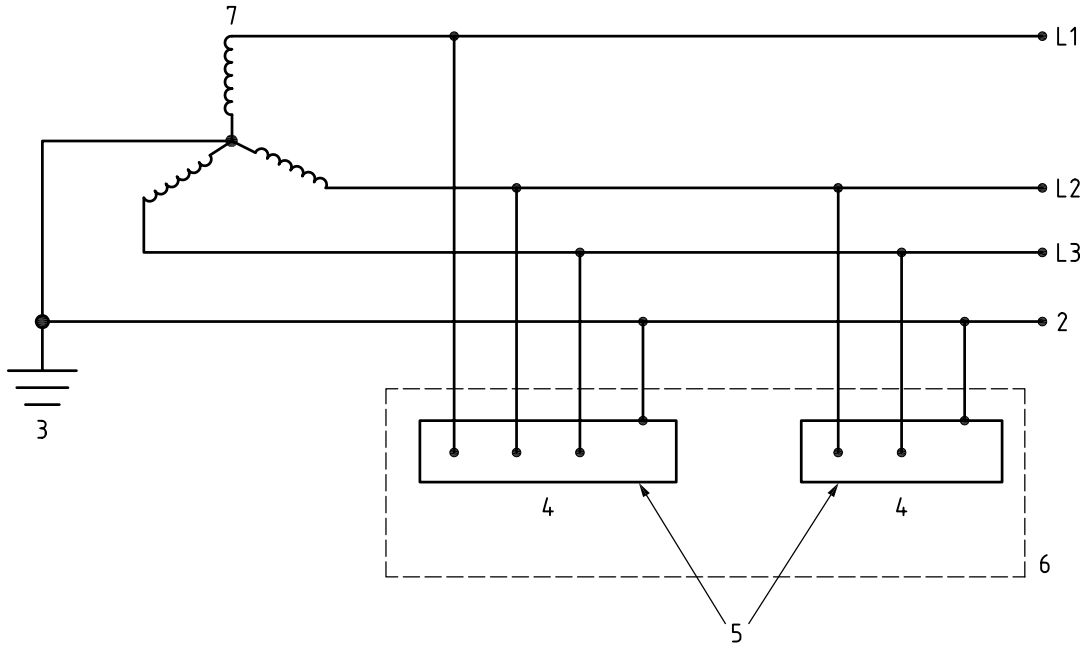
NOTE 2 All references throughout this British Standard to alternating current (a.c.) supplies relate to a frequency of 50 Hz unless otherwise stated. All references to alternating voltage and current relate to r.m.s. values unless otherwise stated.

Figure 1 **Reduced low voltage systems**



NOTE A system in which the nominal line-to-line voltage does not exceed 110 V and the nominal line-to-earth voltage does not exceed 55 V. All exposed-conductive-parts are connected to the protective conductor.

a) Single-phase source



NOTE A system in which the nominal line-to-line voltage does not exceed 110 V and the nominal line-to-earth voltage does not exceed 63.5 V. All exposed-conductive-parts are connected to the protective conductor.

b) Three-phase source

Key

1 Reduced low voltage source – single-phase
2 Protective conductor
3 Source earth
4 Distribution equipment
5 Exposed-conductive-parts
6 Site installation
7 Reduced low voltage source – three-phase

3.1 site
area where any of the following works are undertaken/executed:

a) construction work of new buildings;

b) repair, alteration, extension, demolition of existing buildings or parts of existing buildings;

c) engineering works;

d) earthworks;

e) work of similar nature

4 General

*COMMENTARY ON CLAUSE **4***
*In Great Britain, electrical installations on construction and demolition sites are subject to the requirements of the Electricity at Work Regulations 1989 [1], on which guidance is given in HSE publication HSR25 [2]. The Electricity at Work Regulations 1989 include requirements concerning precautions to be taken against contact with overhead lines and underground cables encountered on site. See also **7.2** and **7.3**.*

*BS 7671:2008, Section **704** specifies requirements for the supply of electricity on construction and demolition sites. Electrical installations of offices, cloakrooms, meeting rooms, canteens, restaurants, dormitories, toilets etc. on construction and demolition sites are covered by the general requirements of BS 7671:2008, Parts 1 to 6.*

Guidance on earthing is given in BS 7430. Guidance on the installation and use of welding equipment is given in BS 638.

4.1 Specialist advice

Because of variations in local circumstances of different construction and demolition sites, this British Standard gives general guidance only. It is important that, for each site, advice is sought from a competent electrical engineer regarding the details of the electrical installation most suitable for that site.

4.2 Early notification of requirements

It is essential that where a supply connection is to be obtained from an electricity distributor, the local office of the distributor is informed as soon as a future construction or demolition activity is considered, and certainly not later than the planning application stage. Discussions should also take place as soon as possible between the main contractor and those who are to carry out the installation.

The electricity distributor should be informed of the following:

a) precisely when and where the supply will be required;

b) the maximum demand load in kVA or amperes (and the nature of the load) which will be required for building construction; and

c) the installed load, which is expected when the site is ultimately developed.

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It is essential to identify and take the necessary precautions to avoid damage to, or accidental contact with, existing overhead lines, underground cables and other services.

The following should be discussed in the preliminary negotiations with the electricity distributor:

1) whether the electrical supply intended for the building or other construction could be made available for site supply purposes in its final position, and if not, what would be involved in providing an alternative supply;
2) the necessary supply voltage based on the maximum expected demand;

   NOTE This can take the voltage outside the scope of this British Standard.
3) the metering arrangements;
4) the anticipated connection date;
5) supply system details;
6) whether an earth connection will be provided by the electricity distributor;
7) the location of the main distribution point;
8) precautions to be taken with regard to existing or proposed overhead lines (see **7.2**), underground cables (see **7.3**) and other services;
9) details of on-site electrical generation (see **6.3**).

5 Materials, appliances and components

Site distribution units for electricity supplies should conform to BS 4363 and/or BS EN 60439-4. These units are described briefly in Annex A.

All materials, appliances and components should conform to the appropriate British Standard.

NOTE Examples of relevant standards are given in Annex B. This list is not exhaustive, as there might be other suitable materials that are not mentioned.

6 Design considerations

6.1 Planning

The provision of an electrical supply to a site needs advance planning. It is essential that the requirements for a site are considered and plenty of warning given to the electricity distributor, for logistic and safety reasons. The electricity distributor needs secure accommodation for metering and other equipment, and, if possible, this should be on the periphery of the site where it is unlikely to be damaged.

Information should be obtained from the electricity distributor concerning earthing requirements (see **6.5.4**) and the fault level (prospective short-circuit current and prospective earth fault current) at the point of supply (see **6.5.1**).

NOTE Where the electricity distributor has a protective multiple earth (PME) system (in which the neutral and earth are combined), the Electricity Safety, Quality and Continuity Regulations 2002 [3] require that all metalwork, including structural metalwork, be bonded together. As this is difficult to achieve on a site where steelwork is being added in the course of the work, most electricity distributors do not connect the site electrical system unless there is an adequate alternative earth. On most sites, therefore, it is necessary to install earth electrodes to ensure that fuses etc. will operate in the event of a fault.

BS 7430 contains guidance on earthing. However, additional specialist advice on the subject of earthing might be necessary to ensure that there is adequate electrical protection in the event of a fault in the electrical system.

In many cases, highly sensitive earth leakage protection might be necessary. Where residual current devices (RCDs) are used for this purpose, devices conforming to BS EN 61008-1, BS EN 61009, or BS EN 60947-2:2006, Annex B or Annex M should be used.

It is important to locate services at the planning stage of a demolition project. All electricity supplies should be cut off before demolition commences, and should be proved dead by a competent person. Demolition plans should be discussed with the owners of both overhead and underground cables in case they are intending to reuse these cables in subsequent redevelopment.

Where the demolition process itself requires the supply of electricity, this should preferably be independent of any electrical apparatus in the demolition area.

6.2 Selection of equipment

Electrical equipment, which includes cabling and wiring, in site installations can be subjected to extreme abuse, and the use of equipment which can withstand particularly adverse conditions is essential. The importance of correct circuit protection, earthing arrangements and frequent inspection and testing cannot be overemphasized.

Fixed installations on site are limited to the assembly of the main switchgear and protective devices.

The metering equipment and switchgear at the supply point should be protected against damage and against adverse environmental conditions. All switchgear should be installed in a position where it is easily accessible (in case of emergency) and not likely to be obstructed as construction progresses.

The site distribution should be via a means of isolation for all circuit conductors which can be locked in the "off" position (but not in the "on" position). Electrical equipment should be provided with a means for disconnection in an emergency.

NOTE 1 This may be a plug and socket conforming to BS EN 60309-2 if the rated current does not exceed 16 A.

Distribution equipment in site installations should embody the following features:

a) flexibility in application for repeated use on contract work, i.e. to allow easy substitution of components for specific duty as might be required from site to site;

NOTE 2 Examples of typical arrangements are given in Annex A.

b) suitability for transport and storage;

c) robustness in construction to resist damage;

d) safety in use;

e) suitability for the environmental conditions;

f) maintainability.

The installation of distribution equipment on site should be such as to allow convenient access and to permit authorized competent operatives to work on the apparatus contained within.

In the particular case of an installation likely to be exposed to flammable surroundings or an explosive atmosphere at any stage of its use, precautions should be taken in accordance with BS EN 60079-14.

6.3 Supply systems

The electricity supply arrangements on a site can vary according to the location. The usual methods of supply are:

a) a supply either by underground cable or overhead line from an electricity distributor; or

b) a supply taken from an adjacent premises (see recommendations for earthing in **6.5.4.1**); or

c) stand-alone generation (usually fixed units with outputs in excess of 100 kVA) for the whole site or for a specific purpose such as welding supplies; or

d) small portable or mobile generating sets for defined tasks such as operating electrically powered tools, or supplying lighting systems; or

e) any combination of items a), b), c) and d).

One site may be served by several sources of supply, including fixed or mobile power generators. In such circumstances, it should be ensured that equipment contains only components connected to the same source of supply, except for control of signalling circuits and input from standby supplies.

NOTE Where it is intended to operate generation in parallel with the public supply, the Electricity Safety, Quality and Continuity Regulations 2002 [3] require that prior agreement with the electricity distributor is obtained.

It is important that where there is an interface between any generation on site and a supply from an electricity distributor, a formal agreement about the earthing arrangements is made. This agreement should be made before any generator is installed on site. It is essential that the earthing arrangements for the installation and the type of generator used conform to this agreement.

6.4 Distribution voltages

6.4.1 General

Typical distribution voltages at mains frequency (50 Hz) employed on construction and demolition sites, together with typical applications, are detailed in Table 1.

Table 1 **Distribution voltages for typical applications**

Application	Voltage	System
	V	
Fixed plant	400	Three-phase
Movable plant fed via a trailing cable over 3.75 kW	400	Three-phase
Installations in site buildings	230	Single-phase
Fixed floodlighting	230	Single-phase
Portable and hand-held tools	110	Reduced low voltage
Site lighting (other than fixed flood lighting)	110	Reduced low voltage
Portable hand-lamps (general use)	110	Reduced low voltage
Portable hand-lamps (confined and damp situations)	50 or 25	SELV

6.4.2 Mains voltages

6.4.2.1 Three-phase

400 V four-wire is the standard three-phase mains supply system voltage for construction and demolition sites.

6.4.2.2 Single-phase

230 V is the standard single-phase mains supply system voltage for construction and demolition sites.

6.4.3 Reduced low voltage

6.4.3.1 General

Reduced low voltage (RLV) should be supplied from a transformer conforming to BS EN 61558-2-23 or from a source providing an equivalent degree of electrical separation.

6.4.3.2 RLV three-phase

The supply should be obtained from a double-wound transformer having the neutral point of its star-connected secondary winding earthed so that the nominal voltage to earth of the secondary circuit conductors is only 110/$\sqrt{3}$ V, i.e. approximately 63.5 V.

6.4.3.3 RLV single-phase

The supply should be obtained from a double-wound transformer having the centre tap of the secondary winding earthed so that the nominal voltage to earth of the secondary circuit conductors is only 55 V.

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6.4.3.4 SELV or PELV 25 V or 50 V single-phase

It is essential that a supply for a separated extra-low voltage (SELV) or protective extra-low voltage (PELV) system is derived from a safety isolating transformer conforming to BS EN 61558-2-6 or from one of the other types of source listed in BS 7671:2008, Regulation **414.3**.

As detailed in BS 7671:2008, Regulation Group **414.4**, it is essential that:

a) SELV and PELV circuits have basic insulation between live parts and other SELV or PELV circuits, and protective separation from live parts of circuits not being SELV or PELV; and

b) SELV circuits have basic insulation between live parts and earth.

BS 7671:2008, Regulation **414.4.1**, permits PELV circuits and/or exposed-conductive-parts of equipment supplied by PELV circuits to be earthed.

Irrespective of the nominal voltage of a SELV or PELV system, BS 7671:2008, Section **704** requires basic protection against electric shock to be provided by insulation or by barriers or enclosures.

Plugs and socket-outlets in a SELV system are not permitted to have a protective conductor contact.

6.5 Electrical protection of circuits

6.5.1 General

Appropriate electrical protection should be provided for all circuits, including final circuits, against overload, short-circuit and earth fault current. The protective devices should be capable of interrupting without damage any overcurrent that might occur.

NOTE Guidance on the application of short-circuit ratings is given in PD IEC/TR 61912-1.

6.5.2 Selectivity (discrimination)

The characteristics of fuses and circuit-breakers used for the protection of circuits should be coordinated so as to afford selectivity (discrimination) in operation to avoid danger resulting from disconnection of other circuits.

NOTE Guidance on selectivity under overcurrent conditions is given in PD IEC/TR 61912-2.

6.5.3 Lightning protection

In special circumstances, protection against lightning on construction and demolition sites might be necessary. If lightning protection is required, it should conform to the BS EN 62305 series.

6.5.4 Earthing

*NOTE General requirements for earthing of the electrical system are specified in BS 7671:2008, Section **542**. There is also a code of practice for earthing, BS 7430.*

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6.5.4.1 General

Protection against electric shock under fault conditions through earthing may be attained in two different ways, as follows.

a) Protection may be attained by providing an earth fault loop path of low enough impedance to enable the overcurrent protective device protecting the faulty circuit or equipment to operate within the maximum disconnection time specified in BS 7671. In the case of mains supply, the means of earthing to achieve this is generally provided by an electricity distributor, and the type of earthing arrangement is generally a TN system.

b) Alternatively, protection may be attained by use of a TT system in which the consumer is required to provide a suitable installation earth electrode arrangement and an appropriate means of automatic disconnection of the supply to the faulty circuit or equipment, generally a residual current device (RCD).

   Where practicable, an insulating enclosure should be used in order to avoid the risk of earth faults between incoming cables and metalwork on the supply side of the principal protective device(s).

   A metallic enclosure may be used if suitable precautions such as insulating glands, gland plates, etc. are employed to similarly reduce the possibility of earth faults. These precautions should provide the equivalence of Class II insulation between the incoming supply conductors and equipment metalwork.

Irrespective of whether a) or b) applies, BS 7671:2008, Regulation **704.411.3.2** requires protection by an RCD having a rated residual operating current not exceeding 500 mA for any circuit supplying one or more socket-outlets with a rated current of 32 A or more.

A TN-C-S system (incorporating PME) cannot normally be used as it is not practicable to ensure that all extraneous-conductive-parts, either existing or added during construction, are adequately bonded at all times.

Particular care should be taken in the case of construction sites that involve extensions to existing buildings, to ensure that extraneous- or exposed-conductive-parts in the existing building that are connected to a TN-C-S system do not come into contact with extraneous-conductive-parts or exposed-conductive-parts within the construction site. Particular care should also be taken to ensure that the ground resistance areas of any electrodes within each system do not overlap.

See also the Note to **6.1**.

6.5.4.2 Low voltage single-phase generators

The generator winding is usually isolated from the frame and brought out to a three-pin socket, which should conform to BS EN 60309-2. The protective (earth) conductor contact tubes are connected internally to the generator frame. A voltage selector switch is often fitted to enable outputs to be obtained at about 240 V and 120 V.

*NOTE Such generators do not provide a reduced low voltage supply (RLV) as defined in **6.4.3**.*

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Where practicable, generators should be of the 110 V type with winding centre tapped so that it can be connected to earth to form a reduced low voltage system (RLV).

Single-phase generators up to about 10 kVA can be run satisfactorily as a floating system, i.e. without the winding connected to the frame or to earth. However, this unearthed system should be used only where the need is short term (for less than one day). The generator should supply only one item of equipment, which should be of Class II construction as defined in BS EN 61140:2002+A1:2006. The cable should be kept short and should be flexible with an extruded oversheath capable of high abrasion resistance.

The cable, plugs and sockets should be inspected frequently, and if defective, they should be replaced, not repaired. Equipment and cables which are in good condition are vital for the continuous safety of an unearthed system and form the first line of protection against the risk of electric shock.

Hand-held 110 V or 230 V portable electrical equipment used with systems supplied by an independent single-phase generator should be of Class II construction as defined in BS EN 61140:2002+A1:2006.

Contact with a conductor exposed through damage or misuse introduces a risk of electric shock. The system should be inspected frequently and care should be taken to use cable routes which minimize the risk of damage.

If there is more than one item of equipment supplied from the generator and a satisfactory earth cannot be obtained, the system should be regarded as an IT system and insulation monitoring is necessary (see BS 7430).

Larger generators, and those permanently installed for the duration of the construction works, should either give a 110 V centre-tapped reduced low voltage output or feed into an isolating transformer conforming to BS EN 61558-2-23, for that purpose.

See also **6.3** regarding any interface between any generators on site and an electricity distributor's system.

6.5.4.3 Reduced low voltage supplies (see 6.4.3)

For reduced low voltage circuits, the operation of the protective devices is dependent on the satisfactory installation of a metallic return path back to the reduced low voltage transformer. This should take the form of a separate circuit protective conductor or the metallic protection of the cable.

Fault protection (against electric shock) in accordance with BS 7671 should be provided by the characteristics of the system.

NOTE Regulations 5 and 11 of the Electricity at Work Regulations 1989 [1] require that an overcurrent protective device is provided to ensure that fault currents are disconnected automatically within a time that limits the thermal and mechanical stress on the system.

It is essential that this protection is provided in all line conductors, arranged to disconnect all line conductors simultaneously.

6.5.5 Protective conductor proving and earth monitoring systems

6.5.5.1 General

The use of flexible cables to supply power at mains voltages to movable plant introduces safety problems in ensuring the continuing efficiency of the earth return path. If the circuit protective conductor incorporated in the cable becomes damaged or discontinuous, it will no longer provide a sound metallic return path for the fault current in the event of an earth fault occurring.

Earth monitoring and/or protective conductor proving may be employed to alleviate this situation.

6.5.5.2 Protective conductor proving

NOTE 1 Information on protective conductor proving is given in BS 4444.

A protective conductor proving system provides a means of establishing a degree of confidence in the continuity of the protective conductor from the proving unit to remote protected apparatus. No provision is made for impedance measuring, but designs centred around the use of specialized relays afford a coarse method of proving.

The proving unit may be connected anywhere between the origin of the installation and the apparatus to be protected.

Detection of short-circuits between pilot and protective conductors may be achieved by the use of d.c. sensitive relays as a part of the proving system.

Continuity may be proved with a shunt connected voltage sensing device or a series connected current sensing device. In either case the protective conductor should be a substantial earth path of low impedance. The impedance of the source and detector combination Z_1 (see Figure 2) should appear in series with the pilot earth path. The total impedance of the monitored loop is the algebraic sum of the impedance Z_1 and the impedance of the rest of the loop Z_2. A value of Z_2 in excess of about 10 Ω should prevent the load apparatus being energized. Furthermore, after the apparatus has been energized, if the monitored loop becomes open-circuited or increases in impedance beyond about 20 Ω, the apparatus should become isolated.

NOTE 2 The impedance values quoted are only examples and the actual values need to be considered in the light of specific applications.

The proving current circulates in a loop circuit which contains the protective conductor to the apparatus, a section of the apparatus casing and a suitable return path. It is essential that any plug and socket and flexible cable therefore provides not only the main protective path but also a return path which is usually known as a pilot conductor.

It is essential that the proving unit itself be earthed in accordance with BS 7430. The fact that the earth loop contains a section of the apparatus casing necessitates the provision of two independent earth terminals on the casing, otherwise there would be a risk of both conductors becoming detached from the casing whilst still maintaining the monitored loop.

NOTE 3 Although the main and pilot paths are monitored in series, they function in parallel as far as actual earth fault currents are concerned.

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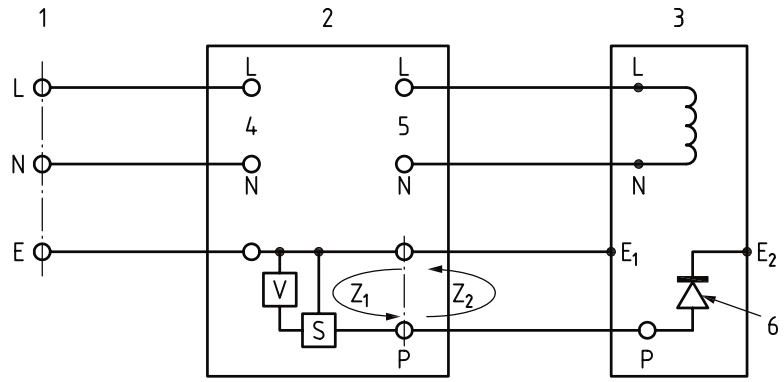
Figure 2 **Typical protective conductor proving circuit with test facility shown open**



Key

1 Origin
2 Proving unit
3 Apparatus
4 Supply terminals
5 Load terminals
6 Diode (optional)
E_1 Protective earth terminal
E_2 Earth terminal for pilot circuit (this may be internal or external)
P Pilot conductor terminal
S Sensing device
V Extra-low voltage source
Z_1 Impedance of source
Z_2 Impedance of the loops

NOTE If a diode is not used then a link has to be provided for a direct connection between terminals P and E_2.

6.5.5.3 Earth monitoring systems

NOTE 1 Information on earth monitoring is given in BS 4444.

An earth monitoring system provides a means of maintaining a high degree of confidence in the impedance level of the protective conductor from the monitoring unit to the remote protected apparatus. The monitoring unit may be connected between the source of energy (if accessible) and the apparatus to be protected.

NOTE 2 The source of energy may be, for example, a generator or a transformer.

Earth monitoring depends upon continuous circulation of a small current at a voltage not exceeding 12 V derived from a SELV source. An interruption of this current is arranged to bring about disconnection of the protected apparatus from the supply.

The monitoring current circulates in a loop circuit which contains the protective conductor to the apparatus, a section of the equipment casing and a suitable return path.

It is therefore essential that any plug and socket and flexible cable provides not only the main protective path but also a return path which is usually known as the pilot conductor.

NOTE 3 Although the main and pilot paths are monitored in series, they function in parallel as far as actual earth fault currents are concerned.

It is essential that the monitoring unit be earthed in accordance with BS 7430. The fact that the earth loop contains a section of the apparatus casing necessitates the provision of two independent earth terminals on the casing, otherwise there would be a risk of both conductors becoming detached from the casing whilst still maintaining the monitored loop.

The impedance of the protective and pilot conductors forms part of a balanced bridge network. The balance is disturbed by variations in the parameters of the loop (e.g. open-circuit or short-circuit) and this can initiate a signal or disconnection.

Typical impedance sensitivity of the balanced bridge network (in the temperature range -10 °C to +4 °C) is 8 $\Omega \pm 2\ \Omega$.

6.6 Plugs, socket-outlets and couplers

It is essential that plugs and sockets conforming to BS EN 60309-2 are used.

The colour identification of plugs, socket-outlets and couplers by voltage should conform to Table 2. It is essential that these colours are only used for the voltages listed.

NOTE Normally these items are manufactured from self-coloured plastics.

It is essential that plugs, sockets and cable couplers rated in excess of 32 A are interlocked so as to prevent on-load separation.

Table 2 **Colour coding of plugs, socket-outlets and couplers**

Operating voltage V	**Colour**
25	Violet
50	White
110 to 130	Yellow
220 to 240	Blue
380 to 415	Red
500 to 650	Black

6.7 Cabling

6.7.1 General

It is essential that all cables are suitable for their intended use. In particular, all cables which are likely to be frequently disturbed in normal use should be flexible cables. Cables should be chosen to meet the expected site conditions, including the lowest environmental temperature.

Wiring should be so arranged that no strain is placed on the terminations of conductors unless they are specifically designed for this purpose.

The protective conductor in a cable should have a cross-sectional area not less than that of the largest circuit conductor.

6.7.2 Fixed cables and wiring

All cables which have applied to them a voltage to earth exceeding 63.5 V (except for supplies from welding transformers to welding electrodes) should be of a type that incorporates an earthed armour or metal sheath or both, suitable for use as a protective conductor, which should be continuous and effectively earthed. In the case of flexible or trailing cables, such earthed armour and/or metal sheath should be in addition to the earth core in the cable and should not be used as the protective conductor.

Non-flexible armoured cables should conform to BS 5467 or BS 6724.

Cables which have applied to them a voltage to earth exceeding 12 V but not exceeding 63.5 V should be either:

a) one of the types described in the preceding paragraph; or

b) an elastomer insulated and elastomer sheathed cable conforming to BS 7919.

6.7.3 Flexible cables

Flexible armoured cables should conform to BS 6708.

Flexible cables should be suitable for correct anchoring and termination in the accessories or other equipment. Flexible cables with a conductor cross-sectional area smaller than 1.5 mm^2 should not be used.

The current rating of flexible cables should be not less than that of the associated protective device.

If elastomer insulated and elastomer sheathed cables are chosen for use on a reduced low voltage system, they should conform to BS 7919. If low temperature thermoplastic insulated and sheathed cable is chosen, it should conform to BS 7919:2001, Table 44.

6.7.4 Cables laid on site

All cables should be installed with adequate mechanical protection, clear of proposed works.

All the locations and routes of underground cables should be clearly marked on the ground and recorded on a map or site plan.

7 Work on site

*NOTE Attention is drawn to the statutory regulations listed in the Commentary on Clause **4**.*

7.1 General

7.1.1 Protection against damage

Where new construction work is concerned, all main control apparatus should have a clear approach and protection against building material hazards. Furthermore, reasonable precautions should be taken to minimize the risk of damage to equipment.

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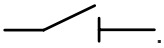
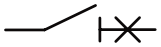
7.1.2 Means of isolation

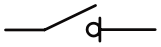
Devices intended to be used as a means of isolation should be of the multi-pole type, constructed such as to break all circuit conductors (including the neutral conductor) simultaneously.

NOTE This recommendation has been included because this equipment may be used or reused on sites with TT supplies.

Switches and circuit-breakers used for isolation should conform to the British Standard applicable to the particular device and be marked with the appropriate isolation symbol.

The generic isolation symbol is  . In some cases this is supplemented by additional elements for particular devices, e.g.

 for a circuit-breaker suitable for isolation;

 for a switch-disconnector.

Any means of isolation other than a plug and socket-outlet or cable coupler should be provided with a facility for securing the operating lever, toggle, etc. of that device so that it can be secured in the "off" position while the load circuit is being worked on. It is essential that the means of securing can be removed only by use of a special tool or key.

7.1.3 Lampholders

Types of lampholders should be selected to ensure so far as is practicable that 110 V and 230 V lamps cannot be inadvertently interchanged.

If Edison screw lampholders are selected for use on RLV systems (see **6.4.3**), they should be fitted with shrouds or skirts or be so placed and safeguarded that neither the lamp cap nor the screw part of the holder can be inadvertently touched when the cap is engaged with the lampholder screw.

Lampholders fitted with pin contacts intended to be pressed into general purpose or heat-resisting elastomer should not be used unless they form part of a festoon lighting system in which the lampholder is shrouded in insulating material and permanently moulded or bonded during manufacture to the cable sheath.

Lampholders not fitted with a lamp should be capped off.

7.1.4 Socket-outlets

It is essential to provide at the commencement of, and throughout, construction operations, facilities for the ready connection of local artificial lighting and electrically operated hand tools for use by operatives not skilled in electrical matters. For this purpose, a well-designed socket-outlet distribution system should be installed of a type which is interchangeable from site to site. The distribution system should be so disposed as to allow for easy redeployment and efficient working as site work progresses.

Where socket-outlets in excess of 32 A are used as a convenient form of connection at mains voltage for heavy electrical plant, e.g. rail mounted tower cranes, socket-outlets conforming to BS EN 60309-2 should be used. They should be either mechanically or electrically interlocked. This is to ensure that the supply to the socket is isolated, before the plug is withdrawn.

7.1.5 Cable routing

Cables should be routed so that they are clear of building operations or engineering constructional work and so that they are not a hazard to operatives. Where possible they should be installed clear of passageways, walkways, ladders, stairs and the like.

All cables should be installed so that they are at least 150 mm clear of piped services such as steam, gas and water. Apparatus and accessories, other than lampholders, should not be suspended from electric cables.

Cables passing under roadways and access ways for transport and mobile plant should be laid in ducts at a minimum depth of 0.6 m, taking into account finished ground levels. A cable marker should be installed at each end of each road crossing.

7.1.6 Isolation

Prior to working on any circuit or item of electrical equipment, it should be isolated from its source of supply. Any means of isolation other than a plug and socket-outlet or cable coupler should be secured in the "off" position by a means which can be removed only by use of a special tool or key.

Circuit conductors should be proved electrically dead at any point of work on the load side of the means of isolation, to ensure that there is no voltage present on the conductors.

The system should allow for an outgoing circuit to be connected or disconnected safely without making any other circuit dead; i.e. all circuits should be shrouded to a degree of protection not less than IP2X (in accordance with BS EN 60529:1992) with the load cable in position.

NOTE Further guidance on safe isolation procedures is given in the Electrical Safety Council's Best Practice Guide No. 2 [4].

7.1.7 Weatherproofing

In view of the conditions that usually prevail on site, switches should be of the weatherproof type or contained in weatherproof enclosures. Socket-outlets, plugs and cable couplers should be of the splashproof type. The minimum degree of ingress protection should be IP44 (in accordance with BS EN 60529:1992).

The use of extension outlet units as specified in BS 4363 generally renders cable couplers unnecessary. When cable couplers have to be used it is strongly recommended that they be supported above ground level.

7.1.8 Lighting

Access and security lighting on floors and staircases should be connected to separate transformer(s) near to the entrance to the site.

7.2 Overhead power lines and suspended cables

NOTE The Electricity at Work Regulations 1989 [1] contain requirements concerning precautions to be taken when working near live conductors.

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7.2.1 Overhead power lines

With regard to overhead power lines belonging to the electricity distributor or anyone else, the contractor should contact the electricity distributor or other owner if the lines are either on or near the site or on access roads, in order to agree what special precautions are necessary. It is essential that this action is taken at the early planning stage (see **6.1**) and not left until work has commenced.

The control measures described in HSE publication GS6 should be implemented when working near overhead power lines. In this context, "work" could include delivery of materials, erection or dismantling of scaffolding etc.

7.2.2 Suspended cables

The use of cables that are suspended above ground on sites is deprecated, but where their use is unavoidable then cables crossing roads or routes where cranes or other mobile plant are likely to pass should be erected so that there is a minimum clear height of 5.8 m. In areas where motor transport and mobile plant are prohibited, cabling should provide for a minimum ground clearance of at least 5.2 m.

Suspended cables should be bound with tapes, coloured yellow and black, conforming to BS 5499-1:2002, Clause **14** and to BS 5378-2. Alternatively, freely moving strips of fabric or plastics may be attached to draw attention to them. In some circumstances, protective barriers might be necessary.

7.3 Underground power cables

NOTE The Electricity at Work Regulations 1989 [1] contain requirements concerning precautions to be taken against contact with underground cables.

Before site works begin, enquiries should be made to determine whether there are underground electric cables on or adjacent to the site. Such enquiries should be addressed to the site owner, the developer, the local authority, the local electricity distributor and, in London, to Transport for London. Other enquiries should also be made as common sense suggests (e.g. the local railway network operator if the site is near an electrified railway line). The location of cables should then be confirmed and the routes marked as recommended in HSE Guidance Note HSG47. The precautions outlined in that document should be followed in order to avoid danger.

The same precautions should be taken for cables that are part of the site distribution or permanent installations laid during the course of work.

7.4 Safe working practices

In addition to the routine safety problems that are common to electrical installations and apparatus everywhere, construction and demolition sites present a particular risk in respect of the changes which are continually occurring. Some risks of this type can be minimized at the design and specification stage (e.g. by the use of isolating switches which can be locked in the "off" position).

*NOTE For guidance relating to demolition projects, see also **6.1**.*

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On temporary installations, secure isolation can be achieved by unplugging the equipment from the supply and placing the plug in a place where the person working on the equipment has it under immediate control. All permanent circuits and those temporary connections which cannot be readily traced should be labelled and the labels changed as and when any alterations are made to the system. To aid labelling, particularly where identical items of plant are involved, it might be necessary to identify individual items of plant by number or other unique identification.

Many near-fatal electrical accidents can be avoided by prompt action. It is recommended that all personnel be instructed to pull out the plug if they see someone who is obviously receiving an electric shock from portable apparatus or leads. Notices should be posted which give advice for treatment in the event of electric shock, and electrical personnel should be given practical training in these techniques. Provision should be made for calling the emergency services.

Precautions should be taken to ensure that anyone who comes onto the site to service electrical equipment is accompanied, to ensure that they do not have an accident or cause one as a result of their activities.

Sites with large or complex electrical systems need special precautions. Formal safety procedures should be established for the control, operation and maintenance of these systems. This could include method statements and/or permit-to-work systems.

8 Work off site

Space should be provided in the contractor's plant yard for the storage of electrical equipment and for an electrical construction workshop with competent staff to deal with equipment for site installations and the overhaul, alteration and repair of such equipment when returned to store.

Before work on site commences, it is recommended that, in close cooperation with the main contractor's site agent, a date sequence chart is prepared indicating the movement on and off site of the major current consuming plant. This information, coupled with drawings of the site offices and plant and general site lighting outlets, should enable the following points to be decided:

a) the rating and type of protective controlgear;

b) the possible locations for main distribution equipment;

c) the layout of main distribution cables;

d) the estimated maximum demand.

9 Inspection and testing

The electrical installation on the site should be inspected and tested in accordance with BS 7671 prior to its initial use, and at suitable intervals thereafter. All electrical equipment on site should be inspected and, as necessary, tested. Records of these inspections and tests should be retained on site.

*NOTE 1 All these installations and equipment are covered by the Electricity at Work Regulations 1989 [1] (see the Commentary on Clause **4**).*

Site work is, of necessity, in a constant state of change and because of this the associated electrical installation is subject to risk of damage or misuse.

Strict maintenance and frequent checking of control apparatus and the wiring distribution system by a competent person is essential to promote safety and efficient operation.

The fixed electrical installation should be inspected every three months or, depending on site conditions, more frequently, and tests carried out to determine its continued integrity. The tests should determine the integrity of the protective conductors and insulation, and remedial action should be taken if necessary. Records should be kept of these tests in such a way that any deterioration can be identified.

Movable installations should be inspected and tested more frequently than fixed installations. The frequency of such inspection and testing depends on how well the equipment was designed, specified and installed in relation to the use or abuse which it actually receives. A weekly inspection by a competent person is recommended as a starting point. Electrical tests should be carried out to determine the integrity of the protective conductors and insulation, and remedial action should be taken if necessary. These periods might need increasing or decreasing depending on what is found at each inspection and test. Maintenance periods should be reviewed as construction work progresses and the nature of the activities change on the site.

NOTE 2 See HSE Guidance Note HSG107 [5].

NOTE 3 Guidance on suggested inspection and test intervals is also provided in the IEE Code of practice for the in-service testing and inspection of electrical equipment *[6].*

The inspection activity should include the security of fixing flexible cables to plugs, couplers, other accessories and mobile equipment. The condition of the sheaths of flexible cables should be checked together with fixing of cover plates and shrouds, the interlocking doors and other protective devices. This list is not exhaustive but gives an indication of the types of item which should be checked.

NOTE 4 Regulation 4(2) of the Electricity at Work Regulations 1989 [1] requires that maintenance is carried out so that danger is prevented, so far as is reasonably practicable.

RCDs should be operated frequently, e.g. at the beginning of each shift, using an integral test button, and should be tested at the three-monthly periodic inspection, by means that are independent of any integral test device, to determine whether they operate within their characteristics.

All electrical equipment on a construction or building site should be permanently and uniquely identified and a record kept of the date of issue, date of the last inspection carried out and the recommended inspection period. This record should be kept on site and reviewed by a competent person.

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Annex A (informative)

A typical distribution system using distribution units

Figure A.1 shows a typical site arrangement utilizing the distribution units specified in BS EN 60439-4 and BS 4363, and Figure A.2 shows in greater detail how these units can be used to provide supplies in a multi-storey building under construction.

Brief descriptions of six types of distribution unit are as follows.

a) *Incoming supply assembly (ISA)*. This comprises an assembly of equipment for the control and distribution of electricity on a site arranged to accommodate the electricity distributor's equipment and to provide facilities for connecting one outgoing circuit.

b) *Incoming supply and distribution assembly (ISDA)*. This comprises an assembly of equipment for the control and distribution of electricity on a site arranged to accommodate the electricity distributor's equipment and to provide facilities for connecting circuits at system voltages up to 400 V three-phase and 230 V single–phase a.c.

c) *Main distribution assembly (MDA)*. This comprises an assembly of equipment for the control and distribution of electricity on a site at system voltages up to 400 V three-phase and 230 V single-phase a.c.

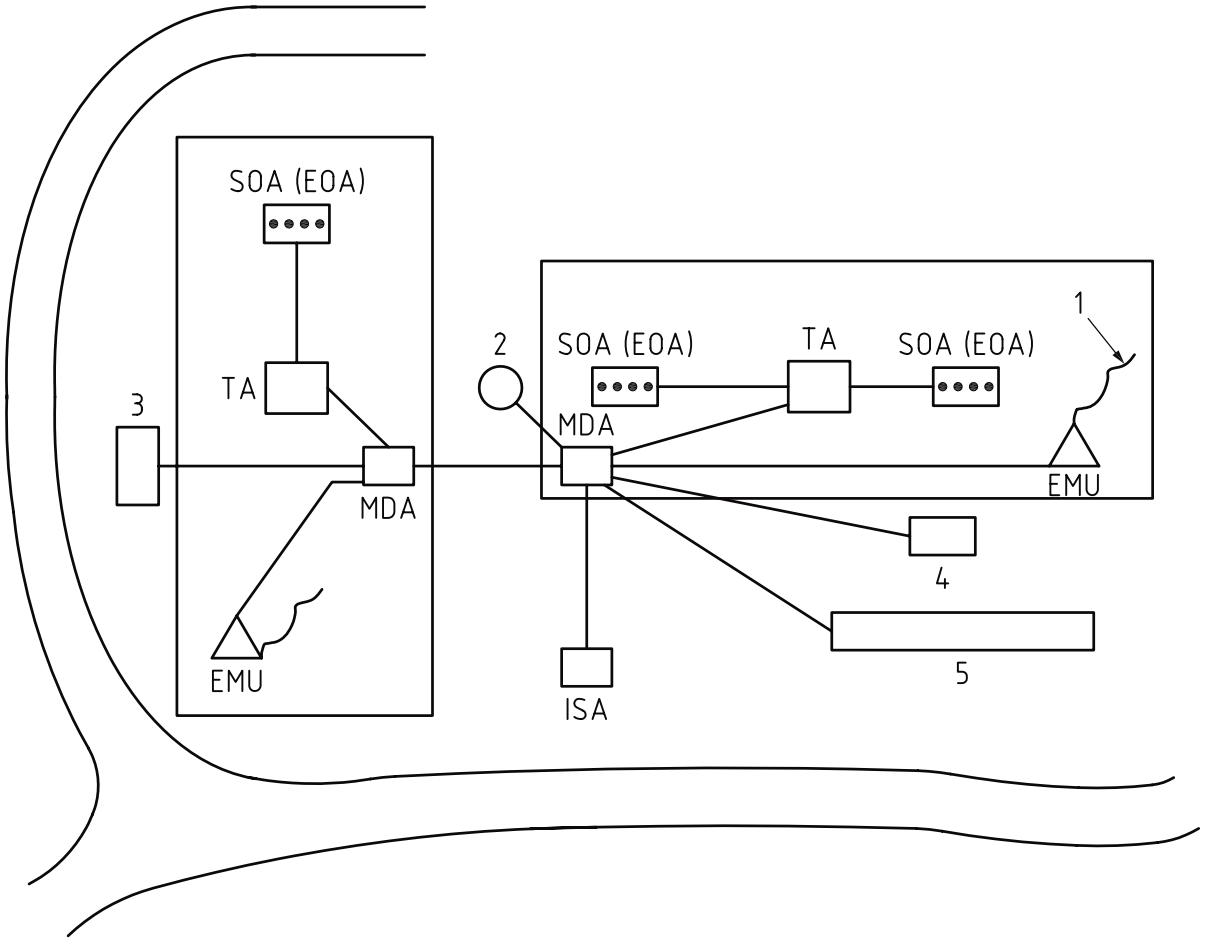
d) *Transformer assembly (TA)(TA/1 single-phase, TA/3 three-phase, TA/1/3 single- and three-phase)*. This comprises an assembly of equipment incorporating a transformer and arranged to distribute electricity at reduced low voltage.

e) *Socket-outlet assembly (SOA)(SOA/1 single-phase, SOA/3 three-phase)*. This comprises an assembly of equipment providing facilities for the control, protection and connection of final circuits at reduced low voltage, this assembly being fed from a 32 A supply.

f) *Extension outlet assembly (EOA)(EOA/1 single-phase, EOA/3 three-phase)*. This comprises an assembly of equipment providing facilities for the connection of final circuits at reduced low voltage, this assembly being fed from a 16 A supply.

NOTE In Figures A.1 and A.2, no differentiation is made between single-phase and three-phase units, and therefore the numerical part of the abbreviations is omitted.

Figure A.1 **Example of a site plan with distribution units conforming to BS EN 60439-4 and BS 4363**



Key

1 Transportable plant at mains voltage connected by flexible cable to an earth monitoring unit (EMU) with circulating current for earth monitoring through earth conductor and pilot core

2 Mixer

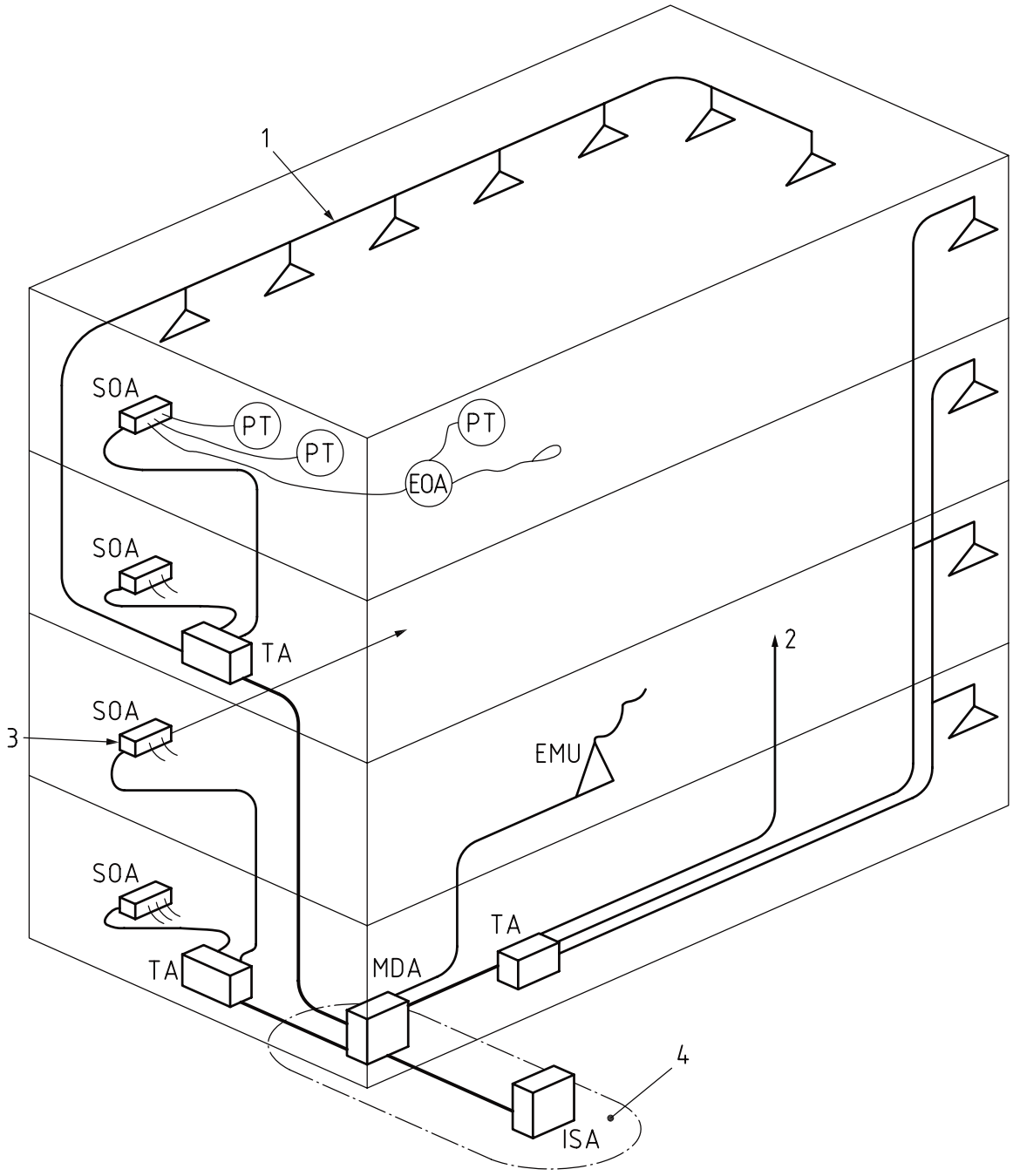
3 Hoist

4 Crane

5 Staff accommodation

NOTE ISA and ISDA may also be provided as one assembly (ISDA) to suit site conditions.

Figure A.2 **Example of arrangement of units to provide an electrical supply to a multi-storey building under construction**



Key

1 General floor lighting connected direct to transformer assembly TA

2 Access and security lighting

3 1.5 to 3.0 kVA heavy portable to suit site conditions; tools, if required, can be connected through a 32 amp optional socket-outlet assembly (SOA)

4 ISA and MDA may also be provided as one assembly (ISDA)

Lighting

PT Portable tool

Earth monitoring unit

NOTE ISA and ISDA may also be provided as one assembly (ISDA) to suit site conditions.

Annex B (informative) Relevant British Standards for materials, equipment and components

The following are examples of relevant standards for materials, equipment and components:

- air-break switches, air-break disconnectors and fuse combination units for voltages up to and including 1 000 V a.c. and 1 500 V d.c.: BS EN 60947-3;
- cables, flexible, for quarries and mines: BS 6708;
- armoured cables for electricity supply: BS 5467 (PVC-sheathed), BS 6724 (LSHF-sheathed);
- circuit-breakers: BS EN 60898, BS EN 60947-2, BS EN 61009;
- contactors: BS EN 60947-4-1;
- contactors, automatic changeover, for emergency lighting: BS 764;
- cranes, overhead travelling: BS 466;
- distribution assemblies for reduced low voltage electricity supplies for construction and building sites: BS 4363;
- earthing clamps: BS 951;
- electrical apparatus for potentially explosive atmospheres: BS EN 60079;
- eyebolts, for lifting purposes: BS 4278;
- flexible cables intended for industrial and similar environments: BS 7919;
- fuses, cartridge, for voltages up to and including 1 000 V a.c. and 1500 V d.c.: BS 88, BS EN 60269;
- lampholders, bayonet-type: BS EN 61184;
- lampholders, Edison screw: BS EN 60238;
- low voltage switchgear and controlgear assemblies for construction sites: BS EN 60439-4;
- motor starters and controllers: BS EN 60470, BS 60947-4-1;
- motors and generators, small-power electric: BS 5000-11;
- motor-operated tools, hand-held electric: BS EN 50144-2-7, BS EN 50144-2-16, BS EN 60745;
- plugs, socket-outlets and couplers, industrial, for a.c. and d.c. supplies: BS EN 60309-2;
- transformers, power: BS EN 60076;
- transformers, safety isolating: BS EN 61558-2-23, BS EN 61558-2-6.

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For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS 466, *Specification for power driven overhead travelling cranes, semi- goliath and goliath cranes for general use*

BS 638 (all parts), *Arc welding power sources, equipment and accessories*

BS 764, *Specification for automatic change-over contactors for emergency lighting systems*

BS 951, *Electrical earthing – Clamps for earthing and bonding – Specification*

BS 4278, *Specification for eyebolts for lifting purposes*

BS 4444, *Guide to electrical earth monitoring and protective conductor proving*

BS 5000-11, *Specification for rotating electrical machines of particular types or for particular applications – Part 11: Small-power electric motors and generators*

BS EN 50144-2-7, *Safety of hand-held electric motor operated tools – Part 2-7: Particular requirements for spray guns*

BS EN 50144-2-16, *Safety of hand-held electric motor operated tools – Part 2-16: Particular requirements for tackers*

BS EN 60076 (all parts), *Power transformers*

BS EN 60079 (all parts), *Explosive gas atmospheres*

BS EN 60238, *Edison screw lampholders*

BS EN 60269 (all parts), *Low-voltage fuses*

BS EN 60470, *High-voltage alternating current contactors and contactor-based motor starters*

BS EN 60745 (all parts), *Hand-held motor-operated electric tools – Safety*

BS EN 60898 (all parts), *Electrical accessories – Circuit-breakers for overcurrent protection for household and similar installations*

BS EN 60947-3, *Low voltage switchgear and controlgear – Part 3: Switches, disconnectors, switch-disconnectors and fuse-combination units*

BS EN 60947-4-1, *Low-voltage switchgear and controlgear – Part 4-1: Contactors and motor-starters – Electromechanical contactors and motor-starters*

BS EN 61184, *Bayonet lampholders*

PD IEC/TR 61912-1, *Low-voltage switchgear and controlgear – Overcurrent protective devices – Part 1: Application of short-circuit ratings*

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