Scottish Health Technical Memorandum 2007

(Part 4 of 4)

Operational management

Electrical services: supply and distribution

The production of this document was jointly funded by the Scottish Executive Health Department and the NHSScotland Property and Environment Forum.

NHSScotland, P&EFEx, June 2001

Contents

1. Scope

1.1 The provision of electrical services in HCPs is a management responsibility at both new and existing sites. This guidance is equally applicable to premises which offer acute healthcare services under the Registered Establishments (Scotland) Act 1998.

1.2 This guidance also provides an insight into the requirements of the Electricity at Work Regulations 1989 (EAW).

1.3 Healthcare and social services premises are totally dependent upon electrical power supplies, not only to maintain a safe and comfortable environment for patients and staff, but also to give greater scope for treatment using sophisticated medical equipment at all levels of clinical and surgical care. Changes in application, design and statutory requirements have led to the introduction of a new generation of equipment and new standards of reliability, hence, a large expansion of material is included in this SHTM.

1.4 Interruptions in electrical power supplies to equipment can seriously disrupt the delivery of healthcare, with serious consequences for patient well-being. Healthcare and social services premises must therefore ensure that their electrical installation provides maximum reliability and integrity of supplies. Every effort must be made to reduce the probability of equipment failure due to loss of power from the Public electricity supply company and from internal emergency power sources.

2. Operations and maintenance policy

General

2.1 Where the operation of some electrical equipment is vital to the continued functioning of the HCP services, maintenance will require special consideration. In such cases, full duplication of plant should be considered.

2.2 Adequate plant isolation and safe staff working areas must be provided for all operations and maintenance contingencies.

2.3 A maintenance policy that pursues and expects the good upkeep of equipment by regular inspection and overhaul is a sign of good housekeeping. An appreciation of safety by operational staff should be encouraged.

2.4 Maintenance and safety are two closely related subjects. General safety is largely dependent upon good standards of maintenance being attained and staff safety disiplines being mutually exercised.

2.5 The merit order of an electrical item for duplication in a plant depends upon its function and operation requirements. Breakdown or long periods of inspection and overhaul can have adverse effects.

Spares

2.6 An assessment should be made of the level of spares to be held for any electrical equipment.

2.7 Where items of electrical equipment have a more general use, they should be manufactured to higher quality assurance. This quality specification will be reflected in the price of purchase. Notwithstanding the guarantees by the manufacturers, a small stock of spare part items should be kept in hand to ensure that simple and rapid repairs can be made.

2.8 The need for standby or replacement electrical equipment should be assessed against the overall urgent need or the time in which any specialised repair can be effected.

Tools

2.9 Special tools to carry out the necessary basic level of breakdown or overhaul maintenance should be held in stock.

2.10 Tools and instrumentation which are classified as safety tools should always be available on site. This reflects the management's statutory obligation to ensure compliance with the Electricity at Work Regulations 1989. SHTM 2020; *Electrical safety code for low voltage systems* and SHTM 2021; *Electrical safety code for high voltage systems* refer.

Instructions

2.11 It is essential that "practical training" is given to all operation and maintenance staff to ensure that work routines, operational procedures and correct application of the safety rules are implemented.

2.12 Training should be given by the manufacturer to all technical staff as part of the contract requirement, and should be based upon the operating and maintenance manuals.

2.13 It is essential that British Standards in maintenance and site operational procedures are used as guide documents, for example BS 6423:1983, 'Code of practice for maintenance of electrical switchgear and controlgear for voltages up to and including 1 kV'; BS 6626: 1985, 'Code of practice for maintenance of electrical switchgear and controlgear for voltages above 1 kV and up to and including 36 kV'; and BS 148: 1998 'Specification for unused and reclaimed mineral insulating oils for transformers and switchgear'.

Frequency of maintenance

2.14 The frequency of maintenance will be influenced by several operating factors:

a. to ensure the quality of manufacture, wherever possible, only electrical equipment manufactured to BS 5750 (IS0 9000), EN29000, 'Quality systems' or BS 9000, 'General requirements for a system for electronic components of assessed quality' should be purchased;

b. frequency of use;

c. environmental conditions;

d. skill of the operators;

e. nature of the service, for example patient life support.

2.15 Manufacturers have an obligation to provide adequate information on the required frequency of maintenance. This information should be utilised to maintain the operational integrity of an item of electrical equipment.

2.16 The philosophy of "planned preventive maintenance" or maintenance at fixed intervals irrespective of a service need, should be balanced against the application of "breakdown maintenance". The best approach is a mix of both.

2.17 The improved quality of goods gives the purchaser confidence in the application of mixed maintenance. For this concept to operate with a high degree of confidence, the need for duplication may be necessary on selected equipment where redundancy at any time is not acceptable. Statutory requirements and service needs will guide the operator to a rationalised scheme of mixed maintenance.

Health and safety

2.18 This subject is of prime consideration and expenditure in the conduct of operational or maintenance programmes. In the electrical sphere, safety from electrocution is the primary objective. SHTM 2020; *Electrical safety code for low voltage systems* and SHTM 2021; *Electrical safety code for high voltage systems* should be carefully followed for advice and guidance in the application of electrical safety.

2.19 Training of staff is the prime route to safety. In-house or specialised safety seminars should be part of management policy to acknowledge the statutory requirements of the Electricity at Work Regulations 1989.

2.20 A corporate approach to health and safety by management, engineers, craftsmen and supporting staff must be fostered. The old procedure of displaying large posters listing the statutory regulations for Health and Safety at Work is no longer accepted as sufficient. Direct instruction and recording of all health and safety education and training is advised.

Maintenance planning

2.21 Irrespective of the scale of operation, maintenance programmes are essential so as to ensure that all the electrical equipment is checked, inspected, tested, repaired or replaced at the proper time. This enhances the operational life span of the equipment.

2.22 To ensure that an organised maintenance programme is carried out economically it should be supported by a reporting system of "defect and failure". Classifications of urgency would allow for those defects requiring extensive plant isolation and shutdown to be slotted into the overall planned maintenance programme.

2.23 An Estates Information and Management System is a computerised series of software programs for storing management, contract, maintenance and data information representing a large proportion of estate requirements. The utilisation of such a system should be encouraged.

Commissioning tests

2.24 These are the contractually agreed records of the original commissioning procedures related to particular items of electrical equipment or plant. They must be handled with care and kept in a safe place. Reference to these documents should be made from copies. They represent the history of the equipment or plant. The originals should not be handled for reference purposes in confirming tests or in discussion, the exception being as legal documents.

Original and amended drawings

2.25 As with test records, these drawings have been contractually agreed, being the original "as-built" form. They are legal documents showing the assembly and construction of an electrical system. These drawings, with dated amendments made during the construction phase up to final acceptance, should not be amended. Where subsequent changes are made, these should be entered on separate amended drawings and noted to indicate the date and reference as appropriate.

Electrical functional tests

2.26 Functional tests are a practical demonstration in the operation of an item of electrical equipment or plant. The commissioning functional test record sheet should be preserved for future reference. It will be the comparative reference for all future maintenance tests in the life of the item of equipment or plant.

2.27 The frequency of such routine tests depends upon the use of the equipment as represented by the running hours or operations. Experience may well dictate this requirement on the basis of routine and specific time checks.

Inspections prior to recommissioning

2.28 Before any electrical equipment or plant is put back into service following a period of maintenance, a thorough inspection of all operational controls, protection settings, alarms and indications should be carried out.

Contract maintenance services

2.29 The development of complex electrical equipment used in HCPs, coupled with the reduction in works staff, has added to the ethos of employing outside contractors to carry out any planned maintenance.

2.30 Generally, contract staff are employed by manufacturers. Approved service agencies sponsored by the manufacturer or a freelance agency can also play an active part. In all cases a services agency can be retained on a contract to carry out periodic inspections and maintenance. They could be engaged to attend breakdowns at short notice or carry out factory instructed modifications to the equipment.

2.31 Maintenance agreements with manufacturers or with a specialised service agency could have some advantages. This should be monitored to ensure value for money.

3. Switching devices

General

3.1 In all inspections and tests involving switching devices it is imperative that the high voltage (HV) and low voltage (LV) electrical safety codes as detailed in SHTM 2021; *Electrical safety code for high voltage systems* and SHTM 2020; *Electrical safety code for low voltage systems* are strictly adhered to. The operation of switching devices embodies the whole concept of electrical safety.

3.2 The test operation of any switching device must be done in such a manner as to prevent disturbances in plant solely dependent upon that source of supply as their main power or as a source of control. Due regard to personnel's safety should also be considered in these tests.

Functional tests

3.3 The maintenance functional tests are listed in SHTM 2007; *Electrical services: supply and distribution*, 'Validation and verification'.

3.4 For maintenance planning purposes, it is important to demonstrate and confirm that the original commissioning tests are repeatable and at the same time examine the switching device for indication of wear in contacts and slackness in moving and rolling linkages.

Protection

3.5 Routine checks in the operation of all relay protection should be carried out at every reasonable opportunity. Before any switching device is returned into service after an extended outage, the operation of the protection must be checked.

3.6 This may be done with the switching device in the isolated or withdrawn position using special jumper leads plugged into the control circuits (if provided). This should be preceded by a visual check in and around the withdrawn truck and in the cubicle housing for dirt or damage and distortion to shutter linkages.

3.7 Secondary injection tests should only be carried out after replacement, or as routine maintenance. The frequency of protection maintenance may vary from one to five years according to site records. The manufacturer's advice and the number of switching operations are to be considered.

Fuse-switches and isolators

3.8 Fuse-switches and isolators should be inspected annually as follows:

a. the open and close action from the operating lever must be smooth and the spring recoil rapid;

b. the operation of the spring recoil must be effective in opening or closing, before the lever arc movement has passed the half travel point;

c. the cubicle door cannot be opened until the switch is in the open position;

d. the bolts and set screws must be tight in the mechanism and the insulation must be free of defect or damage;

e. moving blade surfaces and fixed contacts should be free of metal erosion or burning;

f. the isolator, or fuse-switch, moving contacts must make and break simultaneously with the fixed contacts when closing and opening;

g. the operating lever may be restrained by barrel lock or padlocks to prevent lever operation closing the switch from the open position.

NOTE: For test purposes it may be necessary to bypass this door interlock to inspect the internal mechanism and to observe the "open-close-open" sequences.

Fuse links

3.9 Fuse links should be inspected annually as follows:

a. the rating and rupturing capacity of all fuse links should be clearly shown on a circuit list stored in, or labelled onto, the door of the distribution board (DB) or enclosure;

b. any work on exposed fuse holder contacts should only be done with the incomer supply isolated.

Fuse holders

3.10 Fuse holders should be inspected annually as follows:

a. the fuse holder should be identified by the circuit list and contain the correctly rated fuse link;

b. the shroud on the fuse holder main contact should be removed and the exposed spring contacts checked for firm compression, and signs of overheating. Conductor terminations should be checked for tightness;

c. any dirt or dust should be removed and the DB or enclosure checked and sealed against ingress;

d. both sets of spring contacts should be cleaned and lubricated.

Miniature circuit breakers

3.11 Miniature circuit breakers (MCBs) should be inspected annually as follows:

a. the MCB should be identified by the circuit list and be of the correct type and current rating. The rating should be clearly shown on a circuit list stored in, or labelled onto, the door of the DB or enclosure;

b. MCBs should be operated several times to determine the freedom of the operating mechanism;

c. the MCB terminals should be examined for overheating, and the conductor terminal screws checked for tightness;

d. any doubts as to the suitability or effectiveness of an MCB should lead to its replacement;

e. any dirt or dust should be removed, and the box or enclosure checked and sealed against ingress.

Residual current devices

3.12 Residual current device (RCD) is a generic term to describe several types of insulation protective devices which continuously monitor the insulation resistance of an electrical circuit. This may be as a result of failure in the insulation material or as a direct contact by personnel.

3.13 The RCD senses any difference in the values of the circuit currents flowing in the live and neutral wires. The operating current is normally set at 300, 100, 30 or 10 milliamperes with an operating time of 200 or 40 milliseconds. A summary of operating qualities is shown in Table 1.

Table 1

	RCDs		
	RCCB Residual current circuit breaker	RCBO Residual current circuit breaker	RCD relays control relay
Isolation	T	O	D
Switching	T	T	D
Volt-free control contacts			T
Earth fault protection	T	T	T
Overload protection		T	D
Discriminatory time delay	O		O
Phase/neutral switching	T	T	D

T - typical features

O - optional features

D - dependent on main circuit breaker

3.14 Groups of equipment with a total earth leakage current in excess of 50% of the circuit RCD set operating current, should not be connected to the same circuit outlet. Failure to observe this requirement may result in spurious trip operation of the RCD. Several steps to trouble-free operation with RCDs are to select:

a. RCD with filter;

b. RCD or RCBO (combined MCB/RCD, IEC 1009);

c. RCD with shortest operating time nearest the load;

d. RCD upstream time-delayed;

e. circuit grouping to avoid total excessive earth leakage current.

Motor starters

General

3.15 The operation of motor starters should be checked at regular intervals over and above the planned maintenance routines, especially where repetitive start-stop operations are made.

Inspection tests

3.16 The following tasks should be carried out:

a. small direct on-line starters equipped with the basic stop/start controls will result in the operation of the electric motor when the controls are tested;

b. operation of electric motors can be prevented by the provision of an isolating switch or disconnecting link box at or near the motor;

c. in motor control cubicles the arrangement of starter controls is often simplified for off-load tests. The starter main on-off isolator has a third "test" position, where the power supply is isolated but the control and alarm supplies remain **on**. The starter door close interlock will also be released and the starter cubicle door may then be opened. Control tests can be carried out at the starter local control start/stop and reset push buttons depending upon the selection of the "remote/local/auto" control selection switch as follows.

   (i) confirm the operation of the stop, running and reset push buttons for overload trip/reset and control indication lamps and alarms, in the three modes of control;

   (ii) emergency stop push-button station;

d. operation and reset of the thermal overload at the starter overload trip relay button;

e. removal of contactor flash guards for inspection;

f. closing alignment of the three-phase main contacts and arcing contacts and the set of the auxiliary contacts, using a moving coil analogue meter, at the control terminal blocks;

g. removal of excessive dust or dirt if accumulated.

Routine maintenance

3.17 The following maintenance checks should carried out:

a. the maintenance test and checks should include the validation of the thermal overload up to three times full load motor current and the single phase trip at 2½, times full load motor current;

b. additional checks should include the re-alignment of the main contacts, arcing contacts and any auxiliary contacts operated by the contactor close movement;

c. the operation of the power and control spring contacts associated with the isolator should be checked and replacement made as necessary;

d. the cable box, terminations and glands should be checked for tightness and sealing;

e. auto control features should be checked from the operating sensor and the sensor bench tested for correct operation.

Contactors

General

3.18 Contactors operate at higher current ratings than motor starters. They are not required to interrupt fault capacity currents. The range of operation of contactors should be such that their breaking capacity is within the overload range of the electrical equipment installed in the system circuit.

Inspection tests

3.19 The following tasks should be carried out:

a. the basic inspections will be similar to those of the motor starter. It is not expected that a “test” facility will be available on the isolator. The contactor may be withdrawn from its cubicle or have more cubicle space for inspection;

b. care must be exercised to isolate the contactor mechanism from the switching cubicle incoming and outgoing circuits;

c. the main, arcing and control circuit contacts linked to the contactor should be periodically inspected for alignment, erosion and burning;

d. indication, alarm and control lamps should be regularly checked by a “lamp test”, operating push-button or by replacement.

Routine maintenance

3.20 The following maintenance checks should be carried out:

a. maintenance checks and tests should be based upon the commissioning document functional and protection tests;

b. main contacts, arcing contacts and auxiliary contacts should be replaced at this time, where wear or erosion are significant, and contact alignment reset;

c. main contactor and relay coils should be checked for pull-in and drop-out voltages, and latching contactors for trip operation by reduction in the initiating control voltage;

d. operating time sequence of timing relays should be checked;

e. terminal block connections should be checked for tightness and conductor crimps inspected for breakage or looseness;

f. all fuse links should be examined for signs of overheating at the contacts and current ratings confirmed.

Circuit breakers

General

3.21 The essential function of a circuit breaker is an ability to interrupt safely the maximum prospective fault currents (mpfc) in HV or LV systems.

3.22 HV circuit breakers will normally be found in individually equipped cubicles and connected to a common bus-bar system either as an incomer or feeder device. Exceptions may be found where some auxiliary motor plant may be supplied at HV. These are stacked in tiered cubicles of two and are known as motor switching devices.

3.23 The breaker truck, control arrangements, metering cubicles, current transformer layout and bus-bars will have the manufacturer's characteristic style and preference in the form of "metal-clad" or "metal enclosure". In a metal-clad construction, each specific function will be segregated in a sheet metal sub-cubicle. In metal-enclosed, the whole assembly is surrounded in sheet metal, but the specific functions may be separated by open dividers of sheet metal or sheet insulation.

3.24 Withdrawable circuit breaker trucks are the normal method for separation from the main bus-bar and the circuit contact spouts. Both vertical and horizontal isolation methods are in use. In both cases the breaker truck can be removed from its cubicle for maintenance or inspection. Plant safety requires only the isolation and the locking of the bus-bar and circuit shutters in the closed position.

3.25 Maintenance to the circuit terminals or HV equipment should only be carried out with the circuit breaker earthed. More extensive maintenance in close proximity to the bus-bars, such as work on metal enclosed current transformers or bus-bar shutters, will involve the isolation and earthing of the switchboard bus-bars. SHTM 2021; *Electrical safety code for high voltage systems* refers.

3.26 The circuit breaker truck cubicle must be regularly inspected and kept clean. The sliding contacts and/or plugs associated with the breaker mechanism open/close/indicators/earth and bus-bar/circuit shutter operating linkages should be examined to detect wear and tightness of movement or damage. Suitable lubricant should be applied.

3.27 Planned maintenance should include a full examination of the breaker main and arc contacts and, for vacuum interrupter or SF_6, the chambers and indications. The setting and movement of all circuit breaker actuating linkages using the "slow close" lever should be measured where guidance is given by the manufacturer.

3.28 Secondary injection tests to verify the integrity of protection should be carried out at regular intervals. The frequency of this test is very dependent upon the number of breaker operations and the environment. A maximum time limit should be decided upon, beyond which the breaker protection must be comprehensively inspected and tested. This should be annually or, in special circumstances, more frequent. The frequency should not be arbitrarily decided upon the basis of manpower resources. Plant history, wider experience of other similar installations and the manufacturer's guidance on protection should be the criteria.

3.29 When circuit breakers have been out of service for an extended period the protection/alarms must be proof checked, with the breaker in the Isolated position, before returning to service. This may be done by special test injection push-buttons or by manual operation of the relay or contacts. This will demonstrate the function of the trip circuit connections to the circuit breaker mechanism.

3.30 "Trip circuit faulty" supervision alarm checks should be made frequently at the circuit breaker or switchboard push-button if provided.

3.31 When applying a circuit earth through an oil circuit breaker, it is advised that the circuit breaker close operation be initiated from the remote control station, if at all possible. This general guidance should be adopted as a safe routine. For a single circuit an explosion due to a fault is unlikely. Where the circuit breaker forms part of an interconnecting system, relevant safety guidance in SHTM 2021; *Electrical safety code for high voltage systems* refers.

Vacuum circuit breakers

3.32 Vacuum circuit breakers are generally expected to give long periods of maintenance-free operation. The vacuum interrupter can be expected to give between 10,000 and 50,000 operating cycles.

3.33 The longevity of the interrupter will depend upon:

a. the individual contact wear. A pointer mounted on the interrupter's frame will indicate an approximate maximum distance (mm) as advised by the manufacturer;

b. the maintenance of the vacuum in the vacuum space. The vacuum space in an interrupter may fail for a number of reasons:

   (i) a leak, for example a hole;

   (ii) evaporation of gases from internal metal components;

   (iii) release of gas from high vapour pressure contaminants.

3.34 A failure in one interrupter does not lead to the failure of the circuit breaker to interrupt the load or fault current in a three-phase circuit. The current flow will be broken by the remaining two operating interrupters. The supply voltage will remain connected to the faulty interrupter phase, the load equipment and the adjoining two circuit phases of the circuit breaker.

3.35 Transient over-voltage arrest or protection should be fitted at the terminations of items of HV inductive equipment that are switched by vacuum interrupter circuit breakers.

SF_6 circuit breakers

3.36 Again, SF_6 circuit breakers are generally expected to give long periods of maintenance-free operation. The SF_6 contactor chamber can be expected to give an operational life equivalent to that of the vacuum circuit breaker.

3.37 Contact wear is not such a critical maintenance requirement as with the vacuum breaker. The geometrical construction of contacts is different, there being pairs of sliding and arcing contacts, not a pair of opposing contacts as in the vacuum circuit breaker.

3.38 The pressure of the chamber may be lost, due to leaks. This can be monitored by a pressure sensing and lockout alarm or gauge as required.

3.39 The circuit breaker can operate, in an emergency, in an SF_6, at atmospheric gas pressure.

3.40 Substantial air ventilation should be provided to avoid the inhalation of vapours in the workplace during maintenance.

3.41 If this design of HV circuit breaker is to replace an air or oil circuit breaker associated with older equipment, over-voltage arrestors should be considered at the equipment terminals. This provides some protection against premature insulation failure.

Oil circuit breaker

3.42 It is not expected that an oil circuit breaker (OCB) will be purchased as new equipment. There are many OCBs in current operation as this design has given long, reliable and enduring service over many years.

3.43 Maintenance requirements are more demanding than with the vacuum or SF_6 circuit breaker. Where the maintenance cost of oil circuit breakers is high and time-consuming, a retro-fit breaker mechanism and truck replacement, using either vacuum or SF_6 circuit breakers, may be obtained from some manufacturers.

3.44 The general maintenance of an OCB involves protection relay testing, examination of operating linkage and control circuits terminations the operation of cubicle bus-bar shutters, and sliding/plug-in contacts which are similar to other circuit breakers.

3.45 Main contact maintenance has always been a costly, dirty and time-consuming task for craftsmen. Where OCBs are subject to regular routine operational switching, at periodic examination, samples of the tank oil quality must be tested to ensure that the quality standard of insulation is equal to BS 148: 1998, 'Specification for unused and reclaimed mineral insulating oils for transformers and switchgear'.

3.46 Any circuit breaker operation due to system fault should be determined immediately after the incident. The main contacts of the OCB should be examined and replaced if damaged, and the tank's oil tested and replaced if necessary. All residues of the contaminated oil should be removed by wet suction methods. To protect the switch room floor, a temporary absorbent covering should cover the working area. Craftsmen should be provided with suitable protective clothing and footwear and be restricted from walking outside the area wearing their working footwear.

3.47 A strict record of a breaker's operations by counter should be kept and the returns filed as a maintenance record. The frequency of routine maintenance will be determined by site experience which is related to the frequency of operation, rating of the circuit breaker in comparison with the load rating, and the inductance of the load circuit.

3.48 As a safe routine operation, HV oil circuit breakers should not be operated without first warning staff who may be working within the switchroom. Where there is a choice of a "Remote" operating position, the oil circuit breaker should be operated from that position. The use of the "Local" control should be reserved for maintenance tests with the circuit breaker in the isolated position.

Air circuit breakers

3.49 Air circuit breakers (ACBs) are more in use at LV installations. They are used in some industrial HV systems where a highly inductive d.c. switching component may be reduced by the resistive arc drawn when the air breaker opens.

3.50 The LV circuit breaker is usually located in main switchboards, to control incoming feeds from transformers or as a bus-section switch.

3.51 The safety requirements required for three-phase, 415 V systems are not as wide-ranging as those required for three-phase, 11 kV systems; SHTM 2021; *Electrical safety code for high voltage systems* and SHTM 2020; *Electrical safety code for low voltage systems* refer. Even so, the maintenance and operation of LV high current ACBs should be given the same close attention.

3.52 The routine maintenance programme should call for tests on the protection relays, auxiliary relays, timer relays, coils, terminations and linkages forming the open/close mechanism and bus-bar shutter mechanisms and sliding/plug contacts.

3.53 The main contacts and auxiliary contacts mounted on the mechanism should be routinely inspected for misalignment, contact wear, burning and spring tension. Arc chutes should be kept clear of debris, and metal plates cleaned or replaced as necessary.

3.54 Interlock devices are generally placed on the LV side to prevent parallel operation of transformers.

Ring main units

3.55 Ring main units (RMUs) are fault-making load-breaking devices. There are two such switches to a unit assembly with a third tee-off fuse-switch or circuit breaker connected to an HV transformer. The earth selections are interlocked to prevent mistaken operation.

3.56 The tee-off switch may be manually operated or remotely controlled.

3.57 Fuse link protection is generally provided. This may comprise current limiting fuse links, or time limit fuse links connected in parallel with trip coils fed from a current transformer. On a fault, the fuse link operates through the trip coil, which releases the trip mechanism. Current transformers can also be used to operate electro-mechanical or solid state protection relays.

3.58 The two types of RMU switch available are the oil and SF_6 types.

3.59 The oil switch may be subject to moisture penetration in an unheated or outdoor installation. Water presence in the oil could render the switch dangerous to operate. For this type of switch the fixed and rotary seals must be routinely checked. This is obviously a difficult procedure where a transformer may depend upon the RMU switch tee-off for its HV supply.

3.60 The SF_6, type switch has the main operating contacts contained in a sealed container of epoxy-resin material which has a minimum number of rotary or fixed seal entries. The SF_6 gas operating pressure, for the rating normally used in HCPs, is set slightly above atmospheric pressure to resist moisture penetration. A pressure gauge may be located on the unit to indicate the contained SF_6 pressure. This design does not require fire protection.

3.61 The protection at the tee-off switch may be current limiting fuse links or current transformer operated trip coils. The fault current repetitive endurance of this design makes post-fault maintenance to the sealed container unnecessary.

4. Transformers

General

4.1 The operation and maintenance of transformers, once established, becomes basically a simple routine. The placement of a transformer into the correct load centre of the premises is most important to provide the minimum voltage drop in the distribution cables.

4.2 The magnetic noise of a transformer can be disturbing to patients or staff if adjoining the area.

4.3 It is advisable that oil-cooled transformers are not located in or adjacent to an area containing flammable substances.

Operations

4.4 The routine operational procedures for a transformer normally found in HCPs will be limited to:

a. HV and LV circuit operations;

b. off-load tap change selection when required to adjust LV level;

c. taking routine oil samples from conservator type transformers: SHTM 2007; *Electrical services: supply and distribution*, ‘Validation and verification’ refers;

d. inspection of tank for oil leaks;

e. regular recording of temperature and tank vapour pressure indications;

f. oil level and dryer crystal appearance.

Maintenance

4.5 Once in position and commissioned, the maintenance requirements for any type of transformer are very similar. The following checks are recommended:

a. routine insulation resistance (IR) checks of HV and LV windings. This check would usually include the LV and HV cables. The values of IR should be kept on record as an indicator of any changes in the integrity of the insulation. IR values of both cold and hot windings should be recorded;

b. inspection of HV cable box for indication of deterioration in the terminations and bushings. Signs of any oil or liquid penetration from the tank or ingress from the environment;

c. inspection of the LV cable box for loosening of any multi-lug terminations and for signs of overheating or external ingress of tank oil or water;

d. cleaning of external Insulators;

e. painting of the transformer tank and cooling fins;

f. checking accuracy of temperature gauges and alarms;

g. checking accuracy of sealed tank pressure gauges, and pressure relief diaphragm, where fitted, to manufacturer's instructions;

h. continuity of the earth protective conductor.

Mineral oil-cooled transformers

Sealed and free breathing type

4.6 These types of transformer will be the most likely ones to be installed in HCPs. They are the cheapest to manufacture as an item of equipment. When housed or located near buildings, they should be provided with adequate fire protection facilities. These transformers come in a range of standard designs and ratings and can be easily replaced from stocks of either the manufacturer or the Public electricity supply company.

Dry transformers

General

4.7 There are two types of dry transformer available on the market. These are:

a. the open wound type, formerly known as the class C type. This transformer is of special industrial manufacture which is not available as a standard product;

b. the epoxy-resin type, where the windings are encapsulated in the resin.

4.8 These two designs are fireproof and are used extensively in building services where a fire could have disastrous effects. They are normally enclosed in a steel cubicle.

Ventilation

4.9 The epoxy-resin type is not susceptible to dust/dirt penetration into the windings due to the encapsulated nature of the design. In both designs, good ambient air ventilation must be provided. For sustained overload operation, in-built forced ventilation should be provided.

Access

4.10 Access to the indoor enclosure or cubicle of these transformers is usually controlled by an interlock key, released at the HV circuit breaker when closed to the circuit earth position.

4.11 These transformers are usually located at the end of the main LV switchboard. The HV cables will enter at the HV cable box but the LV is brought from the transformer in solid copper to the LV circuit breaker contacts on the switchboard.

4.12 The transformer star point neutral will be connected to the neutral incomer circuit of the LV switchboard main circuit breaker. This neutral is also connected by protective conductor to the main earth terminal bar.

Tap change

4.13 Off-load tap changing is achieved by moving the positions of the HV winding 3-phase links to different stud positions for the voltage ratio as indicated.

Protection

4.14 A standby earth fault protection current transformer will be located in the transformer neutral. Connections are made to the inter-trip protection relay on the HV circuit breaker.

4.15 Transformer LV protection and metering current transformers will be located in the phase and neutral incomer circuits on the LV circuit breaker.

Synthetic liquid-cooled transformers

General

4.16 Synthetic liquids used for transformer coolant are silicon, Midal 7131 and Formel NF. Askarel is prohibited.

4.17 Both silicon and Midal 7131 are flammable at a higher temperature than mineral oil.

4.18 Formel NF is non-flammable, but it has environmental limitations. Formel NF contains a high proportion of chlorofluorocarbon (CFC) in the mixture. The use of this chemical has been drastically reduced and will be eventually withdrawn by international environmental agreement (the Montreal Protocol, 1990).

4.19 Silicon is a more compatible liquid. It can be mixed with mineral oil up to a limited ratio without degrading the transformer rating. It can be handled quite freely.

4.20 Midal should be handled with the same caution as mineral oil.

4.21 More detailed guidance is given in SHTM 2007; *Electrical services: supply and distribution*, 'Design considerations'.

Handling of coolant liquids

General

4.22 The handling and final disposal of transformer liquid coolants must be carefully controlled. Environmental regulations exist for these chemicals, including the equipment that contains or has contained the chemicals, at the time of disposal. The local environmental officer should be consulted before any disposal work is started.

Precautions

4.23 The entrances to transformer compounds must display all the necessary information relating to the transformer, the type of coolant used, the key holder, and the procedures relating to normal disposal and emergency loss.

4.24 Where it is not certain which cooling liquid is contained, the assumption must be that it is askarel, and the necessary procedure in clothing and environmental guidance sought from the local authority or the Health and Safety Executive.

5. Cables

General

5.1 The choice of the most suitable cable for an installation is governed by six main factors:

a. the voltage of the system;

b. the rating and operating characteristics of current-carrying equipment;

c. the fault/time capacity of the system available at the upstream protective device;

d. the environmental conditions;

e. the ambient temperature;

f. the length of the cable route.

5.2 For design guidance on rating, material and installation of cables refer to SHTM 2007; *Electrical services: supply and distribution*, 'Design considerations'.

5.3 The design requirements of the cable are usually determined for the initial installation. Subsequent equipment changes should be reviewed and follow the same design procedures. Copper will be the most likely conductor.

Safety

5.4 In installations where public, patients' and employees' safety is not endangered by flammable materials and/or noxious corrosive fumes or gas products of combustion, a fire-resistant or fire-retardant cable with oversheath and insulation made of materials having a low corrosive gas emission should be provided. In gas sealed or remote areas where restricted access to the public, patients and unauthorised staff is enforced, or where expensive equipment not susceptible to corrosive fumes is located, the installed cable insulation and oversheath material installed will normally be pvc.

High voltage cables

Choice of insulation material

5.5 For all HV cables operating between 1 kV and 11 kV the preferred cable insulations are ethylene propylene rubber (epr) or cross linked polyethylene (xlpe). The epr is more suitable for very wet, direct buried installations.

5.6 Paper insulated lead covered cable (pilc) is not economical for a new installation, the exception being as a replacement into existing cable boxes when the cost of a new box is considered.

5.7 Polyvinyl chloride (pvc) may be used up to 3.3 kV.

Tests

5.8 HV cables should have been high voltage stress tested at installation and commissioning. Existing cables should not be re-tested at HV unless new joints/terminations have been added to the cable. This HV re-test voltage should not exceed 80% of the last HV test voltage. All replacement new cables must be HV tested to the voltage advised in SHTM 2007; *Electrical services: supply and distribution*, 'Design considerations'.

5.9 The outer sheath test should be included for buried new cable installations. Where a cable outer sheath has been cut or torn, the damage should be bound with the manufacturer's approved binder and the outer sheath re-tested.

5.10 Where cable insulation has been damaged, the damaged section should be removed and replaced by one or two approved joints, as considered necessary.

5.11 All cable conductors must be discharged to earth after insulation resistance/stress tests are completed.

Cable box and gland

5.12 Cable radial dimensions can vary. The gland used in a cable box should be of the type and size approved by the cable manufacturer. The gland bore and fitting rings may only be suitable for a particular type of cable.

5.13 The HV cable gland should have an integral lug fitted. The gland can then be screw connected by copper strip to the equipment protective conductor.

5.14 The HV cable insulation and oversheath must always be shrouded from damage, and be out of reach of personnel.

5.15 HV cable box terminations should be correctly marked for standard RYB phase rotation.

5.16 All HV cable lug terminations must be tightly secured onto the screwed studs with washers and locknuts, and encapsulated with heat shrinkable plastic sleeving of the approved voltage rating.

5.17 Terminal bushings and inner surfaces of cable boxes should be in a dry, clean condition. The bushing surfaces must be wiped clean with a dry, clean, lint-free cloth.

5.18 The cable box must be tightly screwed down onto an undamaged sealing gasket.

5.19 The air desiccator, where fitted, should be checked for the presence of moisture at the time of cable box inspection.

5.20 Explosion diaphragms fitted to generator or motor cable box should be intact.

5.21 Pilc may only be glanded using lead sealing glands and bitumen filled cable boxes. Leading cable and gland manufacturers do not recommend dry cable boxes and compression glands for pilc cables.

Low voltage cables

Choice of insulation material

5.22 LV cables have a greater range of insulating material than is found in HV cables. The extended list of materials and their effect on the environment is given in SHTM 2007; *Electrical services: supply and distribution*, 'Design considerations'.

5.23 For unrestricted use, pvc cables are the most suitable. The chemical content of pvc includes the element chlorine, which when subject to high temperature will burn and emit noxious gases and vapours.

5.24 PVC cables should not be used in high capital cost areas using electronic data equipment. Small emissions of this gas and vapour can quickly cause damage to the electronic circuits.

Low smoke emission cables

5.25 A fire-retardant cable is recommended where the insulation, oversheath and filler materials should not emit noxious gases and vapours when subject to heat. A range of ratings for these cables is now available from manufacturers.

5.26 These types of cable have all the quality expected of pvc cable and are easily terminated. Some cable material may be softer and more pliable than pvc and therefore care should be shown in installation to prevent oversheath or insulation damage.

5.27 This type of cable should be used in areas where the general public, patients and staff may have prolonged and unrestricted access.

Fire areas

5.28 Power cables for connection to fire control cubicles and alarm circuits should have a fire resistance category as given in BS 6387: 1994.

5.29 The conductor insulation should have a fire resistant quality equivalent to mineral insulation, mica, glass, or silicon rubber.

5.30 The conductor bedding and outer sheath should have a low smoke emission and high oxygen index. It should burn without the emission of noxious gases or vapours.

Belated installation of electrical equipment

5.31 The random connection of small or large electrical loads to a supply system without regard for the current capacity or volt drop of the installed cable and switching devices must be regulated.

5.32 All fixed or portable items of electrical equipment which are expected to draw electrical power from the supply should be subject to registration for approved use by the electrical supply authorised person.

5.33 The total diversified load of all registered equipment should not exceed the rated current of the cable or switching devices. The volt drop should not be greater than 4.0% of rated voltage from the sub-main distribution board to the fixed current-using equipment.

Tests

5.34 All 415 V cable conductor insulation resistance (IR) should be routinely measured with a megger type d.c. voltage instrument at a voltage of 500 V d.c. up to and including 500 V rating. Extra-low voltage circuits should be tested at 250 V d.c. when supplied by an isolating transformer (IEE Wiring Regulations refer).

5.35 All armoured power cables which are directly buried or in outdoor ducts should be checked for sheath damage by insulation resistance measurement. Any sheath damage found must be sealed with binders to prevent moisture penetration into the cable and/or corrosion of the armour. Location of sheath damage in buried cable may require special test equipment.

5.36 Cable box phase terminations, where accessible, should be checked for tightness. In LV terminations, the threads, nuts and washers should be lightly covered with a non-corrosive grease.

5.37 The cable box closing plate, cover and seals should be inspected for damage or decay and replaced with new ones if required.

5.38 The terminal block insulation should be inspected for dirt or cracking.

5.39 Motor heater and thermistor terminals should be disconnected and their circuit insulation resistances measured.

6. Control cubicles and instrument wiring

General

6.1 Cubicles must always be kept secure from interference by all unauthorised personnel. Safeguards should be installed to prevent the entry of vermin and penetration of water, liquids or corrosive vapours. Where possible, access to the rear of a cubicle should be provided.

6.2 Small power and control cables usually enter from a concrete cable trench below or above ground level. Entry from overhead traywork at ceiling height is also permissible.

6.3 Incoming or outgoing control cables are normally sized at 2.5 mm^2, comprising seven strands of copper wire, screened and insulated to operate at 110 V or 240 V a.c.

NOTE: 110 V a.c. is the preferred voltage.

6.4 50 V d.c. alarm and indication cables are normally sized at 1.0 mm^2 in twisted pair configuration. They will be screened and may be bunched to form a larger multi-core cable.

6.5 All control, indication and alarm cables should be segregated neatly, loomed and bunched, or run in open plastic trunking to respective points of termination.

6.6 When seeking control faults, loosely bolted terminations or crimped lugs should always be checked first.

Glands and terminations

6.7 The forethought that has been applied at a cable installation to gland-plate arrangement commits the cable entries for the operating life of the equipment.

6.8 Blank gland-plate holes should be plugged.

6.9 Incorrectly sized LV cable diameter entries may be sealed in the gland annular space with a semi-setting compound, but only as an expedient in a dry environment.

6.10 All cable entries must be numbered by approved labels before entry into a gland.

6.11 Terminations of control, indication and alarm wire should be reasonably tight. The terminating crimped lug should be secure and correctly compressed onto the cable.

6.12 Sufficient spare length of cable should be available for an alternative point of re-termination.

6.13 Where a re-arrangement of control, indication or alarm cable becomes necessary, the standard of re-looming should be neat.

6.14 Where spare terminations are available, only single wires to linked terminations should be used. A maximum of two wires at a point of termination is recommended.

7. Small power circuits

Safety

7.1 Where consumer units or distribution boards are accessible to unauthorised personnel, warning notices should be fixed to the access doors of all such equipment forbidding any unauthorised interference.

7.2 All wiring and installation work should be in accordance with BS 7671, the IEE Wiring Regulations.

Consumer units/distribution boards

7.3 All terminations and connections should be examined for looseness or overheating. All contact surfaces should be lightly lubricated with an approved contact lubricating grease.

7.4 All circuit connections at socket-outlets should be examined for tightness. The fuse holder contact springs should be checked for weakness due to any overheating or mechanical stress.

7.5 All socket-outlets should be checked for correct L.N./earth terminal connection.

7.6 Insulation resistance (IR) of circuits from the consumer unit should be measured with all equipment disconnected.

7.7 The electrical continuity of all radial and ring mains should be confirmed from the consumer unit terminations.

Earth loop resistance

7.8 The value of the earth fault loop Impedance should be routinely checked against the commissioning document record. This ensures that the correct rated MCB type or fuse link is installed in the circuit to satisfy the required maximum disconnection of 0.4 second for portable equipment and 5.0 seconds for fixed equipment. The IEE Wiring Regulations refer.

7.9 MCB type numbers 1, 2 or 3 require earth fault loop impedances of differing magnitude to give the 0.1/0.4 second and 5.0 second maximum times for instantaneous trip operation. The higher the earth fault loop impedance, the smaller will be the MCB designated type number required to attain the permitted instantaneous time to trip. An MCB will operate incorrectly in the inverse time-current mode to high earth fault impedance values.

7.10 For equally rated fuses, whether to BS 88 or BS 3036, the actual fault currents required to operate in the maximum 0.1/0.4 second or 5.0 seconds will also be different.

7.11 When choosing fuse link or MCB ratings, the value of the fault current loop impedance must be equal to or less than the value given in the IEE Wiring Regulations.

8. Earth systems

General

8.1 All three-phase, 415 V a.c. power systems should be earthed, either at the neutral star point of the supply transformer LV winding, or when disconnected from the mains supply, at the neutral star point of only one three-phase 415 V a.c. generator winding.

Earth paths

8.2 The two paths of connection to the star point of the transformer or generator are as follows:

a. earth fault loop impedance by the protective conductor in parallel with the neutral core or armour of the main power cable;

b. earth rod loop impedance, by the ground resistance.

Maintenance

8.3 The earth rods and main connections forming the main earth system are under continuous corrosive attack. Regular inspection of joints exposed to the weather or ground influence should be made for evidence of corrosion. In most cases this can be done effectively by use of an ohmmeter or similar very low resistance instrument capable of micro-ohm measurement (for example a ductor).

8.4 Earth electrode corrosive decay is all too easy to ignore. The chemical reaction in the ground can completely destroy the effectiveness of an earth system to ground fault current without the operator being aware of its loss.

8.5 Data equipment may require a separate, low impedance signal earth connection. This is to avoid earth conductor voltage rises that are produced when high impedance earth leakage and noise interference currents are present in an interconnected inductive protective earth conductor system. The data equipment protective earth conductor should be connected to the same earth rod termination but should follow a separate route from the equipment.

Tests

8.6 Regular tests to check the earth electrode ground resistance as a group and split up, should be made annually. Rods which show an increase in resistance compared with the commissioning resistance values should be replaced or marked for later replacement. A value of 2 ohms is acceptable.

Lightning system

8.7 The inspection of lightning down-conductors, earth electrodes and ground connections should follow the same procedure as described for the main earth system. A value of up to 10 ohms is acceptable.

8.8 The presence of a layer of high specific resistivity material, hardcore or chippings surrounding an electrode area will offer a much safer insulating surface to personnel than a grass surface.

8.9 Cable routes of control, indication, alarm and data information, when buried in the ground, should be kept well clear of lightning electrodes. This is to avoid any high potential ground gradient that may be evident on a lightning strike to the building.

8.10 Main power cable risers should be routed along and up the centre of a building. This will allow the maximum possible space away from the lightning down-conductors and building outer steel framework.

References

NOTE:
Where there is a requirement to address a listed reference, care should be taken to ensure that all amendments following the date of issue are included.

Publication ID	***Title***	***Publisher***	***Date***	***Notes***
Acts and Regulations				
	The Building (Scotland) Act	HMSO	1959	
	Clean Air Act	HMSO	1993	
	Electricity Act	HMSO	1989	
	Energy Act	HMSO	1983	
	Health and Safety at Work etc Act	HMSO	1974	
	Registered Establishments (Scotland) Act	HMSO	1988	
	The Water (Scotland) Act	HMSO	1980	
SI 2179 & 187	The Building Standards (Scotland) Regulations (as amended)	HMSO	1990	
	The Building Standards (Scotland) Regulations: Technical Standards Guidance	HMSO	1998	
SI 2092	Carriage of Dangerous Goods (Classification, Packaging & Labelling) and Use of Transportable Pressure Receptacles Regulations	HMSO	1996	
SI 1460	Chemicals (Hazard Information and Packaging for Supply) Regulations (CHIP2)	HMSO	1997	
SI 3140	Construction (Design and Management) Regulations	HMSO	1994	
SI 437	Control of Substances Hazardous to Health Regulations (COSHH)	HMSO	1999	
SI 635	Electricity at Work Regulations	HMSO	1989	
SI 1057	Electricity Supply Regulations (as amended)	HMSO	1988 (amd. 1994)	
SI 2372	Electromagnetic Compatibility Regulations (as amended)	HMSO	1992	
SI 95	Environmental Protection (Disposal of Polychlorinated Biphenyls and other Dangerous Substances) (Scotland) Regulations 2000	HMSO	2000	
SI 2451	Gas Safety (Installation and Use) Regulations	HMSO	1998	

Publication ID	***Title***	***Publisher***	***Date***	***Notes***
SI 917	Health & Safety (First Aid) Regulations	HMSO	1981	
SI 682	Health & Safety Information for Employees Regulations	HMSO	1989	
SI 2792	Health and Safety (Display Screen Equipment) Regulations	HMSO	1992	
SI 341	Health and Safety (Safety Signs and Signals) Regulations	HMSO	1996	
SI 1380	Health and Safety (Training for Employment) Regulations	HMSO	1990	
SI 2307	Lifting Operations and Lifting Equipment Regulations (LOLER)	HMSO	1998	
SI 3242	Management of Health and Safety at Work Regulations	HMSO	1999	
SI 2793	Manual Handling Operations Regulations	HMSO	1992	
SI 1790	Noise at Work Regulations	HMSO	1989	
SI 3139	Personal Protective Equipment (EC Directive) Regulations (as amended)	HMSO	1992	
SI 2966	Personal Protective Equipment at Work (PPE) Regulations	HMSO	1992	
SI 128	Pressure Systems Safety Regulations (PSSR)	HMSO	2000	
SI 2306	Provision and Use of Work Equipment Regulations (PUWER)	HMSO	1998	
SI 3163	Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR)	HMSO	1995	
SI 972	Special Waste Regulations (as amended)	HMSO	1996	
SI 3004	Workplace (Health, Safety and Welfare) Regulations	HMSO	1992	
British Standards				
BS 31	**Specification. Steel conduit and fittings for electrical wiring**	BSI Standards	1940	
BS 88	**Cartridge fuses, for voltages up to and including 1000 V a.c. and 1500 V d.c.** **Part 2.2.** Specification for fuses for use by authorised persons (mainly for industrial application). Additional requirements for fuses with fuse-links for bolted connections	BSI Standards	1988	

Publication ID	***Title***	***Publisher***	***Date***	***Notes***
BS 89	**Direct acting indicating analogue electrical measuring instruments and their accessories.** **Part 2:** Specification for special requirements for ammeters and voltmeters (≡ EN 60051-2 : 1989, IEC 60051-2: 1984)	BSI Standards	1990	
BS 148	**Specification for unused and reclaimed mineral insulating oils for transformers and switchgear**	BSI Standards	1998	
BS 159	**Specification for high-voltage busbars and busbar connections**	BSI Standards	1992	
BS 171	**Specification for power transformers** **Part 3: 1987** **Part 5: 1978** (≡ IEC 60076-5: 1976)	BSI Standards	1970	
BS 697	**Specification for rubber gloves for electrical purposes**	BSI Standards	1986	
BS 921	**Specification. Rubber mats for electrical purposes**	BSI Standards	1976	
BS 970-1	**Specification for wrought steels for mechanical and allied engineering purposes. General inspection and testing procedures and specific requirements for carbon, carbon manganese, alloy and stainless steels**	BSI Standards	1996	
BS 1361	**Specification for cartridge fuses for a.c. circuits in domestic and similar premises**	BSI Standards	1971	
BS 1362	**Specification for general purpose fuselinks for domestic and similar purposes (primarily for use in plugs)**	BSI Standards	1973	
BS 1363	**Specification for 13A fused plugs and switched and unswitched socket-outlets**	BSI Standards	1984	
BS 1387	**Specification for screwed and socketed steel tubes and tubulars and for plain end steel tubes suitable for welding or for screwing to BS 21 pipe threads**	BSI Standards	1985	
BS 2484	**Specification for straight concrete and clay ware cable covers**	BSI Standards	1985	
BS 2692-2	**Fuses for voltages exceeding 1000 V a.c. Expulsion fuses**	BSI Standards	1956	

Publication ID	***Title***	***Publisher***	***Date***	***Notes***
BS 2757	**Method for determining the thermal classification of electrical insulation** (≡ IEC 60085: 1984)	BSI Standards	1986	
BS 2898	**Specification for wrought aluminium and aluminium alloys for electrical purposes. Bars, extruded round tube and sections**	BSI Standards	1970	Partially Replaced
BS 3036	**Specification. Semi-enclosed electric fuses (ratings of up to 100 amperes and 240 volts to earth)**	BSI Standards	1958	
BS 3535-1	**Isolating transformers and safety isolating transformers. General requirements** (≡ ISO 3740-1980)	BSI Standards	1990	
BS 3643-1	**ISO metric screw threads. Principles and basic data**	BSI Standards	1981	
BS 3968	**Specification for current transformers**	BSI Standards	1973	
BS 3941	**Specification for voltage transformers**	BSI Standards	1975	
BS 4066-3	**Tests on electric cables under fire conditions. Tests on bunched wires or cables** (≡ IEC 60332-3: 1992))	BSI Standards	1994	
BS 4196-0	**Sound power levels of noise sorces. Guide for the use of basic standards and for the preparation of noise test codes** (≡ ISO 3740-1980)	BSI Standards	1981	
BS 4293	**Specification for residual current operated circuit breakers**	BSI Standards	1983	Generally Replaced
BS 4568-1	**Specification for steel conduit and fittings with metric threads of ISO form for electrical installations. Steel conduit, bends and couplers**	BSI Standards	1970	
BS 4579	**Specification for performance of mechanical and compression joints in electric cable and wire connectors.** **Part 1:** Compression joints in copper conductors **Part 2:** Compression joints in nickel, iron and plated copper conductors **Part 3:** Mechanical and compression joints in aluminium conductors	BSI Standards	 1970 1973 1976	
BS 4999-0	**General requirements for rotating electrical machines. General introduction and information on other Parts**	BSI Standards	1987	

Publication ID	***Title***	***Publisher***	***Date***	***Notes***
BS 5266	**Emergency lighting** **Part 1:** Code of practice for the emergency lighting of premises other than cinemas and certain other specified premises used for entertainment **Part 2:** Code of practice for electrical low mounted way guidance systems for emergency use **Part 3:** Specification for small power relays (electromagnetic) for emergency lighting applications up to an including 32A **Part 4:** Code of practice for design, installation, maintenance and use of optical fibre systems **Part 5:** Specification for component parts of optical fibre systems **Part 6:** Code of practice for non-electrical low mounted way guidance systems for emergency use. Photoluminescent systems **Part 7:** Lighting applications. Emergency lighting (≡ BS EN 1838: 1999)	BSI Standards	1999 1998 1981 1999 1999 1999 1999	
BS 5311	**High-voltage alternating-current circuit-breakers**	BSI Standards	1996	
BS 5378-1	**Safety signs and colours. Specification for colour and design**	BSI Standards	1980	
BS 5467	**Specification for 600/1000 V and 1900/3300 V armoured electric cables having thermosetting insulation**	BSI Standards	1997	
BS 5655	**Lifts and service lifts** **Part 3:** Specification for electric service lifts	BSI Standards	1989	
BS 5685	**Electricity meters** **Part 1:** Specification for Class 0.5, 1 and 2 single-phase and polyphase, single rate and multi-rate watt-hour meters **Part 3:** Specification for meters having Class 1 electro-mechanical maximum demand indicators	BSI Standards	1979 1986	
BS 5724-1	**Medical electrical equipment. Specification for general safety requirements**	BSI Standards	1979	
BS 5750	**Quality Systems (5750-8: 1991)** (≡ EN 29004-2: 1993, ≡ ISO 9004-2: 1991)	BSI Standards	1991	

Publication ID	*Title*	*Publisher*	*Date*	*Notes*
BS 5839-1	**Fire detection and alarm systems for buildings. Code of practice for system design, installation and servicing**	BSI Standards	1988	
BS 6004	**Electric cables. PVC insulated, non-armoured cables for voltages up to and including 450/700 V for electric power, lighting and internal wiring**	BSI Standards	2000	
BS 6007	**Electric cables. Single core unsheathed heat resisting cables for voltages up to and including 450/750 V, for internal wiring**	BSI Standards	2000	
BS 6121	**Mechanical cable glands (all parts)**	BSI Standards	1989	
BS 6207-2	**Mineral insulated cables with a rated voltage not exceeding 750 V. Terminations**	BSI Standards	1995	
BS 6234	**Specification for polyethylene insulation and sheath of electric cables**	BSI Standards	1987	
BS 6346	**Specification for 600/1000 V and 1900/3300 V armoured electric cables having PVC insulation**	BSI Standards	1997	
BS 6387	**Specification for performance requirements for cables required to maintain circuit integrity under fire conditions**	BSI Standards	1994	
BS 6423	**Code of practice for maintenance of electrical switchgear and controlgear for voltages up to and including 1 kV**	BSI Standards	1983	
BS 6480	**Specification for impregnated paper-insulated lead or lead alloy sheathed electric cables of rated voltages up to and including 33000 V**	BSI Standards	1988	
BS 6500	**Electric cables. Flexible cords rated up to 300/500 V, for use with appliances and equipment intended for domestic, office and similar environments**	BSI Standards	2000	
BS 6622	**Specification for cables with extruded cross-linked polyethylene or ethylene propylene rubber insulation for rated voltages from 3.8/6.6 kV up to 19/33 kV**	BSI Standards	1999	
BS 6626	**Code of practice for maintenance of electrical switchgear and controlgear for voltages above 1 kV and up to and including 36 kV**	BSI Standards	1985	

Publication ID	*Title*	*Publisher*	*Date*	*Notes*
BS 6651	**Code of practice for protection of structures against lightning**	BSI Standards	1999	
BS 6724	**Specification for 600/1000 V and 1900/3300 V armoured electric cables having thermosetting insulation and low emission of smoke and corrosive gases when affected by fire**	BSI Standards	1997	
BS 6899	**Specification for rubber insulation and sheath of electric cables**	BSI Standards	1991	
BS 7071	**Specification for portable residual current devices**	BSI Standards	1992	
BS 7211	**Specification for thermosetting insulated cables (non-armoured) for electric power and lighting with low emission of smoke and corrosive gases when affected by fire**	BSI Standards	1998	
BS 7354	**Code of practice for design of high-voltage open-terminal stations**	BSI Standards	1990	
BS 7361-1	**Cathodic protection. Code of practice for land and marine applications**	BSI Standards	1991	
BS 7430	**Code of practice for earthing**	BSI Standards	1998	
BS 7671	**Requirements for electrical installations. IEE Wiring Regulations. Sixteenth edition**	HMSO	1992	
BS 7735	**Guide to loading of oil-immersed power transformers** (≡ IEC 60354: 1991)	BSI Standards	1994	
BS 9000	**General requirements for a system for electronic components of assessed quality (9000-1: 1989)**	BSI Standards	1989	
BS EN 755-6	**Aluminium and aluminium alloys. Extruded rod/bar, tube and profiles. Hexagonal bars, tolerances on dimensions and form**	BSI Standards	1996	
BS EN 1172	**Copper and copper alloys. Sheet and strip for building purposes**	BSI Standards	1997	
BS EN 1652	**Copper and copper alloys. Plate, sheet, strip and circles for general purposes**	BSI Standards	1998	
BS EN 1653	**Copper and copper alloys. Plate, sheet and circles for boilers, pressure vessels and hot water storage units**	BSI Standards	1998	
BS EN 1654	**Copper and copper alloys. Strip for springs and connectors**	BSI Standards	1998	

Publication ID	***Title***	***Publisher***	***Date***	***Notes***
BS EN 12163	**Copper and copper alloys. Rod for general purposes**	BSI Standards	1998	
BS EN 12164	**Copper and copper alloys. Rod for free machinery purposes**	BSI Standards	1998	
BS EN 12167	**Copper and copper alloys. Profiles and rectangular bar for general purposes**	BSI Standards	1998	
BS EN 50265-1	**Common test methods for cables under fire conditions. Test for resistance to vertical flame propagation for a single insulated conductor or cable. Apparatus**	BSI Standards	1999	
BS EN 50265-2-1	**Common test methods for cables under fire conditions. Test for resistance to vertical flame propagation for a single insulated conductor or cable. Procedures. 1 kW pre-mixed flame**	BSI Standards	1999	
BS EN 60079-14	**Electrical apparatus for explosive gas atmospheres. Electrical installations in hazardous areas (other than mines)** (≡ IEC 60079-14: 1996)	BSI Standards	1997	
BS EN 60265-1	**Specification for high-voltage switches. Switches for rated voltages above 1 kV and less than 52 kV** (≡ IEC 60265-1: 1998)	BSI Standards	1998	
BS EN 60298	**A.C. metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV** (≡ IEC 60298: 1990)	BSI Standards	1996	
BS EN 60439-1	**Specification for low-voltage switchgear and controlgear assemblies. Type-tested and partially type-tested assemblies** (≡ IEC 60439-1: 1999)	BSI Standards	1999	
BS EN 60445	**Basic and safety principles for man-machine interface, marking and identification. Identification of equipment terminals and of terminations of certain designated conductors, including general rules for an alphanumeric system** (≡ IEC 60445: 1999)	BSI Standards	2000	
BS EN 60529	**Specification for degrees of current protection provided by enclosures (IP code)**	BSI Standards	1992	
BS EN 60551	**Determination of transformer and reactor sound levels**	BSI Standards	1993	
BS EN 60694	**Common specifications for high-voltage switchgear and controlgear standards** (≡ IEC 60694: 1996)	BSI Standards	1997	

Publication ID	***Title***	***Publisher***	***Date***	***Notes***
BS EN 60831	**Shunt power capacitors of the self-healing type for a.c. systems having a rated voltage up to and including 1000 V.** **Part 1:** General. Performance, testing and rating. Safety requirements. Guide for installation and operation (≡ IEC 60831-1: 1996) **Part 2:** Ageing test, self-healing test and destruction test (≡ IEC 60831-2: 1995)	BSI Standards	 1998 1996	
BS EN 60871-1	**Shunt capacitors for a.c. power systems having a rated voltage above 1 kV. General, testing and rating. Safety requirements. Guide for installation and operation** (≡ IEC 60871-1: 1997)	BSI Standards	1998	
BS EN 60898	**Specification for circuit-breakers for overcurrent protection for household and similar installations**	BSI Standards	1991	
BS EN 60931	**Shunt power capacitors of the non-self-healing type for a.c. systems having a rated voltage up to and including 100V.** **Part 1:** General. Performance, testing and rating. Safety requirements. Guide for installation and operation (≡ IEC 60931-1: 1996) **Part 2:** Ageing test and destruction test (≡ IEC 60931-2: 1996) **Part 3:** Internal fuses (≡ IEC 60931-3: 1996)	BSI Standards	 1998 1996 1997	
BS EN 60947	**Specification for low-voltage switchgear and controlgear** **Part 1:** General rules (≡ IEC 60947-1: 1999) **Part 2:** Circuit-breakers **Part 3:** Switches, disconnectors, switch-disconnectors and fuse combination units **Part 4-1:** Electromechanical contactors and motor-starters	BSI Standards	 1999 1996 1999 1992	
BS EN 61000	**Electromagnetic compatibility (EMC). Testing and measurement techniques (Parts 4-1 to 4-28)** **Part 4-1:** Overview of immunity tests. Basic EMC publication (≡ IEC 61000: 1992)	BSI Standards	 1995	

Publication ID	***Title***	***Publisher***	***Date***	***Notes***
BS EN ISO 3766	**Construction drawings. Simplified representation of concrete reinforcement**	BSI Standards	1999	
BS EN ISO 7518	**Construction drawings. Simplified representation of demolition and rebuilding**	BSI Standards	1999	
BS EN ISO 11091	**Construction drawings. Landscape drawing practice**	BSI Standards	1999	
Scottish Health Technical Guidance				
SHTM 2011	Emergency electrical services	P&EFEx	2001	CD-ROM
SHTM 2014	Abatement of electrical interference	P&EFEx	2001	CD-ROM
SHTM 2020	Electrical safety code for low voltage systems (Escode – LV)	P&EFEx	2001	CD-ROM
SHTM 2021	Electrical safety code for high voltage systems (Escode – HV)	P&EFEx	2001	CD-ROM
SHTM 2035	Mains signalling	P&EFEx	2001	CD-ROM
SHPN 1	Health service building in Scotland	HMSO	1991	CD-ROM
SHPN 2	Hospital briefing and operational policy	HMSO	1993	CD-ROM
SHPN 48	Telephone Services	HMSO	1997	CD-ROM
SHTN 1	Post commissioning documentation for health buildings in Scotland	HMSO	1993	CD-ROM
SHTN 4	General Purposes Estates and Functions Model Safety Permit-to-Work Systems	P&EFEx	2001	CD-ROM
	NHS in Scotland – PROCODE	P&EFEx	2001	Version 1.1
	PCB Regulations Guide	P&EFEx	2000	
NHS in Scotland Fire Safety Management				
SHTM 81	Fire precautions in new hospitals	P&EFEx	1999	CD-ROM
SHTM 82	Alarm and detection systems	P&EFEx	1999	CD-ROM
SHTM 83	Fire safety in healthcare premises: general fire precautions	P&EFEx	1999	CD-ROM
SHTM 84	Fire safety in NHS residential care properties	P&EFEx	1999	CD-ROM
SHTM 85	Fire precautions in existing hospitals	P&EFEx	1999	CD-ROM
SHTM 86	Fire risk assessment in hospitals	P&EFEx	1999	CD-ROM
SHTM 87	Textiles and furniture	P&EFEx	1999	CD-ROM
SFPN 3	Escape bed lifts	P&EFEx	1999	CD-ROM
SFPN 4	Hospital main kitchens	P&EFEx	1999	CD-ROM

Publication ID	***Title***	***Publisher***	***Date***	***Notes***
SFPN 5	Commercial enterprises on hospital premises	P&EFEx	1999	CD-ROM
SFPN 6	Arson prevention and control in NHS healthcare premises	P&EFEx	1999	CD-ROM
SFPN 7	Fire precautions in patient hotels	P&EFEx	1999	CD-ROM
SFPN 10	Laboratories on hospital premises	P&EFEx	1999	CD-ROM
UK Health Technical Guidance				
MES	Model Engineering Specifications	NHS Estates	1997	As required
Concode	Contracts and commissions for the NHS estate – contract procedures	HMSO	1994	
C41	National health service model engineering specifications: Common services electrical low and extra low voltage	NHS Estates	1997	
C42	National health service model engineering specifications: A Electric traction lifts B Hydraulic C Service lifts	NHS Estates	1997	
C45	National health service model engineering specifications: Electrical sub-station equipment extensions (high voltage)	NHS Estates	1997	
Miscellaneous				
	Electricity Association (EA) standards and engineering recommendations:			
35-1	Distribution transformers (from 16 kVA to 1,000kVA)	EA	1985	
41-26	Distribution switchgear. Ratings up to 36 kV	EA	1991	
C89.1	Termination on polymeric insulation cables rated at 12 kV and 36 kV	EA	1986	
G59	Connection of private generating plant at the electricity supply system	EA	1985	
ET113	Guidance for the protection of private generating sets up to 5 MW, in parallel with the Public electricity supply company distribution network	EA	1989	

Publication ID	***Title***	***Publisher***	***Date***	***Notes***
G5/3	Limits for harmonics in the UK electricity supply system	Electricity Research Association	1976	
ERA 69-30	Part 3, Sustained current ratings for pvc-insulated cables. Part 5, sustained current ratings for cables with thermosetting insulation			
C62.41	ANSI/IEEE Surge voltages in low voltage a.c. power circuits		1980	
EH 40	HSE Occupational Exposure limits	HSE	Annual	
HS(G)41	Petrol filling stations – Construction and operation	HSE	1990	
HS(G)47	Avoiding danger from overhead electrical lines	HSE		
GS6 (rev)	Avoidance of danger from overhead electrical lines	HSE		
HS(G)141	Electrical safety on construction sites	HSE		
HS(G)85	Electrical at work – safe working practices	HSE		
GS38 (rev)	Electrical test equipment for use by electricians	HSE		
GS50	Electrical safety at places of entertainment	HSE		
PM29 (rev)	Electrical hazards from steam/water pressure cleaners etc.	HSE	1995	
PM38	Selection and use of headlamps	HSE	1992	
HS(G)25	Memorandum of guidance on the Electricity at Work Regulations 1989	HSE		
	Code of practice for in-service inspection and testing of electrical equipment	HSE		
Paper No. 6	Waste Management Paper No. 6 – Polychlorinated Biphenyl (PCB) Wastes	HMSO		