Scottish Health Technical Memorandum 2007

(Part 3 of 4)

Validation and verification

Electrical services: supply and distribution

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Contents

1. Scope

1.1 The provision of electrical services in HCP 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.

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 the current 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. Works tests

General

2.1 Each major item of electrical equipment should be type tested. This includes any equipment manufactured to the BS or IEC Standard. The need for type test certificates shall be as stated in the specification document.

Type test certificates

2.2 These certificates should be submitted with each contractor's tender documentation and shall be issued by an approved test house. The test house must be registered by NAMAS or equivalent authority within the EC.

Routine works test certificates

2.3 These certificates shall be provided with each major item of electrical equipment, as tested, and must be approved by the HCP project manager (the engineer) before despatch from the works to site.

NOTE: The term "engineer" refers to the management representative in charge of the works or any person nominated to represent the management.

2.4 The routine works test certificate should be available to commissioning staff before "on-site" commissioning commences.

2.5 All equipment delivered to site should be stored in a warm and dry environment.

3. Site testing and commissioning

Inspection of certificates

3.1 When the installation has reached practical completion in accordance with the contract, a take-over certificate will be issued. This will certify the date on which the installation was taken over and the commencement of the maintenance/defects liability period.

Witness of tests

3.2 There must be a formal and contractual procedure arranged between the engineer and the contractor for all plant verification before acceptance can be agreed.

NOTE: The term “contractor” also implies any person representing the contractor and acting on their behalf.

3.3 The verification should include a thorough inspection of the installation to assess the quality and accuracy of the work and to witness any tests specified in the contract. The engineer shall witness all tests and inspections.

Retention

3.4 Minor defects or deficiencies relating to the work carried out by the contractor should be listed in the take-over certificate and corrected as early as possible during the maintenance/liability period.

3.5 Retention monies, as indicated in the contract document, should be paid on at the end of the maintenance/liability period when all rectification of defects or deficiencies has been completed. This should also include items provided by nominated suppliers.

Wiring diagrams

3.6 Wiring diagrams, instruction manuals, etc, should be given to the engineer supervising the work, preferably at the time of commissioning, but no later than at hand-over.

Commissioning

3.7 Commissioning of equipment, as listed in the schedule of the contract document, must be accompanied by all the associated pre-commissioning data sheets. This should indicate full acceptance, or reservations in performance, by the engineer.

4. Pre-commissioning procedures

Test administration

General

4.1 The basis of pre-commissioning tests is to ensure that all tests are carried out by the contractor before any system or equipment is handed over to the engineer.

Test records of plant items

4.2 The original test records of all electrical equipment should be kept for future reference, whether as a reference to "as-fitted" levels of performance, or as the basis for future comparative designs and costs.

Contract requirements

4.3 All original forms of test records relate to the legal assurances as detailed in the contract document. Where a single level of performance is required, or interrelates to the overall reliability of the whole plant operation, the details of records required to ensure compliance must be negotiated with the contractor at the tender assessment stage.

4.4 The "specification document" must give guidance and contain direct indicators for all final tests required. This should indicate time requirement to validate the overall performances.

4.5 The cost of a rigorous verification programme is not low. Sufficient time must be identified within the project plan to allow for its execution.

4.6 Delays which can arise during the earlier phases of the construction programme must not be allowed to override this aspect of the contract.

4.7 Executive control and responsibility for achieving this should be effective.

Personnel

4.8 Good technical ability and integrity is required of staff carrying out the various test requirements. This would ensure that the results obtained are representative in establishing the effectiveness of the design and its operating provisions as stated or implied within the contract document.

Witness of test documents

4.9 It is essential that the procedures for all tests have been agreed in advance between the engineer and the contractor. Any deviations must be fully recorded.

4.10 The document must be witnessed by both the engineer and the contractor. The time and date shall be recorded and all observations noted.

4.11 If the results of a test do not conform to contract, they should be rejected, and a repeat or revised test demonstration negotiated.

Electrical equipment for test

4.12 Electrical supply and distribution equipment demand a high capital investment in any building project. The electrical equipment for test and documentation will comprise:

a. HV switchgear and associated controlgear;
b. LV switchgear and associated controlgear;
c. power transformers and associated controller;
d. HV cables and associated cable works;
e. LV cables and associated cable works;
f. control wire cables, associated cable works and marshalling cubicles;
g. earthing systems;
h. emergency generators and control gear,
i. battery systems.

NOTE: Emergency generators and battery systems are discussed in Scottish Health Technical Memorandum 2011; *Emergency electrical services*.

General inspection of equipment

4.13 Before the start of any pre-commissioning test, the equipment and its associated installation should be carefully inspected and checks made to ensure:

a. cleanliness and suitability of enclosure;
b. location, positioning, level and structural rigidity, and freedom from vibration;
c. that labels/numbers are correct to the approved contract drawing;
d. that there is adequate heating, ventilation and isolation from any adjacent heat source;
e. that provision is made for the cable entries and terminations;

f. that holding-down bolts, clamps and cleats are connected;

g. that power and control cables are secured correctly;

h. that neatness of control wire looming is evident;

i. that all fuse links are of correct rating;

j. that all terminations are correctly numbered, permanently identified and correctly crimped;

k. that cable entries are secured against insect and vermin infestation;

l. that the electrical equipment is securely locked and materially secure from site theft or operational damage;

m. that an effective earth protective conductor is provided.

Agreement to test

4.14 All the required commissioning tests should be conducted at the permanent installation. No equipment may be formally tested without the agreement and knowledge of the engineer.

4.15 Adequate safety precautions must be applied, as required by SHTM 2021; *Electrical safety code for high voltage systems* and SHTM 2020; *Electrical safety code for low voltage systems* and Health and Safety at Work Regulations. The following should be observed:

a. the tests shall be carried out in accordance with normal good practice exercised in the electrical contracting industry;

b. all test equipment should be provided by the contractor, approved by the engineer, and be available on site for any planned test;

c. all instrumentation and metering equipment should be accompanied by a recent test certificate of guaranteed accuracy;

d. all test results should be recorded on a mutually agreed test data sheet, and be dated and signed by the engineer and the contractor;

e. a register should be kept of names and signatures of all the engineer's and contractor's nominated representatives.

Site test procedures: switchboards and motor control centres

Sequence of tests

4.16 The tests should be in five separately approved parts:

a. inspection and test of switchboards;

b. mechanical functional test of equipment;

c. electrical functional test of equipment;

d. electrical protection test;

e. trip and alarm annunciator test.

NOTE: An approved test data sheet must be used to record each set of test results.

Initial inspection

4.17 Carry out a general inspection for damage and deterioration during storage.

4.18 Ensure labelling and warning signs on switchboards are correct.

4.19 Check that each switchboard is fixed/mounted correctly to the base and structure.

4.20 Check the switchboards' earth connections are connected to the main earth system.

4.21 For the following checks on each switchboard, the switchboard bus-bars must be either not connected or, if previously energised, isolated (earthed for HV) and an appropriate safety document for the work issued:

a. check manual freedom of operation of any circuit or bus-bar shutter door mechanisms;

b. check manual operation of shutter mechanical linkage, device racking mechanism and associated interlocks and keys;

c. check voltage transformer (VT) and current transformer (CT) compartments. Ensure the integrity of the assembly and the identification on the cover plates;

d. test, with a torque wrench, all phase bus-bars, neutral, and frame connected earth circuit-bar bolts to the torque values set by the manufacturer;

e. carry out resistance tests across all bus-bar bolted joints, using a low resistance ohmmeter (ductor). Also measure the resistance between cubicle bus-bar spouts and, for outgoing circuits, between the cable box phase terminations and the cubicle circuit spouts;

f. the resistance across closed circuit breaker contacts should be taken between each pair of phase isolating contacts. The readings should be uniform and approximately 40 micro-ohms per section of bus-bar, and 500 micro-ohms with the circuit breaker contacts closed.

4.22 With VTs isolated and CTs connected to earth, carry out the following measurements:

a. insulation resistance (IR) of VTs;

b. IR of bus-bars before and after HV pressure test;

c. HV pressure test of bus-bar, between phases and phase to earth, for one minute. Record any leakage current; BS EN 60298 refers.

Switching devices - mechanical functions

4.23 Check all components are fitted correctly to approved drawings.

4.24 Check tightness of all secured/bolted fittings.

4.25 Check carriage switch alignments to cubicle sliding contacts.

4.26 Check alignment of switching device in cubicle.

4.27 Check manually the operation of bus-bars and circuit shutters.

4.28 Check manually the operation of isolating, service and earth mechanical semaphore indications.

4.29 Check manually the operation of all device-actuated auxiliary switches.

4.30 Rack switching device into isolated, then service positions. Listen carefully to ensure that bus-bar and circuit shutters have opened before the switching device isolating contacts are fully entered into the bus-bar and circuit chambers.

NOTE: Trolley positions and indications are correct on the panel.

4.31 Carry out mechanical close/open of switching device in service position. Observe open/close mechanical indications.

4.32 Where applicable, set up the earthing equipment, rack into the earth position and observe that only the circuit shutters open. The bus-bar shutters must remain closed and be locked.

NOTE: Trolley position and indications are correct on the panel.

4.33 Reinstate switching device.

Switching devices – electrical functions

4.34 Check the resistance of the long and short sliding contacts and auxiliary switch circuits on the switching device and in the cubicle for the protection, alarms and indication terminals.

4.35 With all fuse links and earth links removed, check IR of switching device of main circuits, CTs and control circuits.

4.36 Carry out HV pressure test of the switching device with closed main contacts between phases and phase to earth for one minute duration; BS EN 60298 refers.

4.37 Repeat IR test.

4.38 Rack switching device into the service position.

4.39 Establish closing and trip supplies and observe switching device indications.

4.40 Open/close switching device, first manually for smooth operation, then electrically.

4.41 Check "close" coil operation at 80% rated voltage (applicable also to spring motor closing). Use power pack or variac transformer.

4.42. For spring "close" mechanisms, measure and record the time to fully charge the spring, at rated and 80% voltages.

4.43 Check "open" coil operation at 50% rated voltage.

4.44 Set up earthing equipment and operate.

4.45 Test maintenance jumper plug, socket and leads where provided.

LV contactor equipment

4.46 Check all components to general assembly drawing.

4.47 Check tightness of all fittings.

4.48 Check labelling and warning signs to relevant design requirement.

4.49 Check that frame earth connections are connected to the main earth.

4.50 Check all contactor flash guards and shrouds are effective and present, and that the main and auxiliary contacts are aligned.

4.51 Check mechanical interlocks and operation of door keys to cubicle.

4.52 Measure IR between phases and phases to earth. Ensure that all electronic equipment circuits are disconnected.

NOTE: Use 500 V d.c. (IR) test instrument on circuits up to 500 volts.

4.53 Check that all power and control fuse links are of correct type and rating.

4.54 Check operation of all d.c. contactor and relay coils at:

a. 80% rated voltage to "close";
b. 50% rated voltage to "drop off".

4.55 Check operation of all a.c. contactor and relay coils at:

a. 85% rated voltage to "close";
b. 75% rated voltage to "drop off".

4.56 Operate all contactors and relays five times at the rated voltage.

4.57 Check indications on panel are correct.

Control equipment and secondary wiring inspection

4.58 All circuits must be systematically checked and operated as per the relevant schematic diagram to ensure the electrical functional response of all components listed in the equipment schedule. All results should be recorded.

4.59 To conclude the test, check connections to earth, terminal tightness, secure end crimping, dust covers and safety shrouds. Ensure all test leads and shorting links are removed from the panel or cubicle.

4.60 Terminal lug crimping tools should be randomly and continuously checked by the engineer to ensure the approved lug crimp pressure is achieved. This is just as important for small wire terminations in control panels as in power cable terminations.

Transformers – mechanical function tests

4.61 Carry out a general inspection for damage and completeness of the assembly.

4.62 Ensure all components are fitted as shown in the general arrangement (GA) drawing.

4.63 Check all fastenings are tightly fitted.

4.64 Check labelling of transformer is correct.

4.65 Ensure transformer is positioned correctly and cable boxes and bushings suitably placed and aligned to receive cables.

4.66 If transformer is of breathing design, check if it is filled with oil or fluid. Take oil/fluid sample at drain valve.

4.67 Check breather is correctly fitted and desiccator crystals, if provided, are blue.

4.68 Check cable box details agree with LV and HV cable sizes and gland requirements. Also check that correct gland plates are provided and threaded ready for glands and HV bushings are sound and unmarked.

4.69 Check inside cable box for oil or fluid leaks and at joints surrounding all necessary entries.

4.70 Check operation of off-load tap changer over the operating range.

Transformers – electrical function test

4.71 Carry out initial IR tests to HV and LV windings.

> **NOTE:** Use a 1000 V d.c. (IR) test instrument for circuits above 500 V supply and a 500 V d.c. below 500 V.

4.72 Check IR of all control, trip and alarm wiring with fuse links removed.

4.73 Set oil and winding hot spot temperature indicators to trip and alarm levels. Tank pressure trip and alarm should have been tested at the works.

> **NOTE:** Use a 500 V d.c. (IR) test instrument.

4.74 Check IR of iron core to earth, if core link is accessible for disconnection (in large transformers).

> **NOTE:** Use a 1000 V d.c. (IR) test instrument for circuits above 500 V supply and a 500 V d.c. below 500 V.

4.75 If transformer is to be filled with oil or fluid on site, test each drum sample **before** filling commences to BS 148. For transformers of the conservator design, already filled, take a sample at the Buchholz relay and one at the tank drain valve.

> **NOTE:** Glass bottles with ground glass stoppers should be used, particularly where analysis is delayed. The bottles should be initially oven dried and the stoppers finally sealed by wax.

4.76 Ensure oil/fluid is at the correct indicated tank level for the ambient temperature.

4.77 Check IR of transformer windings.

> **NOTE:** Use a 1000 V d.c. (IR) test instrument for circuits above 500 V supply and a 500 V d.c. below 500 V.

4.78 To determine the transformer voltage ratio and vector configuration:

a. interconnect, by a single test wire, the HV and LV (A2 and a2) terminals;

b. apply: three phase 415 V a.c. supply to the transformer **high voltage** terminals. Measure and calculate the ratios of HV and LV, three-phase voltages, as indicated, at all off-load tap changer positions;

c. at the nominal ratio, take all available voltage levels between the HV and LV terminals. If an open tertiary winding is provided, check first with the manufacturer for this voltage;

d. confirm nominal voltage ratio is correct. Draw a vector configuration to confirm the transformer phase connections are correct (see SHTM 2007; *Electrical services: supply and distribution*, 'Design considerations', paragraphs 14.11 - 14.16).

4.79 Check the following alarms, trip relays or sensors as applicable:

a. Buchholz alarm - by N_2 injection;

b. winding temperature;

c. tank pressure.

NOTE: Use current or gas injection.

4.80 Check IR of cooling fan motor, if provided, followed by thermal overload current checks and the auto/manual functional cooling temperature control.

NOTE: Use a 500 V d.c. (IR) test instrument.

4.81 Before the initial energisation, carry out IR checks to HV and LV windings from the circuit breakers.

NOTE: Use a 1000 V d.c. (IR) test instrument for circuits above 500 V supply and a 500 V d.c. below 500 V.

4.82 If any delay occurs before continuous energisation, check before energisation that all protection trips, alarms and indications are operational. Ensure cable boxes are secure. A further oil sample may be required from tank drain valve.

Voltage transformers

Polarity

4.83 The polarity of VTs can be checked using the same test procedure as for CTs (see paragraph 5.14a). For the "flick test", care must be taken to connect the battery +/- leads, in turn, across only the phase end terminals, of the **high voltage primary winding** with the ammeter connected to the same phase of the **low voltage secondary winding** end terminals.

Ratio

4.84 The ratio check is made when the HV main circuit bus-bar is energised at rated voltage. The secondary winding line and phase voltages must then be at the expected operating voltages, normally 110 V.

Vectors

4.85 The phase sequence of rotation should be checked at the secondary winding terminals by a suitably rated voltage phase rotation meter. Special additional checks are required where there is a broken tertiary winding provided.

NOTE: The vector relationship may be obtained by connecting a three-phase 415 V a.c. supply to the **primary winding**. The primary winding input and secondary winding output phase and line voltages are measured. Finally a vector diagram is drawn to check the polarity/connection between each phase winding (see paragraph 4.78).

Cables

Cables and terminations

4.86 Carry out general inspection of cable route.

4.87 If cables are not terminated, check ends for correct identification and sealing.

4.88 Check cable trench is of correct depth and bedded with sand and the cables spaced correctly with covering tiles and marker tape *in situ*.

NOTE: The trench should ideally not be back-filled with soil until the HV d.c. tests have been satisfactorily completed on the cable outer sheath and core insulation.

4.89 Check tray work for completeness, and that the cables are placed at correct levels and spacing and are tidily arranged.

4.90 Check cables, in trefoil or flat pattern, are correctly secured to the tray with strap/cleat binders of correct non-magnetic material and are properly spaced.

4.91 Ensure cable entries into ducts or buildings are secured against moisture or vermin penetration.

4.92 Check cable box gland is the correct size and type for the cable, gland-plate and any single core electrical protection.

4.93 Check cable lug is the correct size for cable core and cable box termination stud and that space between cable box terminations of differing phases and to earth is maintained.

4.94 For HV motors or generators, ensure that the cable box is provided with an explosion diaphragm and replaceable silica gel capsule to absorb penetrating moisture.

4.95 The cables must be disconnected at the equipment before any HV d.c. test. The approved HV clearances in air between equipment terminals, cable ends and earth, at both the far and near equipment cable box terminations, should be applied by:

a. disconnection of the cable lugs from the terminal studs;

b. removal of cable box terminal connecting links, if provided.

HV cable test

4.96 The HV cable test should not be carried out with the cable connected to equipment terminations. Cable box test links, if provided, should be removed. This will allow the cable test to include the cabled termination. Agreement of both the equipment and cable manufacturer should be obtained. This is to ensure that the equipment or cable guarantees are not violated.

> **NOTE:** Safety precautions as set out in SHTM 2021; *Electrical safety code for high voltage systems* should be fully applied.

4.97 During the time of the HV test, the area where the test is being carried out should be fenced off and guarded by personnel instructed in safety. All other work along the cable route should cease.

4.98 Carry out an IR test between phases and phases to armour (earth), as required for the cable.

> **NOTE:** Use a 1000 V d.c. (IR) test instrument for circuits above 500 V supply and a 500 V d.c. below 500 V. Maintain the IR test voltage until the megohm reading is steady.

4.99 Discharge cable cores to earth after each separate test.

4.100 Apply direct current HV pressure between each set of phases, and each phase to armour, for 15 minutes' duration. BS 6622 refers.

4.101 The steady charge d.c. leakage current must be recorded for each test. This should relate to the expected IR and cable length tested.

4.102 Once the tests are completed and the results have been approved, the cable should be fully discharged, terminations applied and cable boxes sealed.

Site HV tests on new buried cables

4.103 The tests are best completed on buried HV cables before final termination at both ends and the ducts being closed or sealed, and before the cable is completely buried. This is to avoid extra recovery complications in the event of a failure in the IR and HV tests or damage done during handling and trench laying.

4.104 The tests are done with the trenched cable covered with only the covering layer of dampened sand. The tests then follow the same procedures given in paragraphs 4.96-4.103. These are summarised as follows:

a. record initial and final IR tests between phases and phases to armour;
b. apply an HV d.c. pressure test to cable for 15 minutes and record the leakage current;
c. fully discharge cable;
d. apply termination and seal cable box.

Integrity of cable outer sheath test

4.105 This test checks the outer sheath of a buried section of cable for any damage during laying, and checks insulation from later and subsequent spot damage caused by corrosion in the cable armour.

4.106 The test can be carried out as follows:

a. prepare to apply a d.c. pressure test between the cable armour and a short driven earthed electrode with the trenched cable covered with dampened sand;
b. apply an IR test;
c. by using a d.c. pressure test set, apply a high voltage for a duration of one minute. This test is required at a variable level of 4 kV d.c. per mm of outer sheath material thickness, maximum 10 kV;
d. repeat IR test before closing duct or back-filling trench.

NOTE: Use a 1000 V d.c. (IR) test instrument.

NOTE: BS 6622 and International Electrotechnical Commission publication 229: 1982, 'Tests on cable over sheaths' refer.

NOTE: All cables must be electrically discharged to earth at the end of each test.

5. Electrical protection

Test details

General test procedures

5.1 Electrical protection, instrument and metering tests are carried out after completion of all the pre-commissioning inspections, mechanical functional and electrical functional tests.

5.2 After electrical protection tests have been completed and approved, no further disconnection or modification to tested circuits is permitted.

5.3 If any change is made, that electrical protection circuit must be re-tested and re-approved.

5.4 Immediately before a main circuit is energised, the relays associated with the protection circuits must be operationally demonstrated. This is done with the switching device in the isolated positron, that is, before insertion into the "service" position.

Test instruments

5.5 High grade instrument/meters for this type of protection testing are required. The meters should have been re-calibrated and certified as reliable by an approved test house, and the certificates presented to the engineer for approval.

Relay tests

LV motor thermal overload device

5.6 This test requires a small layout of equipment and should follow the inspection and functional test procedures. The main test procedure is as follows:

a. set thermal relay pointer to motor full load current (FLC) that appears on the nameplate;

b. connect in series all three phases of the overload (O/L) relay;

c. inject 3 x FLC, and measure the time to trip with a stopwatch;

d. compare this time with the O/L current cold curve and determine the percentage time divergence between actual/curve values;

e. allow an extended period of time for the relay to cool, and reset when cooled;

f. allow the thermal relay to stabilise at motor FLC.

5.7 The single phase trip test is carried out as follows:

a. with two phases only in series, inject 2.5 x FLC and measure the time to trip; reset when cooled;
b. record results and compare with O/L current hot curve;
c. check that starter isolator fuse switch and fuse links provide adequate back-up fault protection for the motor cable.

5.8 The stability test is carried as follows: with all three phases of O/L device connected in series, inject motor FLC and observe that the relay remains stable for 15 minutes without operating.

NOTE: The basic equipment required is:

1. 240 V a.c. variac transformer, capable of delivering three times the simulated motor rated current, through the overload device;
2. multimeter with current and voltage indications,
3. stopwatch.

The following particulars should be noted before the test:

a. relay data, that is, type, serial number and manufacturer,.
b. number of thermal elements fitted. Trip level range and setting,.
c. overload, current (OLC) curve of thermal relay current transformers ratio and tapping, full load current (FLC) of motor on nameplate.

Current transformers

5.9 Different types of current transformers (CTs) are provided for differing duties in a switching device: two examples are as follows:

a. for instrument indication, where the indicating meter has a limited deflection above the full scale deflection or maximum current level, it is essential that the CT saturates (the knee point) at just above the maximum current level required;
b. for protection purposes, the CT must not saturate at low levels of current, but must follow a linear output over the full range of overcurrent required for the protection relay to operate. This may be as high as ten times the nominal load current for the circuit load. CTs are identified by a coded system according to BS 3938.

5.10 The CT rated secondary current is normally 1 or 5 amperes. The rated current is normally indicated as, say, 500/1 A for 1 ampere secondary, or 500/5 A for 5 ampere secondary. Multi-ratio CTs should be considered where plant output is to be expanded within the ratings of the existing switching devices.

5.11 The 1 ampere CT is more suitable for long runs of secondary wire due to lesser burden than for the 5 ampere CT.

> **NOTE:** When testing groups of CTs, all the ones that are not being tested must be short circuited at their S1 and S2 terminals. These short circuits must be removed at the end of each successive test and on completion of the final test.

5.12 Secondary S1 and S2 short circuited connections must never be broken when P1/P2 currents flow to avoid induced high voltage in the CT secondary windings.

5.13 The linear accuracy of a CT is demonstrated by the magnetisation curve and is shown graphically by the variation in the input secondary voltage plotted against input secondary current while the primary circuit is open circuited.

5.14 Protection CTs used in three-phase overcurrent or differential circuits should have identical magnetisation curves and be of the same manufacture, type or code and:

a. the polarity of the CT must be checked to ensure the correct installation of the secondary winding S1 and S2 terminals in relation to the primary conductor P1 and P2 terminals. This may be confirmed by the "flick test";

b. the ratio of the CT must be confirmed by injecting a small primary current through P1 and P2 and measuring the current at S1 and S2 terminals. This can be confirmed during the stability, balance or sensitivity tests.

CT balance test

5.15 It is essential that a group of CTs forming an overload and earth fault protection circuit do not operate the relay for any balanced input through current. The CTs must be arranged in the correct polarity for the current flow. The schematic diagram provided by the switchgear manufacturer should refer, and:

a. measured single phase output from a current variac is applied between two phases, on the P2 terminal of the CT;

b. the secondary winding output residual current from the S1 and S2 terminals of the CT is measured in the neutral return loop (all meters, relays and high resistances removed). This neutral circuit residual current should be almost zero in value. If the residual current is twice a single CT output residual current, one of the CTs is incorrectly positioned in relation to P1 and P2 requirements. This process should be repeated to cover the full combination of pairs of CTs, that is, between RY, RB and BY.

Sensitivity of relays

5.16 This test requires the CT's P1 and P2 terminals to be connected to the current variac and the output current from S1 and S2 passed through the operating protection relay, which is usually an earth fault relay located in the CT neutral circuit. The current should be sufficient to activate the relay, normally at 1.5 to 2 times the relay current multiplier setting. Sensitivity test for relays should initially be verified by primary injection into the circuit where the current flow is known, and in relation to the P1 and P2 nomenclature of the CTs marked on the schematic diagram. An operating flow of primary current should cause the protection relay to operate at the set current multiplier.

Stability of relays

5.17 This test demonstrates the correct functioning of differential relay protection circuits in a zone of circuits enclosed by a perimeter of two CTs per phase. The primary current should be at full load to ensure that any characteristic differences in the two perimeter CTs is not sufficient to be detected in error as a lack of balance in the differential circuit. To check the sensitivity of one CT, the primary P1 and P2 should be short circuited, and test current increased to operate the test relay.

5.18 The arrangement of the P1, P2 and CT positions should be in relation to the designated direction of current flow. For a differential scheme, the P1 sides should face inwards towards the zone protected.

5.19 With generators, the ratios of CTs will be equal on either end of the phase/neutral termination of the stator winding.

5.20 For transformers, the ratios will be dictated by the transformer winding ratio/connections to achieve equivalent secondary currents. For the CT secondary protection circuit, the 180° change of phase direction on transformation, plus the phase shift caused by the delta/star primary main circuit connections, must be corrected.

5.21 Reversal of the CT primary P1 and P2 positions or S1 and S2 terminations will correct phase reversal. The CT must be re-labelled. Phase shift due to delta/star connections must be offset by CTs of suitable ratio arranged/connected at each three-phase assembly of CTs into a star-delta in-phase corrective connection.

5.22 The secondary currents and voltages in the respective phases of a delta-star transformer undergo a magnitude change of √3. This magnitude difference must be corrected by interposing current transformers of 1:√3 ratio.

5.23 Possible errors on the circuit diagram or in the actual secondary wiring connections are:

a. CTs star connected on wrong side;
b. wrong delta connection used on current transformers;
c. pilot wires between CTs crossed over.

Secondary injection test equipment

Test plugs

5.24 It is common practice to insert a multi-pin test plug into the relay circuit to facilitate connections of test equipment without disturbing relay circuit wiring.

5.25 By the use of a test plug, the operating and alarm currents of a relay can be injected or measured without disturbing the CT circuit connections. The test plug pins are electrically split; they are inserted between the relay case spring-loaded contacts and short circuited by small links. The spring contacts connect the relay externally to the CT's trip circuits and alarms.

Test variac transformer

5.26 The relay input current is obtained from a purpose-built test variac. This variac should:

a. have sufficient output to replace the CT secondary 1 A and 5 A rating levels (that is, ten times), for the short periods necessary to cause rapid relay operation;
b. be free of harmonic current distortion to the input current;
c. have the input test current flow/time measured to an accuracy of 0.01 second;
d. have metering instruments, control switches and connections to match CT output impedances;
e. be transportable, manoeuvrable at site locations and in switchrooms;
f. have a multimeter capable of accurately indicating 10 A a.c.

Protection relay test criteria

Test arrangements

5.27 The arrangements for the test of the protection relays requires adequate planning because the protective gear is solely concerned with fault conditions.

5.28 Protective relay testing is divided into three stages:

a. factory tests;

b. pre-commissioning tests;

c. periodic maintenance tests.

5.29 The first two stages certify the performance of the protective gear during its development, manufacture and performance in its operational environment. The last stage, when properly planned and carried out, ensures that the relay performance is maintained throughout the life of the protection gear and electrical equipment being protected.

Primary injection test

5.30 The main purpose of this test is to determine the stability of certain types of protective gear under conditions that would prevail in service. This method is also a comprehensive demonstration of the protection, alarm and indication elements provided in a protective gear design.

5.31 The essential requirement of all forms of balanced protection gear is stability under the most extreme through fault current conditions. Under such a fault condition, the CT's primary circuit will be subjected to a sudden rise in current of distorted waveform.

5.32 The growth in primary current will require a corresponding rise in secondary current in the CT. With two differentially connected CTs, any variation in the magnetising characteristic will be shown as an inequality of output and may cause imbalance and incorrect operation of the protective gear.

5.33 The protective systems which may require primary injection tests are:

a. balanced and restricted earth fault protection;

b. bus-bar protection;

c. generator differential protection;

d. pilot wire protection;

e. phase comparison;

f. circuit breaker protection incorporating an earth fault protection element.

Secondary injection test

5.34 Equipment and necessary tests are generally stated in the manufacturers' manuals. These are:

a. a test plug is used in the relay circuits where continuity is maintained by small links inserted into the plug sockets. These short-circuit the split connector pins. Alternatively the sockets may be used to provide a test supply of relay operating current from a test set;

b. portable test equipment can be connected into the relay circuit through the test plug to inject a simulated level of current that would, in an operational circuit, be provided by the CTs. The level of current can be pre-set in multiples of the CT rated current of 1 A or 5 A, then switched into the relay circuit for final adjustment of relay current;

c. when the relay is initiated and the timer started, it will automatically switch off when the relay is tripped to indicate the time of operation.

Scope of relay testing

5.35 Portable test equipment can be applied to the following protection system:

a. overcurrent and earth fault relays;

b. differential relays;

c. pilot wire operated relays;

d. negative phase sequence relays;

e. distance impedance relays;

f. bus-bar protection relays.

Tripping and alarm tests

5.36 During the secondary injection tests, the relay trip and alarm circuits are rendered inoperative by removal of the battery supply fuses, solid links and trip links, etc. This would prevent unnecessary alarms sounding and switch operations. It is essential that on completion of secondary relay testing, all switching device trips, controls, indications and alarms are given a final check for operation.

5.37 The test checks can be performed by operating the relay or trip test buttons to ensure that the correct switching device is operated and the correct flag or signal is annunciated, where the indications are required, at the local or remote control station.

5.38 Where installed, the trip circuit supervision should be checked regularly for operation.

6. Earthing

Power systems

General earthing considerations

6.1 To ensure rapid disconnection of faulty electrical circuits, the site earthing facilities must be considered in relation to the particular plant fault current rating and protection requirement.

6.2 All earthing conductors should be visually inspected at six-monthly intervals and subjected annually to a heavy current injection. SHTM 2021; *Electrical safety code for high voltage systems* refers.

Fault current paths

6.3 The fault current path is defined as the path of minimum impedance starting and ending at the point of the fault. This may take two basic forms:

a. earth fault loop impedance, which is the sum of the impedances starting from the point of fault to the exposed conductive part, the cable earth cores and/or protective conductor, the transformer star point and phase winding, and finally the cable phase conductor returning to the point of fault;

b. earth electrode ground impedance, which is the sum of the impedances starting from the point of fault passing through the building extraneous conductive parts, if present, through the ground to the earth electrode on to the transformer star point and phase winding, and finally the cable phase conductor returning back to the point of fault.

6.4 Where power equipment is supplied by armoured or screened cables, the earth electrode ground impedance may be short circuited by the earth fault loop impedance. Cable armour must not be relied upon as the only earth fault current path.

6.5 An additional conducting path should be present to ensure that the frame of the equipment is solidly connected to earth.

6.6 Equipment with rated currents of 100+ amperes should be connected at the main frame by a 75 mm^2 copper protective conductor directly to the main earth system.

Requirements for an earthed system

6.7 To provide a path to earth for fault currents.

6.8 To eliminate potential dangers to personnel.

6.9 To ensure that all building metal cladding or parts of electrical equipment are connected to earth by a group of low resistance earth electrodes.

6.10 To provide a reference voltage for the correct operation of protective gear to sense and disconnect earth fault currents.

6.11 To allow the passage of sufficient earth current to operate rapidly and safely the largest capacity fuse link in the system.

Recommendations

6.12 Paths of currents in the ground must be of sufficiently low resistance to allow the passage of lightning discharge currents or fault currents from the point of supply to earth. This would prevent the rise of dangerous voltages occurring between any two points that can be touched by one person.

6.13 The main earth system should be linked below ground level to the lightning earth system.

Electronic equipment

6.14 All electronic equipment must be earthed. Electronic equipment for clinical or computer use can be very sensitive to interference caused by fluctuating changes in the volt drop to earth. These occur when they share a protective conductor connected to other items of electrical equipment. A separate earth system to eliminate this interference is recommended. Refer to SHTM 2014 *Abatement of electrical interference* for further guidance.

High frequency heating equipment (industrial and medical diathermy)

6.15 Special care should be taken in high frequency heating operations to ensure that the earth system has a negligible reactance at the frequency of operation.

Earth electrodes

Location of main earth

6.16 The extent of the earth electrode system for the electrical supply must be established early in the construction process. To obtain a stable 2 ohm resistance, the location of the earthing electrode should be selected after repeated ground tests made over an extended period of weather change. Once a location has been agreed with the engineer, it should be marked on the site drawings before structural layout details are drawn. Tests should be taken regularly to determine the effects of site foundations and drainage upon the ground moisture and resistivity (ohm - m^3).

6.17 Resistivity is defined as the ohmic resistance between the two opposite faces of a metre cube of soil. The value of electrode resistance is controlled by:

a. nature of the ground;

b. the density of the earth current flowing through an electrode;

c. the number of electrodes used;

d. the depth of electrode ground insertion.

Earth resistance measurement

6.18 Two methods are generally used:

a. operating a proprietary earth test instrument to the manufacturer's instructions;

b. using a mains supply transformer with controlled secondary output (usually used at large sites).

6.19 In both cases an earth electrode is connected by a surface cable to two driven test earth electrodes where the nearer is placed at approximately half the radius of the farther from the earth electrode.

6.20 A test output current is circulated between the earth electrode and the farther test electrode and the voltage drop is recorded between the earth electrode and the nearer test electrode to give the resistance value. The radius of the nearer test electrode should be varied around the half radius position to ensure that a steady value has been obtained in the voltage drop reading.

NOTE: A high impedance voltmeter must be used (in excess of 200 ohms per volt) to prevent shunting of the ground resistance.

Types of electrode

6.21 There are several types of electrode used. One important consideration is the ground structure and the presence of corrosive electrolytes in the ground soil material. The presence of these electrolytes greatly reduce the life of an electrode. The use of chemicals to lower the soil resistivity is not recommended, as this remedy is not permanent.

6.22 Copper rods, or steel rods encased by a thin copper sleeve, are driven several metres into the ground. Driving copper rods into rock can be very difficult. Examples of different solutions are as follows:

a. in difficult cases, a bore hole should be drilled into the ground and the rod dropped into the hole, and the annulus space then filled with a conductive slurry. In exceptional cases, the bottom of the bore hole may require blasting with explosives to produce ground fissures before the slurry is admitted;

b. cast iron plates or pipes can be buried down to a 3 metre depth. The cast iron parts must be interconnected by waterproof sheathed copper straps or cable. The terminal connections must be suitably protected against metal-to-metal corrosion or ground corrosion by the use of a waterproof tape or compound.

6.23 The use of coke breeze as a contact matrix between the cast iron is not recommended, as the coke contains sulphurous compounds which can accelerate electrode metal corrosion.

Protective conductors

6.24 Copper or aluminium are both satisfactory metals to use as protective conductors. Aluminium, however, presents the least preferred option as it is less easily prepared and jointed than copper, occupies more volume and requires larger fitments.

6.25 Bare copper or aluminium conductors should not be buried in the ground without a PVC protective oversheath. All joints and connections should be wrapped in bitumastic compound or serviceable waterproof woven tape.

6.26 The sizes of earthing conductors which are suitable for switchgear of standard rating is shown in Table 1.

Table 1: Earthing conductor sizes

Switchgear: 3-second rating (kA)	Size of copper conductor cross-sectional area mm^2	Dimensions mm x mm
Not exceeding 14	75	25 x 3
Not exceeding 22	150	25 x 6
Not exceeding 30	228	38 x 6
Not exceeding 44	300	50 x 6

Screened rooms

6.27 If proper planning of hospital departments is carried out, the need for screened rooms is eliminated. These rooms, if constructed, would be used for special treatment/data locations. They are expensive to construct and should be identified at an early stage and advised to the architect.

6.28 All electrical/electronic equipment in such an area should be manufactured to the appropriate standards in respect of their electromagnetic compatibility.

6.29 Where confidential data is processed, all power supplies, control, telephone and data cable should be electromagnetically screened and electrically filtered to prevent radiated or mains borne interference. SHTM 2014; *Abatement of electrical interference* refers.

6.30 A separate earthing system may be necessary, having a short direct route to earth.

Battery earthing systems

6.31 It is recommended that central battery systems should be earthed. Where external telephone systems are provided by others, the telephone earth system equipment will be installed separately by that contractor.

6.32 Battery supplies can cause undesirable corrosion effects in alarm and control circuits activated by the type of polarity connection to the earth system.

NOTE:

1. 50 V batteries should be connected with the positive pole connected directly to earth. This voltage is used generally for telephone and equipment alarm systems.

2. 110 V and 240 V battery supplies should have their positive terminals earthed through a potential dividing instrument designed in such a manner that an earth leakage current flows and activates an alarm when an insulation failure in the circuit is detected. These voltages are used generally for central sources of emergency lighting and control supplies on large switchboards.

7. Power and lighting circuits

Inspection and testing

General

7.1 The purpose of inspection and pre-commissioning is to ensure that the requirements of the contract and the guidance given in the IEE Wiring Regulations are met in the completion of an installation.

7.2 During all pre-commissioning tests on LV circuits, it is essential that due regard is given to the statutory requirements of the Electricity at Work Regulations 1989 and the guidance of SHTM 2020; *Electrical safety code for low voltage systems*.

Identification of circuits and notices

7.3 All distribution boards (DBs) should be correctly and uniformly identified and detailed on a schematic diagram. Where applicable, all DB equipment must display clear numbers and letters on both the front and the inner surfaces.

7.4 All cables entering a DB must be permanently numbered at both ends, and those numbers recorded in the cables schedule with the rating and material details.

Inspection of distribution boards

7.5 All cables entering a DB should be properly glanded and the DB sealed to protect them against vermin.

7.6 Locations of DBs should be suitable for extended work and provide adequate work space.

7.7 All wiring should be neatly arranged and loomed within the DB and all cores identified.

7.8 The DB inspection cover must display, in an accessible manner, a description of all the circuits supplied by or connected to fuse holders or MCBs within the DB.

7.9 Fuse links and MCBs must be correctly sized for the rating of electrical equipment and cables.

Sequence of tests

7.10 It is recommended that the test procedures follow a logical routine and that any incorrect installation be identified at the earliest possible stage in the test. The obvious and easily corrected errors should be recorded for immediate action. The following is a guide to test procedures:

a. ring mains and radial circuit continuity;

b. protective earth conductor continuity;

c. measurement of the circuit's IR;

d. check live and neutral polarities at the load terminals and single phase and/or three-phase sequence of supply at the DB intake;

e. measure the earth fault loop impedance for each circuit to ensure adequate discrimination;

f. where RCDs are installed, check the operation;

g. record tests and observation on the approved record sheets.

Ring main continuity and measurement test

7.11 Method 1:

a. zero the resistance of leads at the test meter;

b. measure the loop resistance of the ring main protective conductor at the DB;

c. measure the resistance between the ring main protective conductor and the earth on the mid-positioned socket-outlet;

d. the resistance of test b should be approximately four times that of test c;

e. repeat b and c for the L and N conductors of the circuit.

NOTE: Before starting the test,ensure that all safety precautions are observed and that both the L and N circuits are isolated and made **dead**.

7.12 Method 2 applied at a common point of test:

a. zero the resistance of leads at the test meter;

b. measure the loop resistance of the ring main protective conductor at the DB;

c. repeat b for L and N circuits;

d. measure the loop resistance, at the DB, between the disconnected Land N circuit wires while the mid-positioned socket-outlet L and N terminals are interconnected;

e. the resistance measured should be approximately half of the resistance of c;

f. measure the loop resistance, at the DB, between the twisted L and circuit protective conductor wires while the mid-positioned socket-outlet L and earth terminals are interconnected;

g. the resistance measured should be approximately one-quarter of the loop resistance of the circuit protective conductor and L conductor circuit resistance obtained in (b) and (c).

Circuit protective conductor continuity test

7.13 Interconnect the circuit protective conductor and N bars within the DB. Measure the resistance between the earth and N terminals at each socket-outlet.

NOTE: Before starting the test, ensure that all safety precautions are observed and that the circuit has been isolated and made **dead**.

High current test of a circuit protective conductor

7.14 Where a steel conduit or enclosure forms part of the circuit of a protective conductor, the circuit should be checked by a high current injection test of 1.5 times the circuit normal rated current, but not greater than 25 amperes.

7.15 A current injected from a controlled source connected between the DB protective conductor bar and the socket-outlet earth terminal should be applied.

NOTE: A continuity test should be carried out prior to commencing this test. This ensures that no excessive voltages will be generated by the controlled current source. It is most essential that the live, neutral and protective conductor of a radial or ring circuit be connected to the correct socket-outlet terminals.

Polarity

7.16 To test for live circuit polarity, the following is carried out:

a. connect a continuity meter between the live terminal in the DB and the L terminals in each socket-outlet of the installation;

b. a correct termination will measure a low circuit resistance; however, an incorrect connection will read an open circuit.

NOTE: The circuit must be isolated and made **dead**.

Insulation tests

Circuit tests

7.17 Single phase circuit insulation resistance test:

a. with the DB isolating switch closed, connect the DB incoming main L and N terminals together;

b. measure the insulation resistance between the connected Land N terminals and the DB protective conductor bar. The measured IR should not be less than 1 Megohm;

c. repeat between L and N with both terminations reinstated.

NOTE:

1. The circuit must be isolated and made **dead**.

2. These tests ensure that a high insulation resistance exists between the live,neutral and the protective conductor connections. A value of at least 1 Megohm is normally expected , from a 240 V system between the nominated socket-outlet L terminal and the N or earth terminals.

7.18 Three-phase circuit insulation test:

a. measure the insulation resistance between each separate phase and the other two phases while the neutral conductor and the protective conductor are shorted;

NOTE: The circuit must be isolated and made **dead.**

Use a 500 V d.c test instrument.

b. isolate the neutral conductor and measure the insulation resistance between the neutral and the protective conductor;

c. the measured insulation resistances should not be less than 1 Megohm.

NOTE: The circuit must be isolated and made **dead.**

Use a 500 V d.c test instrument.

Earth circuit tests

General

7.19 There are two main tests required. These are the earth electrode resistance test and the earth loop impedance test.

7.20 **Electrode resistance**. This test measures the resistivity in ohm-metres offered by the surrounding ground mass to the passage of an electrical current from a buried earth reference electrode. Where more than one earth electrode is driven, each should be measured separately.

7.21 **Earth loop impedance**. The earth loop impedance test measures the impedance to the flow of current from the live terminal into the protective conductor, the main cable armour, through the transformer neutral point and winding and back by the phase conductor to the live terminal. The following refers:

a. earth electrode resistivity test:

(i) the main earth electrode bank must be separated at the main earth terminal bar into temporary sub-banks, one for continued operation and the other for test purposes;

(ii) a proprietary earth electrode tester is connected between the main earth sub-bank test terminal bar and two driven test electrodes at equally spaced distances from the earth electrode bank;

(iii) for a stable reading, adjust the nearer test electrode position. The measured resistance obtained will be in ohms;

(iv) for an instrument giving only a resistivity ohm-metre reading, the resistance of an electrode driven into untreated soil is given by the equation:

$$\text{resistance} = \frac{p}{275L} \log_{10} \frac{(400L)}{d} \text{ ohms}$$

where p = resistivity in ohm-metres;

L = length of rod in metres;

d = distance of the rod in metres , where L is much greater than d;

(v) a 3.6 metre long, 12 mm diameter electrode is capable of carrying a current of 50 to 100 amps where the resistivity is 50 to 200 ohm-metres;

b. earth loop impedance test:

(i) this test uses a proprietary phase-earth loop test instrument and can be carried out from an a.c. socket-outlet position while the circuit is **live**;

(ii) the instrument injects a large current pulse of short time duration into the loop circuit to indicate the earth loop impedance. This current is of insufficient magnitude to activate the protection.

8. Sample test sheets

General

These sample test sheets are presented as examples only. The tests and recorded results for various items of electrical equipment should be mutually agreed between the engineer and the contractor, within the restraints of the contract document.

Contents

8.1: Fixed panels and switchboard inspection

<table>
<tr><td colspan="2">Plant Item: Fixed panels and switchboard inspection</td><td>Completed</td><td colspan="2"></td></tr>
<tr><td colspan="2">Identification/location:</td><td>Incomplete</td><td colspan="2"></td></tr>
<tr><td colspan="2">Contractor:</td><td colspan="3" rowspan="3">PC address - file</td></tr>
<tr><td colspan="2">Manufacturer:</td></tr>
<tr><td colspan="2">Serial No:</td></tr>
<tr><td>No</td><td>Activity</td><td colspan="2">Witnessed</td><td rowspan="2">Date</td></tr>
<tr><td></td><td></td><td>Engineer (HCP)</td><td>Contractor</td></tr>
<tr><td>1</td><td>Check drawing for any damage or incomplete work.</td><td></td><td></td><td></td></tr>
<tr><td>2</td><td>Check all labels, warning symbols, switchboard and circuit identification labels are correct.</td><td></td><td></td><td></td></tr>
<tr><td>3</td><td>Check switchboard is fixed and mounted correctly.</td><td></td><td></td><td></td></tr>
<tr><td>4</td><td>Check switchboard protective earth conductors are connected to the main earth system.</td><td></td><td></td><td></td></tr>
<tr><td>5</td><td>Check terminations, lugs and blocks for tightness.</td><td></td><td></td><td></td></tr>
<tr><td>6</td><td>Check VT and CT compartments assembled correctly.</td><td></td><td></td><td></td></tr>
<tr><td>7</td><td>Check shutter linkage and the locking facilities.</td><td></td><td></td><td></td></tr>
<tr><td>8</td><td>Rack all devices into cubicle service position;
note: shutters must have smooth, easy movement.</td><td></td><td></td><td></td></tr>
<tr><td>9</td><td>Check all bus-bar bolted joints with a set torque spanner, and inspect joint contact surfaces.
Bolts sizes (mm)
Specified torque setting (nm) …………….</td><td></td><td></td><td></td></tr>
<tr><td>10</td><td>Isolate VT, remove fuselinks of voltmeter and CTs
Measure: (i) IR vt. py./sy. (ii) IR CT sys.
(iii) IR bus-bar and circuit bar phases</td><td></td><td></td><td></td></tr>
<tr><td>11</td><td>Measure total conductance of HV bus-bar phases along the switchboard, by ohmmeter measurement: e.g. by:
a. between adjacent cubicle bus-bar phase spouts (BS)
b. between circuit spout (CS) and cable box (BT)
Note: Estimate resistance, from 1.0 m of conductor.</td><td></td><td></td><td></td></tr>
<tr><td></td><td>
<table>
<tr><td>Between spouts</td><td>Red phase</td><td>Yellow phase</td><td>Blue phase</td><td>Res.</td></tr>
<tr><td>BS1 &2</td><td></td><td></td><td></td><td>micro ohms</td></tr>
<tr><td>BS2 & 3</td><td></td><td></td><td></td><td>micro ohms</td></tr>
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<tr><td>2CS & 2BT</td><td></td><td></td><td></td><td>micro ohms</td></tr>
<tr><td>3CS & 3BT</td><td></td><td></td><td></td><td>micro ohms</td></tr>
<tr><td>4CS & 4BT</td><td></td><td></td><td></td><td>micro ohms</td></tr>
</table>
</td><td></td><td></td><td></td></tr>
</table>

Witnessed	Engineer (HCP)	Contractor	Date	Sheet 1 of 1
Print name and sign				

8.2: HV pressure test – switchboards

Plant item: HV pressure test - switchboards	Completed	
Identification/location:	Incomplete	
Contractor:	PC address - file	
Manufacturer:		
Serial No:		

No	Activity	Witnessed Engineer (HCP)	Contractor	Date
1	Before HV test, ensure all covers and fittings are replaced and are secure.			
2	Check: (i) all instrument fuselinks removed; (ii) VT isolated and CT fuselinks removed; (iii) IR test bus-bars before and after pressure test. Megaohm values: R-Y…/…, Y-B…/…, B-R…/… R-N…/…, Y-N…/…, B-N…/… R-E…/…, Y-E…/…, B-E…/…			
3	Ensure the Safety Rules are strictly followed, according to HTM 2021 (HV).			
4	Pressure test bus-bars – as directed by contract e.g. 0.415 kV system – 2 kV a.c. for one minute 3.3 kV system – 8.6 kV a.c. for one minute 11 kV system – 24 kV a.c. for one minute			

	Voltage	Humidity	Temperature
	………..kV	………..%	……….. ºC
Phase leakage current	R-Y ……….mA	Y-E ……….mA	B-E ……….mA
Phase leakage current	R-N ……….mA	R-N ……….mA	B-N ……….mA
Phase leakage current	R-E ……….mA	Y-E ……….mA	B-E ……….mA

No	Activity	Engineer (HCP)	Contractor	Date
5	Check IR of close, open and control circuits. Remarks: Switchboards in site locations should be HV tested and energised as soon as possible, as security against bus-bar copper theft.			

Witnessed	Engineer (HCP)	Contractor	Date	
Print name and sign				Sheet 1 of 1

8.3: Switching devices – mechanical test

Plant Item: Switching devices – mechanical test	Completed	
Identification/location:	Incomplete	
Contractor:	PC address - file	
Manufacturer:		
Serial No:		

No	Activity	Witnessed		Date
		Engineer (HCP)	Contractor	
1	Inspect switch device for damage and cleanliness.			
2	Check all components are assembled and tightened as required in the general arrangement drawing.			
3	Check all device labels against switch schedule.			
4	Check device fixed/moving contact alignments are correct to manufacturer's recommendations.			
5	Carry out manual slow and spring close operations, then trip circuit breaker or device by mech PB.			
6	Establish close, open and control supplies.			
7	Measure resistance across each circuit breaker closed phase contacts at (CB), with ohmmeter.			
	1CB micro ohms 2CB micro ohms 3CB micro ohms 4CB micro ohms			
8	Circuit earth and isolated arrangements. Ensure the cubicle bus-bar shutter door mechanism is locked shut. The circuit shutters must be unlocked for circuit earth test.			
9	(i) at cubicle: rack-in device to earth position, close by electrical operation at the local and remote controls; (ii) repeat for isolated position; (iii) check operation of any circuit key interlocks.			
10	Check movement of auxiliary switches and mechanical semaphores, at both earth and isolated positions.			

Witnessed	Engineer (HCP)	Contractor	Date	Sheet 1 of 1
Print name and sign				

8.4: Switching devices – electrical test

Plant Item: Switching devices – electrical test	Completed	
Identification/location:	Incomplete	
Contractor:	PC address - file	
Manufacturer:		
Serial No:		

No	Activity	Witnessed		Date
		Engineer (HCP)	Contractor	
1	Ensure cubicle bus-bar/circuit shutter door mechanisms are locked shut, if switchboard has been energised.			
2	Carry out IR test between device open main contacts, and when closed, between phases and frame earth. Values: R…/…/…/Y…/…/…/B…/…/…/Megaohms			
3	HV pressure test device – as directed by contract. e.g. 3.3 kV system – 8.6 kV for one minute. 11 kV system – 24 kV for one minute.			
	Kilovolts (kV)			
	(i) between phases, with the circuit breaker closed; — RV-B kV, RB-Y kV, BY-R kV (ii) between phases and frame earth; — RY-BE kV, RB-YE kV, BY-RF kV (iii) across open contacts. — R-Y kV, R-B kV, B-Y kV			
	Values: R…/…/…/Y…/…/../B…/…/…/Megaohms.			
4	Rack the device into the cubicle isolated position, for the close/open operational tests.			
5	Check at local control: close and trip of device at the rated battery voltage: minimum of ten operations.			
6	Check the operation of close and trip at 80% of the rated applied close battery voltage.			
7	Check operation of trip mechanism at 50% of the rated applied trip battery voltage.			
8	Check time of closing mechanism operating spring to recharge, at 80% of rated applied voltage.			
9	Emergency generator set circuit breaker sequence test to SHTM 2011, as applicable.			

Witnessed	Engineer (HCP)	Contractor	Date	
Print name and sign				Sheet 1 of 1

8.5: Transformer – mechanical test

Plant Item: Transformer - mechanical test					Completed		
Identification/location:					Incomplete		
Contractor:					PC address - file		
Manufacturer:							
Serial No:							
No	Activity				Witnessed		Date
					Engineer (HCP)	Contractor	
1	Check drawing: general inspection for damage and completeness.						
2	Check all components fitted to general arrangements.						
3	Prove tightness of all fastenings.						
4	Check all labelling to transformer schedule.						
5	Check transformer correctly positioned in bay for cable box entries/bushing connections.						
6	Check colour of dessicator crystals is blue (conservator type).						
7	State type of coolant in tank.						
8	Check if transformer filled with oil/fluid to operating level – yes/no.						
9	Check for any oil/fluid leaks.						
10	Check if cable box details agree with cable details and requirements.						
11	Check location of loose CTs, if provided, and method of connection in cable-box or to star-point neutral.						
12	Check position of transformer earth lug and connection to main earth system.						
13	Prelim. d.c. IR using megger and res. check of winding.						
	HV-	R-Y: M ……. ohms	Y-B: M ………ohms	B-R: M ……….ohms			
	LV-	r-y: M ………..ohm	y-b: M ………..ohm	b-r: M ………..ohm			
	HV/LV-	R-r: M RYB-E: M	Y-y: M	B-b: M ryb-E: M			

Witnessed	Engineer (HCP)	Contractor	Date	Sheet 1 of 1
Print name and sign				

8.6: Transformer – electrical test

Plant item: Transformer – electrical test Identification/location: Contractor: Manufacturer: Serial No:	Completed		
	Incomplete		
	Pc address - file		

No	Activity	Witnessed		Date
		Engineer (HCP)	Contractor	
1	Check marshalling box wiring connections at termination blocks for tightness and correct labelling/ferrulling.			
2	Check IR of control wiring using megger: (i) marshalling box control wiring; (ii) Buchholz; (iii) temperature indicators: oil/fluid core			
3	Temperature indicators set at oil/fluid ^{0}C alarm ^{0}C trip core ^{0}C alarm ^{0}C trip			
4	Fill transformer with oil/fluid to operating level on conservators, if required. (New transformer oil/fluid to be used. Each barrel to be individually sampled and certified to BS 148 before putting into transformer tank.)			
5	Check IR of core insulation to earth before link is covered with oil/fluid, during fill operation.			
6	Check IR of oil/fluid filled transformer. HV - R–Y: M, Y–B: M, B–R: M LV – r-y: M, y-b: M, b-r: M HV/LV – R-r: M, Y-y: M, B-b: M RYB-E: M, ryb-E: M, N-E: M			

Witnessed	Engineer(HCP)	Contractor	Date	Sheet 1 of 3
Print name and sign				

Plant item: Transformer – electrical test Identification/location: Contractor: Manufacturer: Serial No:	Completed Incomplete	
	Pc address - file	

No	Activity	Witnessed		Date
		Engineer (HCP)	Contractor	
7	Winding ratios at each off-load tap position, and the transformer vector group. (i) apply 415V 3-phase a.c. to HV winding terminals, and interconnect: R – HV phase to R – LV phase. (ii) winding ratio: HV: R-Y: v, Y-B: v, B-R: v. LV: r-y: v, y-b: v, b-r: v. Tap posns 1 v, v, v. 2 v, v, v. 3 v, v, v. 4 v, v, v. 5 v, v, v. 6 v, v, v. 7 v, v, v. 8 v, v, v. 9 v, v, v. 10 v, v, v. 11 v, v, v. (iii) vector group R-Y v, Y-B v, B-R v. r-y v, y-b v, b-r v. R-r v, Y-y v, B-b v, B-Y v, Y-b v, B-b v.			
8	Check trip/alarms supplies voltages: (i) at circuit breaker (as provided); (ii) at transformer: (a) Bucholz (b) oil/fluid temperature (c) Tank pressure (d) cooling fans running			
9	Check IR of tap changer control panel with megger (where provided)			

Witnessed	Engineer(HCP)	Contractor	Date	Sheet 2 of 3
Print name and sign				

<table>
<tr><td colspan="2">Plant item: Transformer – electrical test
Identification/location:
Contractor:
Manufacturer:
Serial No:</td><td colspan="3">Completed
Incomplete
Pc address - file</td></tr>
<tr><td>No</td><td>Activity</td><td colspan="2">Witnessed</td><td>Date</td></tr>
<tr><td></td><td></td><td>Engineer (HCP)</td><td>Contractor</td><td></td></tr>
<tr><td>10</td><td>Check IR of transformer cooling fan motors, and cable termination (where provided).</td><td></td><td></td><td></td></tr>
<tr><td>11</td><td>Check transformer cooling fan motor electrical function in local/remote/auto modes.</td><td></td><td></td><td></td></tr>
<tr><td>12</td><td>Check transformer cooling fan motor overload/time by 3 phase and single phase injection.</td><td></td><td></td><td></td></tr>
<tr><td>13</td><td>Check cooling fan motor rotation.</td><td></td><td></td><td></td></tr>
<tr><td>14</td><td>Check the three phases to each winding of the transformer are not cross-connected between the near or the far terminations.</td><td></td><td></td><td></td></tr>
<tr><td>15</td><td>Final bay check before energising transformer:
(a) take final oil samples for analysis and certification, one from the tank drain valves and one from the Buchholz relay drain cocks;
(b) check IR of the HV and LV windings;
(c) check operation of all protection trips and alarms at initiating devices and control section;
(d) check cooling fan controls are operational;
(e) cable box and bushing connections tight, oil leak free and secure;
(f) transformer bay gate locked shut.</td><td></td><td></td><td></td></tr>
</table>

Witnessed	Engineer(HCP)	Contractor	Date	Sheet 3 of 3
Print name and sign				

8.7: LV contactor gear

Plant item: LV contactor gear Identification/location: Contractor: Manufacturer: Serial No:		Completed		
		Incomplete		
		Pc address - file		
No	Activity	Witnessed		Date
		Engineer (HCP)	Contractor	
1	Check all components fitted to general assembly drawing.			
2	Check tightness of all fastenings.			
3	Check labelling and warning symbols to relevant diagram.			
4	Check earth connection to main earth system.			
5	Check all flash guards and contacts aligned.			
6	Check mechanical operation and interlocks.			
7	*IR check 415V circuit using megger. R-Y / R-B / Y-B R-E / B-E / B-E *Short circuit/disconnect all electronic equipment which could be damaged before megger testing.			
8	D.c. operated contactors – check that contactor operates at: (i) 80% of rated voltage (close); (ii) 50% of rated voltage (trip).			
9	A.c. operated contactors – check that contactor operates at: (i) 85% of rated voltage and remains closed down to 75% of rated voltage.			
10	Operate contactor five times at normal operating voltage.			
11	Check current ratings of all fuselinks.			

IR check table (item 7):

R-Y	R-B	Y-B
R-E	B-E	B-E

Witnessed	Engineer(HCP)	Contractor	Date	Sheet 1 of 1
Print name and sign				

8.8: Motor thermal overload device: overload injection

Plant item: Motor thermal overload device: overload injection Identification/location: Contractor: Manufacturer: Serial No:		Completed		
		Incomplete		
		Pc address - file		
No	Activity	Witnessed		Date
		Engineer (HCP)	Contractor	
1	*Relay data* Type……………………….. Serial no……………………... Element fitted……………. Circuit FLC…………………… CT ratio…………………… CT tapping…………………… Trip level setting…………. Phases……………………….. Note: trip level setting will normally be circuit or motor full load current (FLC). With all three phases connected in series, check starting curve (cold), measure time to trip at three times FLC. Time from curve…………………………………………… sec. Time measured…………………………………………… sec. Time measured to be within…..% of optimum characteristic.			
2	Reduce current to zero and ensure that relay will reset when cold.			
3	Single phasing check: maintain at circuit FLC and allow relay to reach a stable state. Inject 2.5 times FLC level setting through left and centre elements in series. Repeat through centre and right elements in series. Measure times to trip. LH and centre…………………………………………….. sec. RH and centre…………………………………………….. sec. Time measured to be within……..…% of manufacturer's specified time.			
4	Stability check: carry out stability test at FLC level setting for 15 minutes. All temporary connections and shorts removed on completion.			

Witnessed	Engineer(HCP)	Contractor	Date	Sheet 1 of 1
Print name and sign				

8.9: Functional and IR test – secondary wiring

<table>
<tr><td colspan="3">Plant item: Functional and IR test – secondary wiring
Identification/location:
Contractor:
Manufacturer:
Serial No:</td><td colspan="2">Completed</td><td></td></tr>
<tr><td colspan="3"></td><td colspan="2">Incomplete</td><td></td></tr>
<tr><td colspan="3"></td><td colspan="3">Pc address - file</td></tr>
<tr><td colspan="6">Activity</td></tr>
<tr><td rowspan="2">Schematic diagram number</td><td rowspan="2">Circuit description</td><td rowspan="2">Core numbers involved</td><td colspan="3">Results</td></tr>
<tr><td colspan="2">Function check</td><td>IR check</td></tr>
<tr><td></td><td></td><td></td><td colspan="2"></td><td></td></tr>
</table>

Notes of guidance for testers:
The tester must systematically check through all circuits to the approved schematic diagram proving the function of components in the equipment schedule, and also carry out negative checks.

The tester must carry out a final check of connections, and ensure all fuses and solid links, earthing and wiring termination, dust covers, shrouds and all test leads, connections, shorts, etc have been removed from the panels before establishing the permanent supply voltage.

Witnessed	HCP	Contractor	Date	Sheet 1 of 1
Print name and sign				

8.10: Secondary wiring injection test (tripping and auxiliary tripping relays)

Plant item: Secondary wiring injection test (tripping and auxiliary tripping relays) Identification/location: Contractor: Manufacturer:	Complete	
	Incomplete	
	PC address – file	

Activity								
Function and location	Make, type and model number	Serial no	Mech. insp.	Minimum operating volts/amps (not normally applicable to single auxiliary relays) (note 2)		Operate time (note 1)	Reset time (note 1)	Nominal rating volts/ amps
				Operate coil	Reset coil			

Note 1: Operating and reset times to be checked at rated volts for slugged relays and timing relays.
Note 2: An overall minimum operating voltage test should be applied to all relay systems to eliminate possibility of spurious operating conditions.

Remarks:

Witnessed	HCP	Contractor	Date	Sheet 1 of 1
Print name And sign				

8.11: Batteries

Plant item: Batteries Identification/location: Contractor: Manufacturer: Serial No:	Completed	
	Incomplete	
	Pc address - file	

No	Activity	Witnessed		Date
		Engineer (HCP)	Contractor	
	Inspection of battery installation prior to initial charge			
1	Check that battery/battery room labelling/identification is complete and correct.			
2	Check that equipment is undamaged, correctly installed and complete.			
3	Disconnect all solid state electronic monitoring or protection devices during IR tests.			
4	Check insulation resistance to earth of battery using a d.c. megger (battery disconnected). Connections/bus-bars: Positive to earth……………………………………….Mohms Negative to earth……………………………………..Mohms			
5	Check intercell connections are tight and joints greased. *Any damage to paintwork on battery support steelwork must be rectified prior to filling cells.			
6	Fill cells to correct level with electrolyte.			
7	Record cell voltages and s.g.'s (sheet 2).			
8	Check filler caps are secure and vent holes free.			
9	Check bus-bars are shrouded, secured and identified for polarity.			
10	Check wall bushings are secure, sound and clean.			
11	Link box identified, lockable and correct colour (red).			
12	Check battery link box fuse rating correct.			

Witnessed	Engineer(HCP)	Contractor	Date	Sheet 1 of 1
Print name and sign				

8.12: Battery charger – charge test

Plant item: Battery charger – charge test Identification/location: Contractor: Manufacturer: Serial No:		Completed		
		Incomplete		
		Pc address - file		
No	Activity	Witnessed		Date
		Engineer (HCP)	Contractor	
1	Operate charger to fully charge battery.			
2	Connect load equipment up to 50% of charger rating. With charger switched off, check that battery discharges correctly into load (instrument polarities correct, etc). Check that low voltage alarm operates			
3	Switch charger on to "float" and check charger attains fully rated output. Check "current limit" feature operates.			
4	Switch charger to "boost" (where provided), and with load still connected, check that full rated output is obtainable. (This test must not be unattended). Note: Boost current control should be set to maximum. Maximum current may only persist for a short time before a current reduction occurs.			
5	Switch charger to "float" and with load still connected check that d.c. rated voltage is within specification for rated a.c. voltage.			

Witnessed	Engineer (HCP)	Contractor	Date	Sheet 1 of 1
Print name And sign				

8.13: Battery discharge test

Plant item : Battery discharge test Identification/location: Contractor: Manufacturer:	Completed	
	Incomplete	
	Pc address - file	

Activity

Ampere hours ………………………… Ten hour test rate ………………………………
Volts at commence of test …………… Volts at completion ……………………………
Ambient temp. ºC Ambient temp. ºC

Hours of Discharge

Cell no	Init. spg	25 v	1 v	2 v	3 v	4 v	5 v	6 v	7 v	8 v	8.5 v	9 v	9.5 v	10 v	10.5 v	11 v	Final spg	Final v

Energising checks, load and discharge test carried out to BS6290

Remarks:

Witnessed	Engineer (HCP)	Contractor	Date	Sheet 1 of 1
Print name and sign				

8.14: Cables and terminations

Plant item: Cables and terminations Identification/route: Contractor: Manufacturer: Cable type:	Completed	
	Incomplete	
	Pc address – file	

No	Activity	Witnessed: Engineer (HCP)	Witnessed: Contractor	Date
1	Carry out general inspection of cable route.			
2	Check cable ends are correctly identified for each cable and phase(s) end.			
3	Check cable trench is of correct depth, with correct depth of refill sand, cable spacing, tiles and marker tape.			
4	Check arrangement of cables on trays is at correct level, spacing and tidy arrangement.			
5	Check that single core cables in trefoil or flat pattern are correctly secured to tray with straps/cleats/binders of correct material and spacing.			
6	Check duct entries into buildings are secured against moisture penetration, fire hazard or vermin entry.			
7	Check lug is correct size for cable end and termination stud in schedule.			
8	Check cable gland is correct size and type for duty required in schedule.			
9	Check cable boxes/cable ends are prepared for termination to cable manufacturer's recommendations.			
10	SHTM 2021: HV Safety Code Rules apply: a. HV d.c. test on each phase group for 15 mins……kV d.c. b. buried cable: oversheath test for one min……… kV d.c. c. cable IR values between phases and phase to armour to be recorded before and after (a) and (b) HV tests.			

Phase I.R. leakage ma.	R – Y	Y – B	B – R
Phase I.R. leakage ma. Oversheath	R-arm	Y-arm	B-arm
	Armour-earth		I.R.

Witnessed	Engineer(HCP)	Contractor	Date	Sheet 1 of
Print name and sign				

8.15: CT polarity test (flick test)

Plant item: CT polarity test (flick test) Identification/location: Contractor: Manufacturer: Serial Nos/types:	Completed	
	Incomplete	
	Pc address - file	

No	Activity	Witnessed		Date
		Engineer (HCP)	Contractor	
	Polarity and continuity tests For each CT: connect meter (Avo or d.c. voltmeter) across the S1 and S2 terminals; positive to S1 and negative to S2. Apply a low voltage battery supply across the CT. P1/P2 primary input supply: connect negative of battery to P2 side and the positive of battery to P1 side. *Make-break* battery positive/P2 connection. The meter pointer will deflect, +ve/-ve. Correct CT termination/orientation and polarity: +ve deflection on +/P2-make -ve deflection on +/P2-break *Record test results below:* Ferrule nos			

Serial nos	Primary	Secondary
Polarity correct		
Polarity correct		
Polarity correct		
Polarity correct		
Polarity correct		
Polarity correct		
Polarity correct		
Polarity correct		

Indicate number of remark sheets attached

Witnessed	Engineer(HCP)	Contractor	Date	Sheet 1 of 1
Print name and sign				

8.16: CT magnetisation characteristics

Plant item: CT magnetisation characteristics Identification/location: Contractor: Manufacturer:	Completed	
	Incomplete	
	Pc address - file	

Activity												
Function, Ratio and location	Phase and wire nos	CT Terminal nos	Serial nos	CT res. (ohm)	Insul. Res. M-ohm	Secondary magnetisation. Curve-Plot: mA against volts						
	- R Y B	-	-	-		v	v	v	v	v	v	v
	- R Y B	-	-	-		v	v	v	v	v	v	v
	- R Y B	-	-	-		v	v	v	v	v	v	v
	- R Y B	-	-	-		v	v	v	v	v	v	v
	- R Y B	-	-	-		v	v	v	v	v	v	v
	- R Y B	-	-	-		v	v	v	v	v	v	v

Remarks:

Witnessed	Engineer(HCP)	Contractor	Date	Sheet 1 of 1
Print name and sign				

8.17: Secondary injection test (IDMT relay)

Plant item: Secondary injection test (IDMT) relay Identification/location: Contractor: Manufacturer: Serial No:					Completed Incomplete Pc address - file		
Manufacturer's description					Setting for tests		
Test					R	Y or N	B
General inspection Check contacts close at zero Tm time and follow through Check flag operation Measure time to reset from contacts closed, at 1.0Tm Check trip isolation contact Set at 100% Pm, check no creep at 1.0 Psm, and creep commences at/or before 1.25 Psm current values. Check plug bridge continuity, max Pm setting and with plug out Check relay, CT shorts removed	seconds						
CT ratio….. /….., type:	Relay controls				Relay operating times		
Time/current characteristics at 100% Pm and at applied setting	Pm 100%	Tm 1.0 0.5 1	Psm 1.3 2 2 4	amps	R	Y or N	B
Applied setting			2				
Flag reset / Final setting applied							
Remarks:							

Witnessed	Engineer(HCP)	Contractor	Date	Sheet 1 of 1
Print name and sign				

8.18: Secondary injection test (instantaneous relay)

Plant item: Secondary injection test (instantaneous relay) Identification/location: Contractor: Manufacturer: Serial No:	Completed	
	Incomplete	
	Pc address - file	

Manufacturer's description	Setting		
Test	R	*Y or N	B
General inspection Check trip isolation contacts Check flag operation Check CT's shorts Plug bridge continuity (inst o/c relays)			

R		*Y or N		B	
Plug setting	Op amps	Plug setting	Op amps	Plug setting	Op amps
Plug out		Plug out		Plug out	

		R	*Y or N	B
*With stabilising resistor in series and CTs in shunt.	Stab. resistor value			
	Applied setting			
	Operating volts			
	Operating current			

Flag reset	Final setting applied

Remarks:

Witnessed	Engineer(HCP)	Contractor	Date	Sheet 1 of 1
Print name and sign				

8.19: Secondary injection test – instantaneous relay (voltage operated)

Plant item: Secondary injection test – instantaneous relay (voltage operated) Identification/location: Contractor: Manufacturer: Type: Serial No:	Completed	
	Incomplete	
	Pc address - file	

Manufacturer's description	Setting range				Setting	
Test	R	Y	B			REF
General inspection Check trip isolation contacts Check flag operation Check CT shorts						

Voltage setting	R		Y		B			Voltage setting	REF	
	v	a	v	a	v	a			v	a
Setting ( )								Setting ( )		

At setting with CTs in shunt: setting resistors (ohms) and metrosils in circuit. volts…………………………………………. amps………………………………………….	At setting with CTs in shunt and setting resistor (ohms) and metrosils in circuit. volts………………………………………………. amps……………………………………………….

Flag reset	Final settings applied

Remarks:

Witnessed	Engineer(HCP)	Contractor	Date	Sheet 1 of 1
Print name and sign				

8.20: Restricted and standby earth fault relays (ref & set) wiring and circuit resistance diagrams

<table>
<tr><td colspan="4" rowspan="3">Plant item: Restricted and standby earth fault relays (ref & set)
Wiring and circuit resistance diagrams

Identification/location:

Contractor:

Manufacturer:

Cct. diagram no:</td><td>Complete</td><td></td></tr>
<tr><td>Incomplete</td><td></td></tr>
<tr><td colspan="2">Pc address – file</td></tr>
<tr><td>No</td><td colspan="5">Activity</td></tr>
<tr><td></td><td colspan="5">(a) The diagram is to be completed showing the points of injection and measurement.
(b) Complete the measurement of the lead resistances, stabilising resistance and the CT resistance and enter the results in the appropriate boxes of the diagram on sheet.

DIAGRAM TO BE INSERTED
(SEE p52 OF HTM 2001 – IN PROGRESS)</td></tr>
<tr><td colspan="6">Remarks:</td></tr>
<tr><td>Witnessed</td><td>Engineer (HCP)</td><td>Contractor</td><td>Date</td><td colspan="2" rowspan="2">Sheet 1 of 1</td></tr>
<tr><td>Print name and sign</td><td></td><td></td><td></td></tr>
</table>

8.21: Current transformer – primary injection test

Plant item: Current transformer – primary injection test Identification ________________________ Location ________________________ Contractor ________________________	Manufacturer ____________________ Serial No ____________________

Caution: When conducting these tests, care must be taken not to exceed any limitations, eg current or voltage magnitude and duration ratings, of any associated protection or other apparatus which remains connected during the tests, or of those parts which form the injected current path.

CT duty radio and injection point	Phases injected	Primary current (amps)	Details of measurements and phases measured											Witnessed		Date
														HCP	Contr.	

Type of instrument ammeter, voltmeter etc.	Instrument duty	Serial no	Scale Range	Current volts, watts/ vars injected	Power factor	Instrument transformer ratio	Instrument reading	How operated (inst. trans., transducer etc)	Complete Incomplete
									PC address file

8.22: Electrode – soil resistivity

Plant item: Electrode – soil resistivity Identification/location: Contractor: Manufacturer: Serial No:		Completed Incomplete Pc address - file		
No	Activity	Witnessed: Engineer (HCP)	Witnessed: Contractor	Date
1	Select from the site map a grid area where earth electrode bank may be installed.			
2	Record area on site area plan.			
3	Set in-line, test spikes as stated in earth tester instrument operating instructions for a single electrode.			
4	Record earth tester displayed resistance (Rm) reading in ohms. Rod/group | Resistance (Rm) | Resistivity (P) Convert resistance to resistivity (P) in ohm-metres:			
5	P = ZnaRm = ohm-metre where a = distance between test spikes (metres) Rm = displayed/calc. resistance (ohms) Ref BS7430: 1998			

Witnessed	Engineer(HCP)	Contractor	Date	Sheet 1 of 1
Print name and sign				

8.23: Main/lighting earth electrode resistance

Plant item: Main/lightning earth electrode resistance Identification/location: Contractor: Manufacturer: Serial No:	Completed | Incomplete | Pc address - file

No	Activity	Witnessed Engineer (HCP)	Witnessed Contractor	Date
1	Check terminal connections of earth electrodes are located below ground level, enclosed in concrete boxes and identified by the approved nomenclature.			
2	Check omissions, approved terminations and cleanliness of finish of all main earth connecting conductors.			
3	Check all main earth bar terminations are singly connected.			
4	Earth electrode: dia………. length……….no……….			
5	Set out, in-line: test spike A at 25m radius and test spike B at 50m radius to main earth electrodes and connect a 250 vac earth tester, or			
6	Connect 250 vac power source and multi-ammeter between earth electrode and test spike B with a 10 kohm per volt voltmeter between earth electrode and test spike A.			
7	Record earth test resistance or calc.			

Electrode	volts	amps	Res. ohms
Full group			
Half group 1			
Half group 2			

Note: adjust radius of test spike A for steady resistance.

No	Activity	Witnessed Engineer (HCP)	Witnessed Contractor	Date
8	Repeat (5) or (6) with main electrode group split into half groups.			
9	Remake connections and,			
10	Check all bolted terminal connections are weatherproof.			

Witnessed	Engineer(HCP)	Contractor	Date	Sheet 1 of 1
Print name and sign				

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	
BS EN ISO 3766	**Construction drawings. Simplified representation of concrete reinforcement**	BSI Standards	1999	

Publication ID	***Title***	***Publisher***	***Date***	***Notes***
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
SFPN 5	Commercial enterprises on hospital premises	P&EFEx	1999	CD-ROM

Publication ID	***Title***	***Publisher***	***Date***	***Notes***
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	
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	

Publication ID	***Title***	***Publisher***	***Date***	***Notes***
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		