2.1 Purpose of initial verification

610.1 Initial verification is carried out on a new installation before it is put into service. The

6n.2 purpose is to confirm by way of inspection and testing, during construction and on

612.1 completion, that the installation complies with the design and construction aspects of BS 7671, in so far as is reasonably practicable.

Intro (v) It is important to recognise the responsibilities of the signatories for the design, construction and verification. While the inspector is responsible for verifying aspects of both design and construction, he/she cannot and is not meant to absolve responsibility for these elements; indeed, this is why the inspector carries out the inspection and testing so far as is reasonably practicable.

Example

Consider one aspect of the design: the inspector should check that the cable sizes, as specified, have been correctly selected and installed. In order to do this he or she would need the design criteria, say a cable schedule, and would then carry out a visual inspection of the installed cable sizes for comparison. The most logical position to do so would be at the distribution board housing the cables' protective devices. It would be unreasonable for him or her to carry out design cable sizing checks, as this is the responsibility of the designer.

At this point, it would also be unreasonable for the inspector to check that each cable size at the distribution point is maintained throughout the cable's length (this is the responsibility of the installer or constructor).

This example illustrates the principle and responsibilities, that the designer and constructor of the installation are both confirming their facets and that the inspector carries out checks but only in so far as to supplement the responsibilities of others.

611.2 BS 7671 provides a format list in Regulation 611.2 of items to be verified, again so far as reasonably practicable; these are as follows:

Installed electrical equipment is of the correct type and complies with applicable British Standards or acceptable equivalents

The fixed installation is correctly selected and erected

The fixed installation is not visibly damaged or otherwise defective.

Inspections

Inspections are an important element of inspection and testing, and are described in section 2.5 of this Guidance Note.

sect 612 Tests

The tests are described in section 2.6 of this Guidance Note.

631.1 Results

The results of inspection and tests are to be recorded as appropriate. The Memorandum of guidance on the Electricity at Work Regulations 1989 (HSR25) recommends records of all maintenance including test results be kept throughout the working life an installation — see guidance on EWR Regulation 4(2). This can enable the condition of equipment and the effectiveness of maintenance to be monitored.

612.1 Relevant criteria

The relevant criteria are, for the most part, the requirements of the Regulations for the particular inspection or test and most criteria are given in Chapters 2 and 3 of this Guidance Note.

There will be some instances where the designer has specified requirements which are particular to the installation concerned. For example, the intended impedances may be different from those in BS 7671. In this case, the inspector should either ask for the design criteria or forward the test results to the designer for verification with the intended design. In the absence of such data the inspector should apply the requirements set out in BS 7671.

Verification

The responsibility for comparing inspection and test results with relevant criteria, as required by Regulation 612.1, lies with the party responsible for inspecting and testing the installation. This party, which may be the person carrying out the inspection and testing, should sign the inspection and testing box of the Electrical Installation Certificate or the declaration box of the Minor Electrical Installation Works Certificate. If the person carrying out the inspection and testing has also been responsible for the design and construction of the installation, he or she must also sign the design and construction boxes of the Electrical Installation Certificate, or make use of the singlesignature Electrical Installation Certificate.

2.2 Certificates

Appx 6 Appendix 6 of BS 7671 contains three model forms for the initial certification of a new installation or for an addition or alteration to an existing installation, as follows:

multiple-signature Electrical Installation Certificate single-signature Electrical Installation Certificate Minor Electrical Installation Works Certificate.

Examples of typical forms are given in Chapter 5.

Multiple-signature Electrical Installation Certificate

The multiple-signature certificate allows different persons to sign for design, construction, inspection and testing, and allows two signatories for design where there is mutual responsibility. Where designers are responsible for identifiably separate parts of an installation, the use of separate forms would be appropriate.

Single-signature Electrical Installation Certificate

Where design, construction, inspection and testing are the responsibility of one person, a certificate with a single signature may replace the multiple signature form.

Minor Electrical Installation Works Certificate

This certificate is to be used only for minor works that do not include the provision of a new circuit, such as an additional socket-outlet or lighting point to an existing circuit.

The certificate may also be used for the replacement of equipment such as accessories or luminaires, but not for the replacement of distribution boards, consumer units or similar items.

2.3 Required information

.2 BS 7671 requires that the following information shall be made available to the person or persons carrying out the inspection and testing:

Assessment of general characteristics

(a) the maximum demand, expressed in amperes, kW or kVA per phase (after diversity is taken into account)

(b) the number and type of live conductors of the source(s) of energy and of the circuits used in the installation

.2 (c) the type of system earthing used by the installation and any facilities provided by the distributor for the user

(d) the nominal voltage(s) and its characteristics including harmonic distortion

the nature of the current and supply frequency

the prospective short-circuit current at the origin of the installation

the earth fault loop impedance (Z) of that part of the system external to the installation

the type and rating of the overcurrent protective device acting at the origin of the installation.

Note: These characteristics should be available for all sources of supply.

Diagrams, charts or tables

.1 The Health and Safety at Work etc. Act 1974 generally requires relevant information to be available as an aid to safe use, inspection, testing and maintenance. This may include those items listed in Regulation 514.9.1 as follows:

(i) the type and composition of circuits, including points of utilisation, number and size of conductors and type of cable. This should include the installation method shown in Appendix 4 section 7 'Methods of installation' of BS 7671

.2 (j) the method used for compliance with the requirements for basic and fault protection and, where appropriate, the conditions required for automatic disconnection

(k) the information necessary for the identification of each device performing the functions of protection, isolation and switching, and its location (l) any circuit or equipment vulnerable to a particular test.

2-4 Frequency of subsequent inspections

The time intervals between the recommended dates of periodic inspections need consideration. The date for the first periodic inspection and test is required to b considered and recommended by the installation designer, as part of his or her design

The date of each subsequent periodic inspection is required to be considered and recommended as part of carrying out a periodic inspection and test, by the person undertaking that particular inspection and test.

2.5 Initial inspection

2.5.1 General procedure

Inspection and, where appropriate, testing should be carried out and the results recorded on suitable schedules progressively throughout the different stages of erection and before the installation is certified and put into service.

It should be noted that Regulation 610.1 requires inspection and testing to be carried out during the erection stage of the installation, as well as on completion.

A model Schedule of Inspections is shown in Chapter 5 of this guidance note.

2.5.2 Comments on individual items to be inspected

1.3 BS 7671 provides a list of items considered as a minimum to be inspected as follows:

a Connection of conductors

6 Every connection between conductors and equipment/other conductors should provide durable electrical continuity and adequate mechanical strength.

b Identification of cables and conductors

14 It should be checked that each core or bare conductor is identified as necessary. The single colour green must not be used. The colour combination green-and-yellow is only to be used for protective conductors and single-core green-and-yellow identified conductors (other than PEN conductors) must not be overmarked with another colour or alphanumeric symbols at terminations.

c Routing of cables

2.8 Cables and their cable management systems should be designed and installed taking into account the mechanical stresses that users of the installation will make upon the installation.

01 A key requirement to note is for cables installed in a wall or partition at a depth of less 03 than 50 mm from the surface. If the cable used does not incorporate an earthed metallic covering; or, is not installed in an earthed conduit, trunking or duct; or, is not provided with mechanical protection sufficient to prevent damage being caused by nails, screws or similar, or is not supplied via SELV or PELV, it will be necessary to provide additional protection by means of an RCD having a rated residual operating current not exceeding 30 mA. This is a requirement even when cables are run within the permitted cable routes described in Regulation 522.6.202 (v), as stated at the end of Regulation 522.6.201.

$2 Another requirement relates to cables installed in a wall or partition, the construction )3 of which contains metallic component parts such as studs, frames or skins Irrespective of the depth at which the cables have been installed, they are required to be OVIded

with additional protection by an RCD having a rated residual operating current not exceeding 30 mA, or be mechanically protected sufficiently to avoid damage to them during construction of the wall or partition and during the installation of the cables, or comply with the requirements referred to in the previous paragraph.

Furthermore, if the cables are installed at a depth of 50 mm or less from the surface of the wall or partition, the requirements mentioned in the previous paragraph also apply.

Cable selection

132.7 The cable sizes should be assessed against the overcurrent protective arrangement sect 523 and the requirements for limitation of voltage drop, based upon information provided sect 524 by the installation designer (where available). sect 525

Reference should be made, as appropriate, to Appendix 4 of BS 7671.

e Verification of polarity — single-pole device in a TN or TT system

132.141 It must be verified that single-pole devices for protection or switching are installed in 530.3.2 line conductors only.

f Accessories and equipment

Correct connection (suitability, polarity, environmental, etc.) must be checked.

553.1.3 Table 55.1 of BS 7671 is a schedule of types of plug and socket-outlet, ratings, and the associated British Standards.

553.2.2 Particular attention should be paid to the requirements for cable couplers to ensure that the connector (female part) of the couplers is fitted at the end remote from the supply.

559.5.1.205 Bayonet lampholders B15 and B22 should comply with BS EN 61184 and be of temperature rating T2.

g Selection and erection to minimize the spread of fire

Sect 527 Fire barriers, suitable seals and/or protection against thermal effects should be provided if necessary to meet the requirements of BS 7671. These are good examples of items which can and should be inspected during the erection stage.

Each sealing arrangement should be inspected to verify that it conforms to the manufacturer's erection instructions. This may be impossible without dismantling the system and it is essential, therefore, that inspection should be carried out at the appropriate stage of the work, and that this is recorded at the time for incorporation in the inspection and test documents.

h Measures of protection against electric shock

Chapter 41 The three tables below list the various measures of protection against electric shock given in BS 7671. The measures are discussed in more detail later in this section.

410.32 The tables divide up the measures into those that are generally permitted, those that are for use only where access is restricted to skilled or instructed persons, and those that are for use only where the installation is controlled or supervised by skilled or instructed persons. The tables also list the provisions for basic protection and fault protection that make up the protective measures.

Additional protection may also be specified as part of a protective measure under certain conditions of external influence and in certain of the special installations or locations. See later in this section.

V Protective measures generally permitted

411

412

413

Sect 414

V Protective measures for use only where access is restricted skilled persons or instructed persons under their supervision

417.1

417.2

V Protective measures for use only where the installation is controlled or supervised by skilled or instructed persons

418.1

418.2

418.3

I Not recognized for general application.

2 To be used only in special circumstances.

Protective provision of basic protection by insulation of live parts and/or barriers or enclosures

This protective provision forms part of a number of different protective measures, as shown in the tables above.

416.1 The inspection of this protective provision is to check that insulation has not been 416.2 damaged during installation and that barriers and enclosures have been selected and installed to provided at least a degree of protection of IPXXB or IP2X and, for readily

accessible top surfaces, at least IPXXD or IP4X, and are not damaged (Insulation resistance is of course a fundamental test to be carried out — section 2.6.)

(ii) Protective measures generally permitted

Automatic disconnection of supply

411.2 The provision for basic protection in this protective measure is basic insulation of live parts and/or barriers or enclosures, the inspection of which is discussed earlier in this section.

41 1.3 The provision for fault protection is protective earthing, protective equipotential bonding and automatic disconnection in case of a fault. Although a significant main part of verification is measurement of earth fault loop impedance for each circuit in order to confirm disconnection times, there are inspection aspects to be dealt with for verifying fault protection, as follows.)

Presence of appropriate protective conductors:

542.3 earthing conductor sect 543 circuit protective conductors

Sect 544 protective bonding conductors main bonding conductors supplementary bonding conductors (where required).

312.2 The type of system earthing must be determined, e.g.

TN-C-S system (usually with protective multiple earthing (PME)) TN-S system

TT system (earth electrode(s) used as the means of earthing for the installation)

1.5 (TN) The earth fault loop impedance must be appropriate for the protective device, i.e. RCD

1.5 (IT) or overcurrent device.

1.5 (TT)

Double or reinforced insulation

412.1 .1 For double insulation, basic protection is provided by basic insulation, and fault protection is provided by supplementary insulation.

For reinforced insulation, both basic protection and fault protection are provided by reinforced insulation between live parts and accessible parts.

413.1.3 Where double or reinforced insulation is to be employed as the sole protective measure, it is important to confirm that the installation or circuit so protected will remain under effective supervision to prevent any unauthorised change being made that could impair the effectiveness of the measure.

Electrical separation for the supply of one item of current-using equipment

13.1.1 Electrical separation is a protective measure where basic protection is provided by basic insulation of live parts and/or by barriers and enclosures, in accordance with Section 416, and fault protection is provided by simple separation of the separated circuit from other circuits and from Earth.

Extra-low voltage provided by SELV or PELV

Sect 414 For SELV and PELV, requirements include:

4141.1 (a) the nominal voltage must not exceed 50 V a.c. or 120 V d.c.

414.3 (b) an isolated source, e.g. a safety isolating transformer to BS EN 61558-2-6

4141.1 (c) protective separation from all non SELV or PELV circuits

4141.1 (d) for SELV, basic insulation between the SELV system and Earth

414.1.) (e) SELV exposed-conductive-parts must have no connection with earth, exposedconductive-parts or protective conductors of other systems.

Protective measures for use only where access is restricted to skilled persons or instructed persons under their supervision

Obstoc/es Protection by obstacles provides basic protection only, not fault protection. It protects against unintentional contact with live parts. Where this measure is used, the area must be accessible only to skilled persons or to instructed persons under their supervision. The measure is not to be used in some installations and locations of increased shock risk. See Part 7 of BS 7671. Placing out of reach Placing out of reach also provides basic protection only. The distances referred to in Regulations 417.3.1 and 417.3.2 should be increased where long or bulky conducting objects are likely to be handled in the vicinity, taking account of the dimensions of those objects. 410.3.5 Bare live parts are permitted only in areas accessible only to skilled persons or to instructed persons under their supervision. The dimensions of passageways should be checked against the guidance in Appendix 3 of the Memorandum ofguidance on the Electricity at Work Regulations 1989 (HSR25) issued by the Health and Safety Executive. Sect 729 Section 729 — Operating and maintenance gangways — of Amendment No. I to BS 7671 was included covers situations where open switchgear or busbars are permitted and where access is restricted to skilled or instructed persons. Inspection for verification in areas covered by Section 729 requires careful checking, including the measurement of separation distances, for example those associated with 'arm's reach', as per Figure 417 of BS 767 J; these must be confirmed with the installation isolated.

Protective measures for use only where the installation is controlled or supervised by skilled or instructed persons

Non-conducting location

418.1.1 Where this protective measure is employed, such as in an electronic equipment test area, it must be verified (amongst other things) that all installed electrical equipment meets the requirements of Section 416 with regard to provisions for basic protection.

418.1 7 Further, the exposed«onducttve.pmts of the tnstatvatton should be arranged that it is not possible for persons to make stmuttaneous contact wtth ether two e.xpoqedconductive-parts, or an exposed«onductive-part and any extraneous-conductive-part under normal operating conditions, if these parts are liable to be at different potentials as a result of failure of the basic insulation of a we part.

418.1.3 The inspector should confirm the achievement ofthis and check thatwithin the location there are no protective conductors (see also the specific test for this method in 2.6.12),

4182 Earth-free loco/ equipotentia/ bonding

The use of this protective measure is intended to prevent the appearance of a dangerous touch voltage under fault conditions. In some cases this protective measure is combined with the protective measure of electrical separation.

418.2.1 Where protection by earth-free local equipotential bonding is employed, it must be verified (amongst other things) that all installed electrical equipment should meet the requirements of Section 416 with regard to provisions for basic protection.

418.2.2 All simultaneously accessible exposed-conductive-parts and extraneous-conductiveparts should be interconnected by local protective equipotential bonding conductors.

418.2.3 Measures must be taken to ensure that the local equipotential bonding conductors are not connected to Earth either directly or unintentionally via the exposed- and extraneous-conductive-parts to which they are connected.

418.2.5 A warning notice complying with Regulation 514.13.2 must be fixed in a prominent position adjacent to every point of access to the location concerned.

The inspection, supplemented with tests, should verify that no item is earthed within the area and that no earthed services or conductors enter or traverse the area, including the floor and ceiling. Inspection should confirm whether or not this has been achieved.

Electrical separation for the supply of more than one item of current-using equipment

418.3 If it is intended to supply more than one item of current-using equipment using Sect 413 electrical separation, it will be necessary to meet the requirements of Regulation 418.3. This is in addition to meeting the requirements of Section 413, some of which are referred to earlier in this section of this guidance note in relation to the use of electrical separation for the supply of one item of current-using equipment.

418.3.3 The separated circuit should be protected from damage and insulation failure.

418.3.4 Any exposed-conductive-parts should be connected together by insulated, nonearthed equipotential bonding conductors, which should not be connected to the protective conductor or exposed-conductive-parts of any other circuit or to any extraneous-conductive-parts.

4183.5 Socket-outlets should have a protective conductor contact, which is connected to the protective bonding system described above.

4183.6 All flexible cables should contain a protective conductor for use as an equipotential bonding conductor, except where such a cable supplies only items of equipment double or reinforced insulation

4183.7 If two faults affecting two exposed-conductive-parts occur and where conductors of different polarity feed these, a protective device should disconnect the supply in

accordance with the disconnection time given in Table 41.1.

4183.8 The product of the nominal voltage (volts) and length (metres) of the wiring system should not exceed 100,000 Vm and the length of the wiring system should not exceed 500 m.

(v) Additional protection

Additional protection by one or more RCDs

415.1.I It should be confirmed that an RCD selected to provide additional protection has a rated residual operating current (IA) not exceeding 30 mA and an operating time not exceeding 40 ms at a residual current of 5 IAn.

415.1.2 It should also be confirmed that appropriate protective measures in accordance with Sections 411 to 414 are in place, as an RCD must not be used as the sole means of protection against electric shock.

Additional protection by supplementary bonding

415.2.1 Where supplementary bonding is provided it should encompass all simultaneously accessible exposed-conductive-parts, extraneous-conductive-parts and the protective conductors of all equipment in the location where this protective measure is being applied.

415.2.2 The effectiveness of supplementary equipotential bonding as provided may be verified where the resistance between simultaneously accessible exposed- and extraneousconductive-parts fulfil the applicable one of the following condition.

for a.c. systems, R < 50 V/la for d.c. systems, R < 120 V/la

where la is the operating current of the protective device in amperes; for overcurrent devices, this is the 5 second operating current, and for RCDs, IA n.

i Prevention of mutual detrimental influence

Sect 515 Regulations 132.11 and 515.1 require electrical equipment to be so selected and erected so that there will be no harmful influence (such as electromagnetic interference or heat) between the electrical installation and other electrical and non-electrical installations. The inspector is advised to give careful thought to this whilst carrying out the inspection.

j Isolating and switching devices

Sect 537 BS EN 60947-1 Specification for low voltage switchgear and controlgear — General rules defines standard utilisation categories which allow for conditions of service use and the switching duty to be expected.

All switch utilisation categories must be appropriate for the nature of the load see Table 2.1. It would be part of the design to specify the appropriate type of device.

GN2 Guidance Note 2: Isolation & Switching provides more comprehensive guidance on this subject and should be consulted and its contents taken into account

V Table 2.1 Examples of utilisation categories for alternating current installations

If switchgear to BS EN 60947-1 is suitable for isolation it will be marked with the symbol:

This may be endorsed with a symbol advising of function, e.g. for a switch disconnector:

Table 53.4

Guidance on the suitability or otherwise of protective, isolation and switching devices to be employed for one or more of the functions of isolation, emergency switching and functional switching is given in Table 53.4 in BS 7671 and Guidance Note 2.

An isolation exercise should be carried out to check that effective isolation can be achieved. This should include, where appropriate, locking-off and inspection or testing to verify that the circuit is dead and no other source of supply is present.

Note (5) to Table 53.4 in BS 7671, added by Amendment No. 3, points out that circuitbreakers and RCDs are not intended for frequent load switching. The note gives further guidance relating to this.

k Presence of undervoltage protective devices

Sect

Suitable precautions should be in place where a reduction in voltage, or loss and subsequent restoration of voltage, could cause danger. Normally such a requirement concerns only motor circuits. If precautions are required they will have been specified by the designer; however, the devices used must be confirmed as matching the equipment specification and the relevant regulations in Section 445.

Protective devices

Chap 43

Some protective devices have user or on-site configurable settings and the inspector needs to confirm that the installer has correctly set up such protective devices.

Labelling of protective devices, switches and terminals

Sect 514 Each protective device must be arranged and identified so that the circuit protected 514.81 can be easily identified, and a diagram or chart indicating the function of each circuit 514.9. I and size of conductors is required; the inspector should have this key document in order to carry out much of his or her inspection and testing.

n Selection of equipment and protective measures appropriate to external influences

512.2 Equipment must be selected with regard to its suitability for the environment — ambient Sect 522 temperature, heat, water, foreign bodies, corrosion, impact, vibration, flora, fauna, radiation, building use and structure. A careful inspection is necessary to confirm the suitability of each item of equipment.

o Adequacy of access to switchgear and equipment

132.12 Every piece of equipment that requires operation or attention by a person must be Sect 513 so installed that adequate and safe means of access (related to the amount of its use) and sufficient working space are afforded; the inspector should check that these requirements are met.

p Presence of danger notices and other warning notices

Sect 514 Suitable warning notices, suitably located, are required to be installed to give warning of:

Voltage

514.10 Where a nominal voltage exceeding 230 V to earth exists within an item of equipment or enclosure and where the presence of such a voltage would not normally be expected. The wording of this regulation was revised for

Amendment No. 1 to BS 7671:2008 and it is clarified that only 'unusual' system voltages exceeding 230 volts to earth require warning labels. An example would be the use of a 690 volts three-phase a.c. power transformer used on an American air base located in the UK.

Isolation

514.11 Where live parts are not capable of being isolated by a single device. The

location of disconnectors should also be indicated except where there is no possibility of confusion.

Periodic inspection and testing

514.12.1 The wording of the notice is given in Regulation 514.12.1.

RCDs

514.12.2 The wording of the notice is given in Regulation 514.12.2.

Non-standard colours

51414.1 For installations containing both pre-BS 7671:2008 (pre-harmonized colours) cable colours as well as cable colours to BS 7671:2008 and later editions (harmonized colours) an appropriate warning notice must be present at or near the relevant distribution board. The wording of the notice is given in Regulation

514.141.

Alternative supplies

51415.1 For installations with alternative voltage sources, a 'multiple-source' warning notice is required at mains positions, points of isolation, distribution boards and at any remote metering. The wording of the notice is given in Regulation 514.15.1.

514.16 High protective conductor current

543.7.1.205For circuits with a high protective conductor current, information must be provided at the relevant distribution board indicating these circuits, as required by Regulation 543.7.1.205.

Earthing and bonding connections

514.13.1 The requirements for the label and its wording are given in Regulation 514.13.1. 514.13.2 The wording of the notice required where protection by earth-free local equipotential bonding (Regulation 418.2.5 refers) or by electrical separation for the supply to more than one item of equipment (Regulation 418.3 refers) is given in Regulation 514.13.2.

q Erection methods

Chapter 52 contains detailed requirements on selection and erection. Fixings of switchgear, cables, conduit, fittings, etc. must be adequate for the environment and a detailed visual inspection is required during the erection stages as well as at completion.

2-5.3 Inspection checklist

Listed below are requirements to be checked when carrying out an installation inspection. The list is not exhaustive.

General

Equipment complies with a product standard or equivalent (511.1)

Equipment is installed using good workmanship (134.1.1)

Equipment is accessible for operation, inspection and maintenance (513.1)

Suitable for local atmosphere and ambient temperature (512.2). For installations in potentially explosive atmospheres, the requirements of BS 7671 are supplemented by the requirements or recommendations of other British or

Harmonized Standards or by those of the person ordering the work (110.1.3)

final circuits are separate, including the neutral conductors (314.4)

Protective devices identified to indicate the circuits they protect (514.8.1)

Protective devices adequate for intended purpose (Ch. 53)

Disconnection times for protection against electric shock likely to be met by installed protective devices (Ch. 41)

All circuits suitably identified (514.1, 514.8, 514.9)

Suitable main switch provided (Ch. 53)

Supplies to any safety services suitably installed, e.g. fire alarms to BS 5839 and emergency lighting to BS 5266 (Ch. 56)

(I) Auxiliary circuit are suitably installed (557)

Means of isolation suitably labelled (514.1, 537.2.2.6)

Provision for disconnecting the neutral (537.2.1.7)

Main switches to single-phase installations, intended for use by an ordinary person, e.g. domestic, shop, office premises, to be double-pole (537.1.4)

RCDs provided where required (411.3.3, 41 1.4, 411.5, 415.1, 422.3.9, 522.6.201,

522.6.202, 532.1, 701.411.33, 702.53, 702.55.1, 702.55.4, 703.411.3.3, 704.410.3.10, 704.411.3.2.1, 705.411.1, 705.422.7, 706.410.3.10, 708.553.1.13, 708.553.1.14, 709.531.2, 710.41 1.3, 710.531 .2.4, 71 1.410.3.4t 71 1.3.3, 712.411.3.2.1.2, 714.411.3.3, 717.41 1.1, 717.41 1.6.2, 717.413, 717.4151, 721.411.1, 722.531.2.101, 740.410.3, 740.415.1, 753.41 1.3.2t 753.41 5.1)

Discrimination between RCDs considered to avoid danger (314.1, 531.2.9)

Main earthing terminal provided (542.4.1), readily accessible and identified where separate from switchgear (514.13.1)

Provision for disconnecting earthing conductor (542.4.2)

Cables used comply with British or Harmonized Standards (Appendix 4 of BS 7671)

Earth tail pots installed where required on mineral insulated cables (543.2.7)

Non-conductive finishes on enclosures removed where necessary to ensure good electrical connection and, if necessary, made good after connecting (526.1)

Adequately rated distribution boards (to the relevant parts of BS EN 60439 or BS EN 61439 (may require derating, see GN 6)

Correct fuses or circuit-breakers installed (Sect 531, Sect 533)

All connections secure (134.1)

Protection provided against voltage disturbances, including overvoltages, where required (Ch. 44)

Measures taken against electromagnetic disturbances where required (Ch. 44)

(ab) Overcurrent protection provided where applicable (Ch. 43)

(ac) Suitable proximity (separation or segregation) of circuits (528) (ad) Label notice for first periodic inspection and test provided (514.12.1) (ae) Sealing of the wiring system, including fire barriers (527.2).

Switchgear

Meets requirements of BS EN 61008, BS EN 61009, BS EN 60947-2, BS EN 60898, relevant parts of BS EN 60439 or BS EN 61439 where applicable, or equivalent standards (Sect 511)

Securely fixed (134.1.1) and suitably labelled (514.1)

Switchgear assemblies, including consumer units, are complete with, or additionally housed in, fire protecting enclosures (421.1.201).

Non-conductive finishes on switchgear removed at protective conductor connections and if necessary made good after connecting (526.1)

Suitable cable glands and gland plates used (526.1)

Correctly earthed (Ch. 54)

Conditions likely to be encountered taken account of, i.e. suitable for the foreseen environment (512.2)

Suitable as means of isolation, where applicable (537.2.2)

Need for isolation, mechanical maintenance, emergency and functional switching met (537)

Firefighter's switch provided where required (537.6)

All connections secure (526)

(I) Cables correctly terminated and identified (514, 526)

No sharp edges on cable entries, screw heads, etc., which could cause damage to cables (134.1.1, 522.8.11)

Adequate access and working space (132.12 and 513.1).

General wiring accessories

Complies with appropriate standards, for example, BS 5733 (general accessories) or BS EN 60670-22 (junction boxes) (511.1)

Box or other enclosure securely fixed (134.1.1)

Metal box or other enclosure earthed where required (Ch. 54)

No sharp edges on cable entries, screw heads, etc. which could cause damage to cables (134.1.1, 522.8.] l)

Non-sheathed cables, and cores of cable from which sheath has been removed not exposed outside the enclosure (526.8)

Conductors correctly identified (514.3)

Bare protective conductors having a cross-sectional area of 6 mm2 or less to be sleeved green-and-yellow (514.4.2, 543.3.201)

Terminals tight and containing all strands of the conductors (526)

Cable grip correctly used or clips fitted to cables to prevent strain on the terminals (522.8.5, 526.6)

Adequate current rating (512.1.2).

Note: Reference should also be made to the recommendations contained in Approved

Document M (England and Wales) and the Scottish Building Standards with regard to the

heights at which socket-outlets, switches and other controls should be installed in order to afford compliance with Building Regulations. See also the IET publication Electrician's Guide to the Building Regulations.

Lighting controls

Light switches comply with BS 3676 or BS EN 60669-1 (511.1)

Selected for external influences (512.2)

Single-pole switches connected in line conductors only (132.14.1)

Correct colour coding or marking of conductors (514.3)

Earthing of exposed metalwork, e.g. metal switchplate (Ch. 54)

Adequate current rating allowing for any capacitive or inductive effects (512.1.2)

Device that simultaneously disconnects all live conductors is provided where a group of luminaires is divided between three line conductors of a circuit with only one common neutral (559.5.5)

Switch labelled to indicate purpose, where this is not obvious (514.1.1) (i) Appropriate controls suitable for the luminaires (559.5.1.206)

(j) Standard wall accessory switches installed beyond zone 2 in bathroom.

Lighting points

Lights connected via a recognised accessory (559.5.1), lampholders being in compliance with BS EN 60598

Ceiling rose complies with BS 67 (559.5.1)

Luminaire couplers comply with BS 6972 or BS 7001 (559.5.1)

Installation couplers comply with BS EN 61535 (559.5.1)

Recognised connecting device used for luminaires that do not provide a device for connection of the supply (559.5.4)

Track systems comply with BS EN 60570 (559.3.4 and 715.521.1)

Systems for ELV lighting comply with BS EN 60598-2-23 (715.521.])

Bare conductors of ELV lighting installations comply with all requirements of Regulation 715.521.106 (715.521.1)

Not more than one flex unless designed for multiple pendants (559.5.1.201)

Flex support devices used and suitable for the mass suspended (559.5.2)

Switch-lines identified (514.3.2 and Appendix 7 of BS 7671). For two-core switch wires, blue conductors are overmarked with brown or L at terminations; for three-, four- or five-core cables, all non-brown line conductors of switch and intermediate strappers are overmarked at terminations with brown or L

(I) Penetrations in fire-rated ceiling made good (527.2.1)

Ceiling roses and similar not used for circuits having supply exceeding 250 V (559.5.1.201).

Protection from UV radiation (if any) is provided to external wiring within or passing through a luminaire (559.5.6).

Socket-outlets

comply with BS 546, BS 1363-2 or BS EN 60309-2 (5531.3) and shuttered for household and similar installations (553.1.201)

Where used for electric vehicle charging, socket-outlets complying with BS 1363-2 are of a type approved by the socket-outlet manufacturer for such use (722.55.201.1)

Mounting height above the floor or working surface suitable (553.1.6) (d) Correct polarity (612.6)

If in a location containing a bath or shower, installed at least 3 m horizontally from the bath or shower unless shaver supply unit or SELV (701.512.3)

Suitably protected against the expected external influences where mounted in a floor (512.2)

Not used to supply a water heater having uninsulated elements (5543.3)

Where metal conduit (including the accessory box) or earthed cable sheath or similar used as a protective conductor, presence of an earth tail between accessory box and socket-outlet terminal (543.2.7).

Junction boxes, joint box and terminations

All cable joints and terminations installed so that they are accessible for future inspection (except soldered, encapsulated, etc. joints or marked maintenance\_ free accessory; see 526.3)

Enclosures of terminals provide suitable protection against mechanical damage (526.7).

Fused connection unit

Correct rating and fuse (533.1)

Complies with BS 1363-4 (Table 53.4, 559.5.1 vii).

Cooker control unit

Sited to one side and low enough for accessibility and to prevent flexes trailing across radiant plates (522.2.1)

Cable to cooker fixed to prevent strain on connections (522.8.5).

Conduit systems General

Securely fixed, box lids in place and adequately protected against mechanical damage (522.8)

Draw points are accessible (522.8.6)

Recommended quantity of cables for easy draw not exceeded during installation, to avoid causing insulation damage; adequate boxes suitably spaced. Item should be inspected during the erection stage as the care and workmanship of the installer can be verified (522.8.1 and see On-Site Guide Appendix E)

Solid elbows and tees used only as appropriate (522.8.1)

Unused entries blanked off where necessary (416.2 and 522)

Conduit system components comply with a relevant British Standard (511.1) (g) Provided with drainage holes and gaskets as necessary (522.3) (h) Radius of bends such that cables are not damaged (522.8.3).

Rigid metal conduit

Complies with BS EN 61386-21 (521.6)

Connected to the main earthing terminal (411.4.2, 411.5.1)

Line, neutral and any additional protective conductors are contained in the sam conduit (521.5.1)

Conduit suitable for wet, damp or corrosive situations (522.3, 522.5)

Fixed appropriately (522.8 and see Guidance Note I Appendix G)

Unpainted ends and scratches, etc. protected by painting (134.1.1, 522.5) (g) Ends of conduit reamed and bushed where relevant (134.1.1, 522.8).

Rigid non-metallic conduit

Complies with BS 4607, BS EN 60423 or the BS EN 61386 series (521.6)

Ambient and working temperatures within permitted limits (522.1, 522.2)

Provision made to allow for expansion and contraction (522.15.1)

Boxes and fixings suitable for mass of luminaire suspended at expected temperature (559.5.2).

Flexible metal conduit

Complies with BS EN 61386 series (521.6)

Separate protective conductor provided (543.2.3)

(c) Adequately supported and terminated (522.8)

(d) Line, neutral and any additional protective conductors are contained in the same conduit (521.5.1).

Trunking

General

Complies with BS 4678 or BS EN 50085-1 (521.6)

Securely fixed and adequately protected against mechanical damage (522.8)

Selected, erected and routed to avoid ingress of water (522.3)

Proximity to non-electrical services, i.e. sources of heat, smoke etc. cannot cause damage (528.3)

Internal sealing provided where necessary (requires inspection during the erection stage) (527.2.2)

Holes surrounding trunking made good (527.2.1)

Band I circuits partitioned from Band Il circuits or insulated for the highest voltage present (528.1)

Circuits partitioned from Band I circuits or wired in mineral insulated metalsheathed cables (528.1)

Cables supported for vertical runs (522.8.5).

Metal trunking

Line, neutral and any additional protective conductors are contained in the same trunking (521.5.1)

Protected against damp or corrosion (522.3, 522.5) (c) Earthed (411.4.2, 411.5.1)

(d) Joints mechanically sound and of adequate continuity (543.2.5).

Busbar trunking and powertrack systems

Busbar trunking system complies with BS EN 60439-2 or BS EN 61439-6 or other appropriate standard; powertrack system complies with BS EN 61534 series or other appropriate standard (521.4)

Securely fixed and adequately protected against mechanical damage (522.8) (c) Joints mechanically sound and of adequate continuity (543.2.5).

Insulated cables

Non-flexible cables

Correct type (521)

Correct current rating (523)

Protected against mechanical damage and abrasion (522.8)

Suitable for high or low ambient temperature as necessary (522.1)

Non-sheathed cables are protected by enclosure in conduit, duct or trunking

(except for protective conductors of 4 mm2 and larger) (521.10)

Sheathed cables concealed in a wall at a depth of less than 50 mm from the surface and not forming part of a SELV or PELV circuit are routed in allowed zones and additional protection is provided by RCD having Ian not exceeding 30 mA, or provided with mechanical protection complying with 522.6.203 (522.6.201)

Cables concealed in a partition containing metallic structural parts are provided with additional protection by RCD having Idn not exceeding 30 mA, or

provided with adequate mechanical protection to suit both the installation of the cable and its normal use, or in compliance with 522.6.203 (522.6.202)

Cables exposed to direct sunlight are of a suitable type or suitably shaded (522.11)

Not run in lift shaft unless part of the lift installation and of the permitted type (528.35)

Cables buried in the ground are correctly selected and installed for use (522.8.10)

Cables installed overhead are correctly selected and installed for such use (522.8.4)

Internal radii of bends not so tight as to cause damage to cables or to place undue stress on terminations to which they are connected (522.8.3 and Guidance Note I Appendix G)

Correctly supported (522.8.4, 522.8.5)

Not exposed to water, etc. unless suitable for such exposure (522.3)

Metal sheaths and armour earthed (411.3.1.1)

Conductors identified at terminations (514.3)

Joints and connections electrically and mechanically sound and adequately insulated (526.1, 526.2)

All wires securely contained in terminals, etc. without strain (522.8.5, 526) (s) Enclosure of terminals (526)

Glands correctly selected and fitted with shrouds and supplementary earth tags as necessary (526.1)

Joints and connections mechanically sound and accessible for inspection, except as permitted otherwise (526.1, 526.3).

Flexible cables (521.9)

Correct type (521.9.1)

Correct current rating (523)

Protected where exposed to mechanical damage (522.6, 522.8)

Suitably sheathed where exposed to contact with water (522.3) or corrosive substances (522.5)

Protected where used for final connections to fixed apparatus, etc. (526.8)

Selected for resistance to damage by external heat sources (522.2)

Segregation of Band I and Band Il circuits (528; see also BS 6701 and BS EN 50174 series)

Fire alarm and emergency lighting circuits segregated (528; see also BS 5839, BS 5266)

Cores correctly identified (514.3)

Connections to have durable electrical continuity, adequate mechanical strength and be made using appropriate means (526.1, 526.2)

Where used as fixed wiring, relevant requirements met (521.9.1)

Final connections to current-using equipment properly secured and arranged to prevent strain on connections (526.6)

Mass supported by cable to not impair safety of the installation (559.5.2).

Protective conductors

Cables incorporating protective conductors comply with the relevant BS (511.1)

Joints in metal conduit, ducting or trunking comply with Regulations for preservation of continuity (543.3)

Flexible or pliable conduit is supplemented by a protective conductor (543.2.3)

Minimum cross-sectional area of copper conductors (543.1)

(e) Copper conductors of 6 mm2 or less protected by insulation (5433.201) Circuit protective conductor at termination of sheathed cables protected by sleeving (543.3.201)

Bare circuit protective conductor protected against mechanical damage and corrosion (543.3.1)

Insulation, sleeving and terminations identified by colour combination greenand-yellow (514.4.2)

Joints electrically and mechanically sound (526.1)

Separate circuit protective conductors of not less than 4 mm) if not protected against mechanical damage (543.1.1)

Main and supplementary protective bonding conductors of correct size (544).

Enclosures

General

(a) Suitable degree of protection ('IP Code' in BS EN 60529) appropriate to external influences (416.2, 512.2, 522, Part 7).

2.6 Initial testing

612.1 The test methods described in this section are recommended to be used for verification. This does not rule out the use of other test methods provided they give valid results.

2.6-1 Test results

The test results must be recorded on the Schedule(s) of Test Results and compared with relevant criteria. For example, in order to verify disconnection times, the relevant criteria would be design earth fault loop impedance values provided by the designer.

A model Schedule of Test Results is shown in Chapter 5.

2.6.2 Electrical Installation Certificate

631.1 Regulation 631.1 of BS 7671 requires that, upon completion of the verification of a new, modified or extended installation, an Electrical Installation Certificate based on the model given in Appendix 6 of BS 7671 shall be provided. Chapter 63 requires that:

632.1 (a) the Electrical Installation Certificate be accompanied by schedules of inspection and schedules of test results. These schedules shall be based on the models given in Appendix 6 of BS 7671

632.2 (b) the schedule of test results shall include test results for every circuit

631.4 (c) the Electrical Installation Certificate is signed or otherwise authenticated by the electrically skilled person responsible for each facet of design, construction and inspection and test and competent in such work.

Note: The person responsible for carrying out the initial verification and signing the inspection and test box has certain responsibilities for checking some design and construction aspects (see Regulation 611.2, Section 632 and section 2.1 of this Guidance Note).

632.4 (d) any defects or omissions revealed by the inspector shall be made good, and as necessary inspected and tested again, before the Electrical Installation Certificate is issued; it is not the responsibility of the person or organization carrying out the inspection and testing to make good defects or omissions.

Typical forms for use when carrying out inspection and testing are included in Chapter 5 of this Guidance Note.

612.1 2.6.4 The sequence of tests

Initial tests should be carried out in the following sequence where relevant and practical:

Continuity of protective conductors, including main and supplementary bonding (2.6.5);

Continuity of ring final circuit conductors (2.6.6);

Insulation resistance (2.6.7);

Protection by SELV, PELV or by electrical separation (2.6.8, 2.6.9);

Protection by barriers or enclosures provided during erection (2.6.11);

Insulation resistance of non-conducting floors and walls (2.6.12); (g) Polarity (2.6.13);

Earth electrode resistance (2.6.14);

Protection by automatic disconnection of the supply (2.6.15);

Earth fault loop impedance (2.6.16);

Additional protection (2.6.19);

(I) Prospective fault current (2.6.17);

(m) Check of phase sequence (2.6.18); (n) Functional testing (2.6.19, 2.6.20);

(o) Verification of voltage drop (2.6.21).

2.6.5 Continuity of protective conductors, including main and supplementary bonding

612.2.1 Regulation 411.3.1.1 requires that installations that provide protection against electric 41131.1 shock using automatic disconnection of supply must have a circuit protective conductor run to and terminated at each point in the wiring and at each accessory. An exception is made for a lampholder having no exposed-conductive-parts and suspended from such a point.

Regulation 612.2.1 requires that a continuity check be carried out on all protective conductors. This includes the earthing conductor, the protective conductors of all circuits, all main protective bonding conductors and all supplementary bonding conductors.

Similarly, Regulation 612.2.2 requires that a continuity check be carried out on each conductor of every ring final circuit, including line, neutral and protective conductors.

There are two widely used test methods that have evolved for checking conductor continuity. 'Test method 1' uses the circuit cable shorted out and 'Test method 2' uses a supplementary length of test cable (this method being popularly known as the 'wandering lead' method).

Instrument: Use a low resistance ohmmeter for these tests — see section 4.3.

The relevant conductors, mentioned above, should be tested to verify that they are electrically sound and correctly connected.

Test method l, detailed below, as well as checking the continuity of the protective conductor, also measures (RI + R) which, when added to the external impedance

(Z), enables the earth fault loop impedance (Z) to be checked against the desjgn (see 26.16). (RI + R) is the sum of the resistances of the Gne conductor, RI, and the circuit protective conductor, R2.

Test readings may be affected by parallel paths through exposed-conductive-parts and/or extraneous-conductive-parts.

Parallel earth paths and effects on test readings

Inspectors should be aware of the possible existence of parallel earth return paths. These may take the form of metallic cable management products, extraneousconductive-parts or indeed other metallic parts. Examples include installations incorporating steel conduit, steel trunking, MICC, steel wire armoured or other metal sheathed cables, equipment and accessory boxes fitted to metal stud walls orto the building fabric, and luminaires fitted in grid ceilings. They exist in domestic, commercial and industrial installations.

earth return paths is that the measured value of protective R2, tends towards a zero value. It is often impractical and in to carry out testing with some or all of the parallel paths

Make a temporary shorting link of cable and connect the line conductor to the protective conductor at the distribution board or consumer unit. Then test between line and earth terminals at each outlet in the circuit as shown in Figure 2.1a. The resistance of the test leads should either be auto-nulled by the test instrument or measured and deducted from the readings obtained.

Where the installation has all-insulated wiring (see notes on parallel earth paths and effects on test results above) and the cable accessories are not in contact with earth, then this test measures (RI + R), i.e. the resistance of the line conductor, RI, plus the resistance of the protective conductor, R2, for that circuit which, if added to the earth fault loop impedance at the distribution board, can be taken as the circuit's earth fault loop impedance. It is important to record the value of (RI + R) obtained at the circuit's extremity, namely the furthest circuit distance from the distribution board.

The results should first and foremost indicate no discontinuity in the protective conductors. For insulated wiring systems installed in conditions where accessory boxes and similar are not connected to fabric or other elements that may be earthed, then as stated earlier the readings measured will be the sum of the line and protective conductor resistances (RI + R). This test can detect poor continuity at junctions and connections since, for a new installation with new accessories, the contribution of resistance of healthy connections to the measured resistance is negligible and can be ignored. Thus, by employing the resistance data for copper conductors given in Appendix B, expected values for healthy circuits can be approximated, and compared with the test readings obtained.

As an example, a radial circuit of length about 55 m with 2.5 mm2 line and protective conductors should have an (RI + R) resistance as follows:

Length of circuit is 55 m

Resistance of cable is 7.41 mQ/m (at 20 oc) from Table BI

Theoretical minimum d.c. resistance = (55 x 2 x 7.41)/1000 = 0.82 Q

When verifying this circuit the inspector should be looking for a reading of that order, so a reading of, say, 0.8 to 1.2 Q would be acceptable. If the circuit had several outlets, thus meaning that the circuit conductor was broken and connected in screw terminals at each accessory, then a slightly higher value may be measured, as there would be some resistance at the terminations.

Test method 2 (for circuits)

Instrument: Use a low-resistance ohmmeter for this test. Refer to section 4.3.

One lead of the test instrument is connected to the earth terminal at the distribution board via a length of test cable or 'wandering lead'. The other test lead is used to make contact with the protective conductor at various points on the circuit under test, e.g. luminaires, switches, fused connection units, etc. as shown in Figure 2.1b,

test are

This test measures the of the arcuit conductor which should be recorded on the Schedule of Test Results (see earlier note 'Parallel earth paths and effects on test readings').

2.1b Connections for testing continuity of protective conductors: method 2

Expected results for test method 2

The results should first and foremost indicate no discontinuity in the protective conductors. For insulated wiring systems installed in conditions where accessory boxes and similar are not connected to fabric or other elements that may be earthed, then the measurement will equate to the protective conductor resistance, R2. This test can detect poor continuity at junctions and connections since, for a new installation with new accessories, the contribution of resistance of healthy connections is negligible and can be ignored. Thus, by employing the resistance data for copper conductors given in Appendix B, expected values for healthy cable and connections can be checked.

As an example, a radial circuit of length about 55 m with a 2.5 mm2 copper protective conductor should have an R2 resistance as follows:

Length of circuit is 55 m

Resistance of cable is 7.41 mQ/m (at 20 oc) from Table Bl

Theoretical minimum d.c. resistance = (55 x 7.41)/1000 = 0.41 Q

When verifying this circuit the inspector should be looking for a reading of that order, say 0.4 to 0.5 Q. If the circuit had several outlets, thus meaning that the protective conductor was broken and connected in screw terminals at each accessory, then a slightly higher value may be measured, as there would be some resistance at the terminations.

Testing bonding conductors and earthing conductors of protective conductors, of test readings test method being 2

Rh01Jld be tbken of the

earj,er in this section. For this reason it may be

otft the test with the protecfß,e conductor disconnected at one pgacttcable. firm a bonding connection between Thts method can also be used to con conductive-parts where it is not possible to see a bonding connection bonding clamps have been built int The test would such as be metallic done by pipes, connecting and lookinth ts,

of the instrument between any two poin Id be noted that not all a low reading of the order of 0.05 Q (it shou ohmmeters can read this low, see section 4.3).

Where metallic enclosures have been used as the protective conductors, e.g. conduit trunking, steel-wire armouring, etc. the following procedure should be employed.

Inspect the enclosure along its length for soundness of construction

Perform the standard continuity test using the appropriate test method described above.

Instrument: Use a low-resistance ohmmeter for this test — section 4.3.

Expected test results

The results should first and foremost indicate no discontinuity in the protective conductors. For lengths of conductor use Appendix B for resistance data. For joints across bonds by earth clamps and similar, the readings should approach 0.05 Q taking into account both the resolution of the instrument and its accuracy at low values.

2.6.6 Continuity of ring final circuit conductors

2.2 A three-step test is required to verify the continuity of the line, neutral and protective conductors and the correct wiring of every ring final circuit. The test results show if the ring has been interconnected to create an apparently continuous ring circuit, which is in fact broken or connected as a 'figure of eight' configuration.

Instrument: Use a low-resistance ohmmeter for this test — see section 4.3.

Step 1

The line, neutral and protective conductors are visually identified at the distribution board or consumer unit and the end-to-end resistance of each is measured separately (see Figure 2.2a).

test

These resistances are n, rn and r) respectively. A finite reading confirms that there is no discontinuity on the ring conductors under test. The resistance values obtained should be of the same order if the conductors are the same size. If the protective conductor has a smaller cross-sectional area, the resistance of the protective conductor loop will be proportionally higher than that of the line or neutral loop, e.g. 1.67 times for 2.5/1.5 mm2 cable. If the resistance readings are not as expected this could mean the following:

readings lower than the expected resistance l , would suggest that the ring is incorrectly configured, possibly wired in a 'figure of eight' connection; this may be further confirmed by the step 2 test below readings higher than the expected resistance], would suggest that one or more of the conductor terminations is poorly made

I The 'expected resistance' mentioned above is that found from the tabulated d.c. resistance for the conductor size per metre multiplied by the installed length and corrected for measured temperature. A small allowance should be made for instrument errors. Table Bl gives values of d.c. resistance for conductors.

Step 2

The open ends of the line and neutral conductors are then connected together so that the outgoing line conductor is connected to the returning neutral conductor and vice versa (see Figure 2.2b).

V Figure 2.2b Connections for testing step 2

The resistance between line and neutral conductors is measured at each socketoutlet. The readings at each of the sockets wired into the ring should be substantially the same and the value will be approximately one-quarter of the resistance of the line plus the neutral loop resistances, i.e. (n + rn)/4 (see mathematical explanation in figure 2.3). Any sockets wired as spurs will give a higher resistance value due to the resistance of the spur conductors.

used, care should be taken to verify that the line

Note: 1%ete single-core cables are

oppositeends of the ring circuit are connected together. An in thts respect will be apparent from the readings taken at the socket-outlets progressiv

tncteasing value as read,ngs ate taken towards the midpoint of the ring, then again tcwatds the other end of the ring

The open ends of the line conductor and cpc are then cross-connected (see

2.20

Figure 2.2c Connections for testing step connector3 block

d at each socket-outlet. The reading The resistance between line and earth is measure •Il be substantially the sa obtained at each of the sockets wired into the ring WI and the value will be approximately one-quarter Of the resistance of the line me

A cpc higher loop resistance resistances, value i.e. will (n + be r)/4 recorded (the explanation at any sockets for this wired being as spurs. similarThe to step highest'Plus2)

value recorded represents the maximum (RI + R) Of the circuit and is recorded the Schedule of Test Results. The value can be used to determine the earth fault loop impedance (Z) of the circuit to verify compliance with the loop impedance

The inspector is again reminded to take note of the effects of possible parallel return

figures b and c show the resistances of each leg of the ring as a test is applied at this point as per step 2 (line-neutral).

The equivalent connects are then represented in figure d.

The equivalent circuit diagram and resultant resistance are shown in figure e.

Thus, in summary the open loop resistances are 0.6 ohm for both line and neutral, giving an (n + rn) value of (0.6 + 0.6), or 1.2 ohms.

From Figure e above it can be seen that a correctly connected ring will give a step 2 reading of a quarter of the (rl + r) value, or:

in this case = 0.3 ohm

setp 2 test

2.6.7 Insulation resistance

612.3 Insulation resistance testing is a fundamental test for inspectors. Often on larger construction sites, cables will be insulation resistance tested during various stages of installation to prove the integrity of installed cables. It is always preferred to re-test cables and equipment for insulation resistance as part of initial verification as well as during construction.

612.3.1 BS 7671 requires that insulation resistance is measured between all of the live conductors and between the live conductors and the protective conductor with the protective conductor connected to the earthing arrangement. This key change to the procedure was introduced in the 17th Edition in 2008 and is an important change to practice for many installers and inspectors. Taking cables as an example, previously it was acceptable to test a cable between the various cores, and test to earth (often the armouring or sheath of the cable); sometimes these cables were terminated without further testing. This is not acceptable now and it is essential to test to the protective conductor (the armouring in the case of this example) with it connected — via a fly-lead if necessary — to the installation earthing arrangement. This is shown in Figure 2.4c. It is a good idea to test all cables, including those tested during the construction stage using this method.

The purpose of the insulation resistance test is to verify that the insulation of conductors provides adequate electrical insulation, is not damaged and that live conductors or protective conductors are not short-circuited.

As a reminder, prior to carrying out the test, check that:

the protective conductor of the item (switchgear or cable etc.) is connected to the main earthing terminal, which must be connected to the means of earthing

pilot or indicator lamps, and capacitors are disconnected from circuits to avoid an inaccurate test value being obtained (see note below)

voltage-sensitive electronic equipment such as dimmer switches, touch switches, delay timers, power controllers, electronic starters for fluorescent lamps, emergency lighting, RCDs and similar equipment are disconnected so that they are not subjected to the test voltage. The functional earthing leads of RCBOs should also be disconnected so that a low insulation resistance reading or damage to an RCBO will not be caused.

Note: b and c are necessary because, as testing occurs between all conductors, anything connected and in circuit will be subjected to the test voltage.

Instrument: Use an insulation resistance tester -- see section 4.4.

able 61 Insulation resistance tests should be carried out using the appropriate d.c. test voltage specified in Table 61 of BS 7671. The installation will be deemed to conform with the Regulations in this respect if the main switchboard, and each distribution circuit tested separately with all its final circuits connected, but with current-using equipment disconnected, has an insulation resistance not less than that specified in Table 61, reproduced here as Table 2.2.

Simple installations that contain no distribution circuits should preferably be tested as a whole, see example in Figure 2.4a.

The tests should be carried out with the main switch off, all fuses in place, switches and circuit-breakers closed, lamps removed, and fluorescent and other discharge luminaires and other equipment disconnected. Where the removal of lamps and/or the disconnection of current-using equipment is impracticable, the local switches controlling such lamps and/or equipment should be open.

To perform the test in a complex installation it may need to be subdivided into its component parts.

Although an insulation resistance value as low as I MQ would comply with the Regulations, a new installation should not yield a test result this low.

Example (i) — Insulation resistance test of a whole consumer unit

V Figure 2.4a Example of an insulation resistance test of a whole consumer unit

Figure 2.4a shows an example of testing a whole consumer unit (i.e. installation) in one test (only the line to neutral test is shown). The tests required are a test between the live conductors (line to neutral) and tests between the live conductors and earth (line to earth and neutral to earth).

For circuits containing two-way switching or two-way and intermediate switching, the switches must be operated one at a time and the circuits subjected to additional insulation resistance test in these configurations.

For circuits/equipment vulnerable to the test voltage, the test is made with the line and neutral conductors connected together and earth. It is essential that the incoming earth connection is connected to the installation main earthing terminal (and that this is connected to the means of earthing) for these tests.

Example (ii) — Insulation resistance test of a final circuit

Figure 2.4b shows an example of testing a single final circuit at a consumer unit (only the line to neutral test is shown). The tests required are a test between the live conductors (line to neutral) and tests between the live conductors and earth (line to earth and neutral to earth).

For circuits containing two-way switching or two-way and intermediate switching, the switches must be operated one at a time and the circuits subjected to additional insulation resistance test in these configurations.

For circuits/equipment vulnerable to the test voltage, the test is made with the line and neutral conductors connected together and earth. It is essential that the incoming earth connection is connected to the installation main earthing terminal (and that this is connected to the means of earthing) for these tests.

V Figure 2.4b Example of insulation resistance test of a final circuit

Notes: (a) the test should be initially carried out on the complete installation (b) bonding and Earthing connections are in place

Insulation resistance testing of a three-phase 4-core power cable The cable is tested as per Table 2.3.

V Table 2.3 Insulation resistance test on 4-core power cable

The lowest value of these tests is recorded as between live conductors'

Test 5 Ll + L2 + L3 (connected together) to earth neutral earth

The lowest value of these tests is recorded as 'between live conductors and earth"

Note: It is essential for tests 5 and 6 that the cable earth is connected to the installation earthing terminal.

V Figure 2.4c Insulation testing of a three-phase power cable (showing the neutral to earth test)

Insulation resistance readings obtained should be not less than the minimum values referred to in Table 2.2.

.4 2.6.8 Confirming SELV or PELV circuits by insulation testing

In order to establish which insulation tests are required for verifying a SELV or PELV system, the requirements of Section 414 of BS 7671 must firstly be understood.

There are situations where the provision of insulation of SELV or PELV circuits for basic protection is generally not required by BS 7671, i.e. for the following voltages:

upto 12 volts a.c or 30 volts d.c. in wet areas up to 25 volts a.c. or 60 volts d.c. in dry areas

Part 7 However, for bathrooms, swimming pools, saunas and some other special locations, basic protection by insulation is required for SELV and PELV at all voltages.

It is Often, therefore, easier to carry out insulation tests of these circuits as a matter of course.

Where SELV or PELV is used as a protective measure and insulation testing is required, Tables 2.4 and 2.5 set out the requirements.

Instrument: Use an insulation resistance tester for these tests. Refer to section 4.4.

612.4.1 V Table 2.4 SELV insulation resistance tests

Note: In situations where the SELV conductors are separated by just insulation, such as within a multicore cable with low voltage circuits, then the test voltage shall be increased to 500 volts d.c. and the insulation resistance shall be not less than 1 MO.

612.4.2 V Table 2.5 PELV insulation resistance tests

Note: In situations where the PELV conductors are separated by just insulation, such as within a multicore cable with low voltage circuits, then the test voltage shall be increased to 500 volts d.c. and the insulation resistance shall be not less than I MQ.

2.6.9 Testing of electrically separated circuits

612.4.3 The source of supply should be inspected to confirm compliance with the Regulations.

413.3.2 In addition, should any doubt exist, the voltage should be measured to verify it does not exceed 500 V.

Insulation tests are then made as per Table 2.6.

Instrument: Use an insulation resistance tester for these tests. Refer to section 4.4.

V Table 2.6 Tests made to verify electrical separation

Additional inspections and tests for separated circuit supplying more than one item of current-using equipment:

418.3 (a) Apply a continuity test between all exposed-conductive-parts of the separated circuit to ensure that they are bonded together. The non-earthed protective bonding conductor should then be subjected to a 500 V d.c. insulation resistance test between it and the protective conductor or exposed-conductiveparts of other circuits, or to extraneous- conductive-parts. The insulation resistance should be not less than 1.0 MO. Instruments: Use a low-resistance ohmmeter and an insulation resistance tester for these tests. Refer to Chapter 4.

4183.5 (b) All socket-outlets must be inspected to ensure that the protective conductor contact is connected to the non-earthed protective bonding conductor.

418.3.6 (c) All flexible cables other than those feeding Class Il equipment must be inspected to ensure that they contain a protective conductor for use as an unearthed protective bonding conductor.

4183.7 (d) Operation of the protective device must be verified by measurement of the able 41.2 fault loop impedances (i.e. between live conductors) to the various items able 41.3 of connected equipment. These values should then be compared with the able 41.1 maximum Zs value required by Regulation 411.4.5, with reference to the type and rating of the protective device for the separated circuit. For 230 V systems, Tables 41.2 and 41.3 of Chapter 41 of BS 7671 may be used for the maximum Zs values for fuses and circuit-breakers respectively. Although these tables pertain to the line/protective conductor loop path, and the measured values are between live conductors, they give a reasonable approximation to the values required to achieve the required disconnection time of Table 41.1.

2.6.10 Testing of functional extra-low voltage (FELV) circuits

411.7 A FELV system is an extra-low voltage system meeting the requirements of Regulation Group 411.7 (Functional extra-low voltage (FELV)). The system does not meet all the requirements of Section 414 of BS 7671 relating to SELV or PELV, and it use is permitted only where SELV or PELV are not necessary.

6124.4 Regulation 612.4.4 requires that FELV circuits shall meet the test requirements for low voltage circuits (such as 'mains voltage' circuits). This includes the testing of:

Additional inspections and tests for separated circuit supplying more than one item of current-using equipment:

418.3 (a) Apply a continuity test between all exposed-conductive-parts of the separated circuit to ensure that they are bonded together. The non-earthed protective bonding conductor should then be subjected to a 500 V d.c. insulation resistance test between it and the protective conductor or exposed-conductiveparts of other circuits, or to extraneous- conductive-parts. The insulation resistance should be not less than 1.0 MO. Instruments: Use a low-resistance ohmmeter and an insulation resistance tester for these tests. Refer to Chapter 4.

418.3.5 (b) All socket-outlets must be inspected to ensure that the protective conductor contact is connected to the non-earthed protective bonding conductor.

418.3.6 (c) All flexible cables other than those feeding Class Il equipment must be inspected to ensure that they contain a protective conductor for use as an unearthed protective bonding conductor.

4183.7 (d) Operation of the protective device must be verified by measurement of the

Table 41.2 fault loop impedances (i.e. between live conductors) to the various items

Table 41.3 of connected equipment. These values should then be compared with the

Table 41.1 maximum Zs value required by Regulation 411.4.5, with reference to the type and rating of the protective device for the separated circuit. For 230 V systems, Tables 41.2 and 41.3 of Chapter 41 of BS 7671 may be used for the maximum Zs values for fuses and circuit-breakers respectively. Although these tables pertain to the line/protective conductor loop path, and the measured values are between live conductors, they give a reasonable approximation to the values required to achieve the required disconnection time of Table 41.1.

2.6.10 Testing of functional extra-low voltage (FELV) circuits

411.7 A FELV system is an extra-low voltage system meeting the requirements of Regulation Group 411.7 (Functional extra-low voltage (FELV)). The system does not meet all the requirements of Section 414 of BS 7671 relating to SELV or PELV, and it use is permitted only where SELV or PELV are not necessary.

612.44 Regulation 612.4.4 requires that FELV circuits shall meet the test requirements for low voltage circuits (such as 'mains voltage' circuits). This includes the testing of:

612.2 continuity of protective conductors (see 2.6.5)

612.3

insulation resistance (see 2.6.7), the test voltage being 500 V d.c. and the

612.4.5

basic protection by a barrier or enclosure provided during erection of the installation (see 2.6.12)

612.6

polarity (see 2.6.14)

It should also be checked by inspection that:

411.72 the exposed-conductive-parts of the FELV system are connected to the

411.7 protective conductor of the primary circuit of the source, provided that the primary circuit is subject to protection by automatic disconnection of supply in accordance with Regulation 411.3 to 6, and the source of the FEW system is one that meets the requirements of Regulation

411.7.5 plugs, socket-outlets, LSCs, DCLs and cable couplers of the FELV system all have a protective conductor contact (connected to the protective conductor) are not dimensionally compatible with those used for any other systems in use at the same premises.

434.5 Automatic disconnection of supply for protection against electric shock is not required in a FELV system, but may be required for other reasons, such as protection against thermal effects.

2.6-11 Protection by barriers or enclosures provided during erection

612.4.5 This test is not applicable to barriers or enclosures of factory-built equipment. It is

416.2.] applicable to those constructed on site during the course of assembly or erection

416.2.2 and therefore is seldom necessary. Where, during erection, an enclosure or barrier is 416.2.] provided for basic protection, a degree of protection not less than IPXXB or IP2X is required. Readily accessible horizontal top surfaces must have a degree of protection of at least IPXXD or IP4X.

Whilst enclosures are covered by product standards, barriers may not be and the inspector must use judgement in deciding if a barrier is fit for purpose.

The degree of protection afforded by IP2X is defined in BS EN 60529 as protection against the entry of 'Fingers or similar objects not exceeding 80 mm in length. Solid objects exceeding 12.5 mm in diameter'. The test is made with a metallic standard test finger (test finger 1 to BS EN 61032).

Both joints of the finger may be bent through 90 0 with respect to the axis of the finger, but in one and the same direction only. The finger is pushed without undue force (not more than 10 N) against any openings in the enclosure and, if it enters, it is placed in every possible position.

A SELV supply, not exceeding 50 V, in series with a suitable lamp is connected between the test finger and the live parts inside the enclosure. Conducting parts covered only with varnish or paint, or protected by oxidation or by a similar process, must be covered with a metal foil electrically connected to those parts that are normally live in service.

The protection is satisfactory if the lamp does not light.

The degree of protection afforded by IP4X is defined in BS EN 60529 as protection

against the entry of 'Wires or strips of thickness greater than 1.0 mm, and solid objects of 1.0 mm diameter or greater'.

The test is made with a straight rigid steel wire of I mm diameter applied with a force of 1 N ± 10 per cent. The end of the wire must be free from burrs, and at a right angle to its length.

The protection is satisfactory if the wire cannot enter the enclosure.

Reference should be made to the appropriate product standard or BS EN 60529 for a fuller description of the degrees of protection, details of the standard test finger and other aspects of the tests.

2.6.12 Proving and testing of non-conducting location (insulation resistance/impedance of floors and walls)

418.1 Where fault protection is provided by a non-conducting location, the following should be verified, prior to carrying out insulation testing:

418.1.2 (a) Exposed-conductive-parts should be inspected to confirm that no one can come into simultaneous contact with: two exposed-conductive-parts, or an exposed-conductive-part and any extraneous-conductive-part

418.1.3 (b) In a non-conducting location there must be no protective conductors

(c) Any socket-outlets installed in the location must not incorporate an earthing contact.

418.1.5 Following these checks, the insulation resistance between the insulating floors and

612.5.1 walls to the installation main earthing terminal (via a local earth terminal of the general installation) should be measured. It is required that at least three measurements are made. One measurement must be made approximately one metre from any accessible extraneous-conductive-part, e.g. metal pipe, in the location and the other measurements should be made at distances further away. Methods of measuring the insulation resistance/impedance of floors and walls are described below.

Test method

The insulation resistance test may be made using an insulation resistance tester, see section 4.4, and the test is made between test electrode I or test electrode 2 (see Figures 2.5a and 2.5b) and the main protective conductor of the installation.

Measuring insulation resistance of floors and walls

Appx 13 A magneto-ohmmeter or battery-powered insulation resistance tester providing a no-load voltage of approximately 500 V (or 1000 V if the rated voltage of the installation exceeds 500 V) is used as a d.c. source.

The resistance is measured between the test electrode and the main protective conductor of the installation.

The test electrodes may be either of the following types. In case of dispute, the use of test electrode 1 is the reference method.

It is recommended that the test be made before the application of the surface treatment (varnishes, paints and similar products).

The test electrode shown in Figure 2.5a comprises a metallic tripod of which th parts resting on the floor form the points of an equilateral triangle. Each supportin part is provided tested with over a flexible an area base of approximately ensuring, when 900 loaded, mm2 and close having contact a combineWith thed

surface being resistance of less than 5000 Q between the terminal and the conductive rubber pads

Before measurements are made, the surface being tested is cleaned with a cleaning liquid. While measurements of the floors and walls are being made, a force Of approximately 750 N (75 kg in weight) for floors or 250 N for walls, is applied to the tripod.

Fig 13A V Figure 2.5a Test electrode 1

view from above profile view

section of a contact stud in a conductive rubber

view from below

Test electrode 2

The test electrode shown in Figure 2.5b comprises a square metallic plate with sides that measure 250 mm and a square of dampened water-absorbent paper or cloth, from which surplus water has been removed, with sides that measure approximately 270 mm. The paper/cloth is placed between the metal plate and the surface being tested. During measurement a force of approximately 750 N (75 kg in weight) for floors or 250 N for walls is applied on the plate.

13B V Figure 2.5b Test electrode 2

750 N wooden plate metal plate damp cloth floor covering

Expected results

The floors and walls are considered to be non«onducung where the measured resistances are at least 50 ko (where the system voltage to earth does not exceed 500 V).

612.5.2 A further test is specified in BS 7671 for extraneous-conductive-parts that are within the location but to which insulation has been applied during construction. In these cases a 'flash' insulation tester is required which, after the standard 500 V insulation test, applies a 2000 V a.c. rms test and measures the leakage current (which should be no more than 1 mA).

2.6.13 Polarity testing

612.6 The polarity of all circuits must be verified before connection to the supply, with either an ohmmeter or the continuity range of an insulation and continuity tester. A typical test on a lighting circuit is shown in Figure 2.6.

Alternatively, polarity can be verified by visually checking core colours at terminations, thus verifying the installer's connections. Whatever method is used, polarity checks are required at all points on a circuit.

Instrument: Use a low-resistance ohmmeter for these tests — see section 4.3.

It is necessary to check that all fuses and single-pole control and protective devices are connected in the line conductor. The centre contact of screw-type lampholders must be connected to the line conductor (except E14 and E27 to BS EN 60238).

Note: The continuity test (see 2.6.5) and ring continuity test (see 2.6.6) may confirm polarity.

V Figure 2.6 Polarity test on a lighting circuit

Note: the test may be carried out either at lighting points or switches

REMEMBER TO REMOVE THE TEMPORARY SHORTING LINK WHEN TESTING IS COMPLETE.

Earth electrode resistance testing

77

Three methods of measuring the resistance of an earth electrode are described is

•2 1 Section. Test method El uses a dedicated earth electrode tester (fall of

2 three or four-terminal type), test method E2 uses a dedicated earth electrode (stakeless or probe type) and test method E3 uses an earth fault loop impedan tester.

Test method El: Measurement using dedicated earth electrode tester

(fall of potential, three- or four-terminal type)

It is essential to ensure that the installation is securely isolated from the supply. It is also necessary to disconnect the earthing conductor from the earth electrode Caution: If this is the only earth electrode this may leave the installation unprotected against earth faults and complete isolation of the installation must be made. This disconnection will ensure that the test current only passes through the earth electrode and not through any has parallel been paths. completed The installation and the earthmust remain isolated from the supply until all testing electrode connection reinstated.

Ideally, the test should be carried out when the ground conditions are least favourable such as during dry weather.

The test requires the use of two temporary test spikes (electrodes), and is carried out in the following manner:

Connection to the earth electrode is made using terminals CI and PI of a four-terminal earth tester. To exclude the resistance of the test leads from the resistance reading individual leads should be taken from these terminals and connected separately to the electrode. Where the test lead resistance is insignificant, the two terminals may be short-circuited at the test instrument and connection made with a single test lead, the same being true if using a three-terminal tester. Connection to the temporary spikes is made as shown in Figure 2.7.

V Figure 2.7 Typical earth electrode test using a three- or four-terminal tester

The distance between the test spikes is important. If they are too close together their resistance areas will overlap. In general, reliable results may be expected if the distance

between the electrode under test and the current spike, C2, is at least ten times the maximum dimension of the electrode system, e.g. 30 m for a 3 m long rod electrode.

Three readings are taken:

firstly, with the potential spike, T2, inserted midway between the electrode under test and the current spike, TI secondly, with T2 moved to a position 10 per cent of the overall electrode-tocurrent spike distance back towards the electrode under test last, with T2 moved to a position 10 per cent of the overall distance towards the current spike, from its initial position between the electrode under test and T l .

By comparing the three readings, a percentage deviation can be determined. This is calculated by taking the average of the three readings, finding the maximum deviation of the readings from this average in ohms, and expressing this as a percentage of the average.

The accuracy of the measurement using this technique is typically 1.2 times the percentage deviation of the readings. It is difficult to achieve an accuracy of measurement better than 2 per cent, and inadvisable to accept readings that differ by more than 5 per cent. In this event, to improve the accuracy of the measurement the test must be repeated with a larger separation between the electrode under test and the current spike.

The test instrument output may be a.c. or reversed d.c. to overcome electrolytic effects. Because these instruments employ phase-sensitive detectors, the errors associated with stray currents are eliminated.

The instrument should be capable of checking that the resistance of the temporary spikes used for testing is within the accuracy limits stated in the instrument specification. This may be achieved by an indicator provided on the instrument, or the instrument should have a sufficiently high upper range to enable a discrete test to be performed on the spikes.

Where the resistance of the temporary spikes is too high, measures to reduce the resistance will be necessary, such as driving the spikes deeper into the ground or watering with brine to improve the contact resistance. In no circumstances should the latter technique be used to temporarily reduce the resistance of the earth electrode under test.

ON COMPLETION OF THE TEST, ENSURE THAT THE EARTHING CONDUCTOR IS RECONNECTED.

Test method E2: Measurement using dedicated stakeless or clampbased earth electrode tester

A number of types of earth electrode resistance tester are available that utilise clamps .1 and can carry out measurements without the earth electrode under test having to be 2 disconnected from the installation. The use of two such types is described here.

Instrument using one test coil

The instrument whose use is described here uses a method of measurement similar to the fall of potential method (Method El, described earlier), in that it uses two temporary test spikes (electrodes), as shown in Figure 2.8. These are placed in the

ground, away from the earth electrode under test, in similar fashion to that described for the fall in potential method.

V Figure 2.8 Instrument using one test coil

The clamp containing the test coil is placed around the earth electrode under test, or around the conductor connected to that electrode. This eliminates the effects of parallel resistances so that only the resistance earth electrode under test is measured.

The resulting level of accuracy is similar to that given by Tall of potential' method.

Instrument using two test coils

The instrument whose use is described here relies for its operation on there effectively being a number of earth electrodes within the installation, not just the electrode under test. The electrodes other than the one under test might not be actual earth electrodes; they might be extraneous-conductive-parts buried in the ground or in concrete buried in the ground, such as metallic services pipes or buried structural metalwork.

The instrument uses two coils placed a small distance apart around the earthing conductor of the installation, as shown in Figure 2.9, by means of clamps forming part of the instrument. In practice the coils may be combined into a single clamp. One coil induces a known voltage in a loop circuit containing the earth electrode under test, the general mass of Earth and other connections with Earth within the installation. The second coil measures the test current.

The instrument carries out a calculation using the formula below. This produces a resistance reading intended to represent the resistance of the earth electrode under test.

Where:

reading is the resistance reading given by the test instrument

RE is the actual resistance of the earth electrode under test

RI, R2 etc. are the resistances of the other 'earth electrodes'

The accuracy of the test reading (Rreaång) depends on the existence of multiple parallel paths for the returning test current to the instrument, such that the effective parallel resistance of these paths is low enough to be neglected.

For example, if there are four other 'earth electrodes', effectively connected in parallel, each having a resistance of, say, 40 Q, their combined resistance would be 10 Q. If the resistance of the earth electrode under test was 100 Q, the total resistance, Rreading' measured by the test instrument would be 100 Q +10 Q =110 Q. Consequently, the measured value (Rreading) would be 110 % of the actual value (R), an error of 10 %.

However, if there was only one earth electrode other than the one under test, the error in the measurement could be significantly greater, as the effective path would then be through two electrodes effectively connected in series. Using the same values as in the previous example, this would mean resistance, Rreading, measured by the test instrument would be 100 Q + 40 Q =140 Q. Consequently Rreading would then be 140 % of the actual value (RE), an error of 40 %.

Test method E3: Measurement using an earth fault loop impedance tester

An earth electrode may be tested using an earth fault loop impedance tester. It is recognised that the results may not be as accurate as using a dedicated earth electrode tester.

SWITCH OFF suppLY BEFORE DiscoNNECTlNG THE EARTHING CONDUCTOR The earth fault loop impedance tester is connected between the line conductor at the source of the installation and the earth electrode, and a test performed impedance reading taken is treated as the electrode resistance.

ON COMPLETION OF THE TEST ENSURE THAT THE EARTHING CONDUCT0R Is RECONNECTED BEFORE THE SUPPLY SWITCHED ON AGAIN.

Results of earth electrode testing

For TN-S systems and generator supplies, electrode resistance values may not have been specified, as electrodes often simply provide a local reference earth.

For TT systems, in the absence of the designer's specification, BS 7671 maximum values for RCDs are as follows:

411.5.3 Regulation 411.5.3 requires:

(a) The disconnection time shall be that required by Regulation 411.3.2.2 or

411.3.2.4, and (b) 50 V

where:

The maximum disconnection time required by Regulation 411.3.2.2 (for final circuits rated at not more than 32 A) at a nominal voltage to Earth, IJo, of 230 V is 0.2 s where an RCD is used for fault protection.

The maximum disconnection time required by Regulation 411.3.2.4 (for a distribution circuit or a circuit not covered by Regulation 411.3.2.2) is 1 s.

is the sum of the resistances of the earth electrode and the protective conductor(s) connecting it to the exposed-conductive-parts (in ohms)

An is the rated residual operating current (in amperes).

For a nominal voltage, of 230 V, Table 2.7 gives maximum values of Zs for nondelayed RCDs, which may be substituted for RA in the equation in (b) above.

V Table 2.7 Maximum values of earth fault loop impedance (Zs) for non-delayed RCDs to

BS EN 61008-1 and BS EN 61009-1 for of 230 V

Where a delayed RCD is used to provide fault protection the maximum value of earth fault loop impedance including the earth electrode resistance must be such that the requirements of 411.3 and 411.5 are met. This is likely to require a lower figure than

The table indicates that the use of a suitably rated RCD will theoretically allow much higher values of RA, and therefore of zs, than could be expected by using the circuit

It is advised that earth electrode resistance values above 200 C) may not be stable, as soil conditions change due to factors such as soil drying and freezing.

2.6.15 Protection by automatic disconnection of supply

The effectiveness of measures for fault protection by automatic disconnection of supply can be verified for installations within a TN system by:

measurement of earth fault loop impedance (as described in 2.6.16 below) confirmation by visual inspection that overcurrent devices have suitable shore time or instantaneous tripping setting for circuit-breakers, or current rating (In) and type for fuses where RCDs are employed, testing to confirm that the disconnection times of Chapter 41 of BS 7671 can be met (see 2.6.16 and 2.6.19).

For installations within a TT system, effectiveness can be verified by:

measurement of the resistance of the earthing arrangement of the exposedconductive-parts of the equipment for the circuit in question confirmation by visual inspection that overcurrent devices have suitable shorttime or instantaneous tripping setting for circuit-breakers, or current rating (In) and type for fuses where RCDs are employed, testing to confirm that the disconnection times of Chapter 41 of BS 7671 can be met (see 2.6.16 and 2.6.19).

2.6.16 Earth fault loop impedance verification

6129 Where limitation of earth fault loop impedance is part of a protective measure, then it is fundamental that the initial verification process includes verification of earth fault loop impedances.

The earth fault current loop comprises the following elements, starting at the point of fault on the line-earth loop:

the circuit protective conductor the main earthing terminal and earthing conductor for TN systems, the metallic return path or, in the case of TT and IT systems, the earth return path the path through the earthed neutral point of the transformer the source line conductor winding and the line conductor from the source to the point of fault.

612.8 There are two methods used for verifying total earth fault loop impedance for a circuit:

612.9 measurement of total earth fault loop impedance (Z) using an earth fault loop impedance tester measurement of (RI + R) during continuity testing of a circuit (see 2.6.5 and 2.6.6 ) and addition to the measured earth fault loop impedance external to that circuit (Z).

Which method is used comes down to a matter of personal choice and both are described below

Measurement Of total earth fault loop impedance (Z) using an earth fault loop impedance tester

Measurement of Zs is made on a live installation and for safety and practical reasons neither the connection with Earth nor bonding conductors are disconnected.

Instrument: Use an earth fault loop impedance tester for this test — section 4.5.

Measurement of (RI + R) during continuity testing of a circuit and addition to the earth fault loop impedance external to that circuit (Z)

This procedure is described in section 2.6.5 and, for ring circuits, section 2.6.6, and the (RI + R) value recorded for a particular circuit is added to the earth fault loop impedance at the origin of that circuit.

For a consumer unit at the origin of an installation, this is as follows:

where:

is the total earth fault loop impedance in ohms is the external earth fault loop impedance, 'external' to the installation

is the measured resistance of the line conductor and circuit protective conductor, measured during the continuity test method 1 or ring circuit continuity test step 3.

For consumer units or distribution boards not at the origin, there can arise confusion over the term 'external earth loop impedance' (Z) and some prefer to write or note the earth fault loop impedance at the distribution board as Zdb. As this value is not external to the installation, the formula is modified to:

Residual current devices

The test (measuring) current of earth fault loop impedance testers may trip any RCD protecting the circuit. This will prevent a measurement being taken and may result in an unwanted disconnection of supply to the circuit under test.

Instrument manufacturers can supply loop testers that are less liable to trip RCDs by either limiting the test current (to less than 15 mA) or by d.c. biasing (this technique saturates the core of the RCD prior to applying the test).

Measurement of external earth fault loop impedance, Ze

542.4.2 The external earth fault loop impedance, Ze, is measured using an earth fault loop 610.1 impedance tester at the origin of the installation. The impedance measurement is made between the line conductor of the supply and the means of earthing with the main switch open or with all the circuits isolated. The means of earthing must be disconnected from the installation earthed equipotential bonding for the duration Of the test to remove parallel paths. Care should be taken to avoid any shock hazard to the testing personnel and other persons on the site both whilst establishing contact, and whilst performing the test.

ENSURE THAT THE EARTH CONNECTION HAS BEEN REPLACED BEFORE RECLOSING THE MAIN SWITCH.

See Figure 2.10 for test method connections.

Instrument: Use an earth fault loop impedance tester for this test — see section 4.5.

V Figure 2.10 Example test of Ze at the origin of an installation

As described above, the measured Ze can be used to add to circuit (RI + R) values.

Determining external earth fault loop impedance, Ze, by enquiry

The external earth fault loop impedance, Ze, can be determined by enquiry to the electricity distributor. However, if this is relied upon, a test must be made to ensure that the distributor's earth terminal is actually connected with Earth, using an earth fault loop impedance tester or a test lamp; it is usually easier simply to measure Ze.

Verification of earth fault loop impedance test results

612.1

Table 41.2 Table 41.3

Table 41.4

It is important to recognise that BS 7671 requires the inspector not only to test the installation but also to compare the results with relevant design criteria (or with criteria within BS 7671). This may seem obvious, but it is not uncommon for some inspectors to pass test information back to their office without making the necessary comparisons, possibly assuming that the office or someone else will check the results; the office might then assume that the inspector has checked the results against criteria, but no one has!

Values of Zs should be compared with one of the following:

for standard thermoplastic (pvc) circuits, the values in Appendix A of this Guidance Note

earth fault loop impedance figures provided by the designer. See also Appendix A, which provides information on how to correct measured results for ambient temperature as this may not have been done by the designer (the inspector will need to clarify this point)

tabulated values in BS 7671, corrected for temperature. See Appendix A, which provides information on how to correct measured results for ambient temperature

using a factor of 0.8, see Appendix A2.

APPendix A provides a formula for making temperature adjustments, together With worked example.

2.6.17 Prospective fault current, Ipf

612.11

Regulation 612.11 requires that the prospective fault current under both short-circuit and earth fault conditions, be measured, calculated or determined by another method at the origin and at other relevant points in the installation.

434.1 Regulation 612.11 introduces the requirements of Regulation 434.1 into the testing section, the designer being required to determine the prospective fault current under both short-circuit and earth fault conditions, at every relevant point of the installation. This may be done by calculation, be ascertained by enquiry or b measured directly using an instrument. The expression 'every relevant point' means every point where a protective device is required to operate under fault conditions, and includes the origin of the installation.

The inspector must have knowledge of the design in this respect as, for example, if the switchgear at the origin of an installation is suitably rated for prospective fault current and switchgear of similar short-circuit rating is used downstream of that point, then no further checks are necessary. This is because the magnitude of the prospective fault current decreases with increasing distance downstream of the origin, assuming that there is not another source of supply, such as a generator, connected to the installation at a point other than the main supply terminals of the installation.

434.5.1 Regulation 434.5.1 requires that, except where back-up protection is provided by Part 2 another device in accordance with the second paragraph of that regulation, the breaking capacity rating of each protective device shall be not less than the prospective fault current at its point of installation. The term prospective fault current includes the prospective short-circuit current and the prospective earth fault current. The maximum prospective fault current at the point of installation of a protective device is the greater of these two prospective fault currents at that point, which should be determined and compared with the breaking capacity of the device.

With the power on, the maximum value of the prospective short-circuit current can be obtained by direct connection of the instrument between live conductors at the protective device at the origin or other relevant location within the installation. Both two-lead and three-lead instruments capable of determining prospective fault current are available and it is important that any instrument being used is set on the correct range and connected in accordance with the manufacturer's instructions for its use. Failure to do so could be dangerous, could result in damage to the instrument and might result in misleading readings being obtained.

Instrument: Use the prospective fault current range of a suitable earth fault loop impedance tester for this test - see section 4.5 (final paragraph).

With some instruments, the voltage between line conductors cannot be measured directly. Where this is the case, it can be assumed that for three-phase supplies the maximum balanced prospective short-circuit level will be, as a rule of thumb, approximately twice the single-phase value. This figure errs on the side of safety.

Prospective earth fault current may be obtained with the same instrument Again, care must be taken to ensure that the instrument is set correctly and connected as per the manufacturer's instructions for use.

The values obtained should be compared with the breaking capacity of the appropriate protective device. The breaking capacity of the protective device should be greater than the highest value of prospective fault current obtained using the instrument.

Whichever is the greater of the prospective short-circuit current and the prospective earth fault current obtained should be recorded on the Schedule of Test Results.

For a three-phase system, the prospective three-phase short-circuit current will always be larger than the single-phase line to neutral or earth fault currents.

Note on accuracy of earth fault loop impedance and prospective fault current testers (see also section 4.5)

Earth fault loop impedance testers become less accurate at smaller value readings, such as when measuring close to a transformer or other low impedance source. It should be noted that the standard instrument used for determining prospective fault current is effectively an earth loop impedance instrument.

Displayed test result less than about 0.2 Q, or about 1.0 Q when on the lower current range (such as 15 mA), could be prone to significant errors. Such errors can significantly affect the calculation of prospective fault current.

Rated short-circuit breaking capacities of protective devices

The rated short-circuit capacities of fuses, circuit-breakers to BS EN 60898 and BS 3871 (now withdrawn) and RCBOs to BS EN 61009 are shown in Table 2.8. Note that BS 3871 identified the short-circuit capacity of circuit-breakers with an 'M' rating.

\* Two short-circuit capacity ratings are defined in BS EN 60898 and BS EN 61009: lcn the rated short-circuit capacity (marked on the device) ICS the service short-circuit capacity.

t BS 1361 has been withdrawn.

The difference between the two short-circuit-ratings described above is the condition of the circuit-breaker after manufacturer's testing.

lcn is the maximum fault current the device can interrupt safely, although its characteristics may have been altered and it may no longer be usable.

is the maximum fault current the device can interrupt safely without loss of performance.

The lcn value is marked on the device in a rectangle for the majority of applications the prospective fault current at the terminals of the circuit-breaker should not exceed this value.

For domestic installations the prospective fault current is unlikely to exceed 6 kA, up to which value lcn will equal ICs.

For switchgear, the relevant fault current (short-circuit) rating of the switchgear (or assembly) should be equal to or exceed the maximum prospective fault current at the point of connection to the system. The terminology to define the short-circuit rating of an assembly is given in the BS EN 61439 series of standards as follows:

rated short-time withstand current lcw rated peak withstand current Ipk rated conditional short-circuit current ICC.

Where a service cut-out containing a cartridge fuse to BS 88-3 (formerly BS 1361) supplies a consumer unit which complies with BS 5486-13 or BS EN 60439-3 Annex

ZA, then the short-circuit capacity of the overcurrent protective devices within consumer units may be taken to be 16 kA.

Fault currents up to 16 kA

Except in London and some other major city centres, the maximum fault current for 230 V single-phase supplies up to 100 A is unlikely to exceed 16 kA.

The short-circuit capacity of overcurrent protective devices incorporated within consumer units may be taken to be 16 kA where:

the consumer unit complies with BS 5486-13 or BS EN 60439-3 the consumer unit is supplied through a type 2 fuse to BS 1361:1971 rated at no more than 100 A.

Recording the prospective fault current

Both the Electrical Installation Certificate and the Electrical Installation Condition Report contain a box headed Nature of Supply Parameters, which requires the prospective fault current at the origin to be recorded. The value to be recorded is the greater of either the short-circuit current (between live conductors) or the earth fault current (between line conductor(s) and the main earthing terminal). If it is considered necessary to record values at other relevant points, they can be recorded on the Schedule of Test Results. Where the protective devices used at the origin have the necessary rated breaking capacity, and devices with similar breaking capacity are used throughout the installation, it can be assumed that the Regulations are satisfied in this respect for all distribution boards (provided there is not another source of supply, such as a generator, connected to the installation at a point other than the main supply terminals of the installation).

2.6.18 Phase sequence testing

612.12 The 17th Edition introduced in Regulation 612.12 a requirement to verify that the phase sequence is maintained for multiphase circuits within an installation. In practice, this will be achieved by checking polarity and connections throughout the installation.

Optionally and occasionally, the inspector may wish to check phase sequence by using a phase rotation tester, either

rotating disc type, or indicator lamp type.

Instruments containing both of the above forms of indication are also available.

Various types exist, a rotating disc, an electronic LCD equivalent or other means of indication. Generally, coloured or labelled leads are connected to the installation and if the phase sequence/rotation is correct the indication confirms this.

In the case of a rotating disc type instrument, the disc will be rotating either clockwise or anticlockwise.

With the indicator lamp type either the Ll/L2/L3 (formerly R/Y/B) lamp or the 11/13/ L2 (formerly R/B/Y) lamp will be illuminated.

Both types of phase sequence indicator can also be used to verify phase sequence/ direction of rotation at the supply terminals to motors and to confirm the correct labelling/identification of plain conductors.

2.6.19 Operation and functional testing of RCDs

The operating times of RCDs are required to be tested in the following CirCUmstances:

8.] where they are relied on for disconnection for compliance with Chapter 41

612.10 where they are installed as additional protection as specified in Chapter 41.

Where RCDs are installed with circuit-breakers and the circuit has the characteristics to satisfy Chapter 41 without the RCD, then testing of the RCD is not essential unless it is specified for additional protection.

Operation of residual current devices

411.4.5 For each of the tests, readings should be taken on both positive and negative half411.5.3 cycles and the longer operating time recorded.

Prior to these RCD tests it is essential, for safety reasons, that the earth loop impedance is tested to check the requirements have been met.

Instrument: Use an RCD tester for these tests, see section 4.7.

Test method

The test is made on the load side ofthe RCD between the line conductor of the protected circuit and the associated cpc. The load should be disconnected during the test. These tests can result in a potentially dangerous voltage on exposed-conductive-parts and extraneous-conductive-parts when the earth fault loop impedance approaches the maximum acceptable limits. Precautions must therefore be taken to prevent contact of persons or livestock with such parts.

411.4.5 The operating time should be no greater than those in Table 2.9, noting that all RCDS should first be tested at 50 per cent of rated current and must not operate/open with this test. Operation in accordance with Table 2.9 provides compliance with the appropriate product standard and will provide compliance with Regulation 411.4.5 (for a TN system) or Regulation 411.5.3 (for a TN system), as applicable.

V Table 2.9 Operational tripping times for various RCDs

415.1 Where an RCD with a rated residual operating current, IA n, not exceeding 30 mA is 612.10 used to provide additional protection in the event of failure of basic protection and/or failure of the provision for fault protection or carelessness by users, the operating time of the device must not exceed 40 ms at a test current of 5 IA n. The maximum test time should not exceed 40 ms, unless the protective conductor potential rises by less than 50 V. (The instrument supplier will advise on compliance.)

Integral test device

612.13.] An integral test device is incorporated in each RCD. This device enables the functioning of the mechanical parts of the RCD to be verified by pressing the button marked 'T' or 'Test'.

Operation of the integral test device does not provide a means of checking:

the continuity of the earthing conductor or the associated circuit protective conductors, or

any earth electrode or other means of earthing, or (c) any other part of the associated installation earthing, or (d) the sensitivity of the device.

The RCD test button will only operate the RCD if it is energized.

2.6.20 Other functional testing

612.13.2 All assemblies, including switchgear, controls and interlocks, should be functionally tested - that is, operated to confirm that they work and are properly installed, mounted and adjusted.

2.6.21 Verification of voltage drop

612.14 Where it may be necessary to verify that voltage drop does not exceed the limits stated Sect 525 in relevant product standards of installed equipment, BS 7671 provides two options to do so. Where no such limits are stated, voltage drop should be such that it does not

impair the proper and safe functioning of installed equipment.

Voltage drop problems are quite rare but the inspector should be aware that long runs of circuit conductors and/or high currents can sometimes cause voltage drop problems.

Measurement of voltage drop within an installation is not practical as this would mean measuring the instantaneous voltage at both the origin and at the point of interest simultaneously, together with the instantaneous load current.

Verification of voltage drop is not normally required during initial verification.

It is usually sufficient to check that voltage drop calculations have been undertaken.

Table 4Ab Appendix 4 of BS 7671 gives maximum values of voltage drop for lighting and for other uses, depending upon whether the installation is supplied directly from an LV distribution system or from a private LV supply.

It should be remembered that voltage drop may exceed the values stated in Appendix 4 in situations such as motor starting periods and where equipment has a high inrush current where such events remain within the limits specified in the relevant product standard or reasonable recommendation by a manufacturer.

2-6.22 Verification in medical locations

Sect 710 Medical locations were introduced into BS 7671:2008 by Amendment No. 1:2011 and were subsequently modified by a corrigendum dated June 2013.

710.61 The installation and testing of installations in medical locations is very much a specialist area and only the general requirements of BS 7671 are covered in this Guidance Note. Initial verification is carried out by an inspection and functional tests of the isolation IT system equipment including the insulation monitoring devices. Testing is required to measure the leakage current of the output circuit of medical IT isolating transformers and measurement of the resistance of the supplementary equipotential bonding.

2.6.23 Verification of protection of low voltage installations against temporary overvoltages due to faults in the high voltage or low voltage system

Sect 442 The protection referred to in this section of the Guidance Note is the subject of Section CNI 442 of BS 7671. For more information, see IET Guidance Note l .

442.2.1 Temporary overvoltages due to a high voltage system fault

442.2.2 Regulations 442.2.1 and 442.2.2 give the requirements concerning the magnitude and duration of temporary overvoltages occurring due to a fault in the HV system (typically 1 1 kV) supplying the substation from which the low voltage installation is supplied.

442.2.3 Regulation 442.2.3 points out that the requirements of Regulations 442.2.1 and 442.2.2 are deemed to be met if the low voltage installation is supplied from a system for distribution of electricity to the public. This assumes that the public electricity supply distribution system is appropriately designed and constructed, as is the case in Great Britain. Where this is the case, there is no need for the inspector to check compliance with Regulations 442.2.1 and 442.2.2.

442.2.1 Where the low voltage installation is supplied from a privately-owned substation, the 4422.2 design responsibility for complying with Regulations 442.2.1 and 442.2.2 rests with the designer(s) of the substation and the associated low voltage distribution network up to the incoming terminals of the low voltage installation. The inspector will need to be in possession of sufficient information provided by this party (or parties) about the intended means compliance, to enable him or her to verify, so far as is reasonably practicable, that these means have been properly put into effect. Matters to be checked by the inspector include:

that the high voltage and low voltage earthing arrangements of the substation have been correctly installed and that their resistances to Earth meet the designer's requirements that the high voltage earthing and low voltage arrangements are interconnected or, where appropriate, separated, according to the designer's requirements that any global earthing system or additional connections with Earth in the LV network that are relied on for safety are in existence and properly installed, and that the resistance of connections with Earth meets the designer's requirements that the rated currents and settings of protective devices are as intended by the designer.

Temporary overvoltages due to a low voltage system fault

442.3 Regulations 442.3, 442.4 and 442.5 require consideration to be given to the stress

442.4 voltages that would occur in an installation in the event of loss of the neutral conductor 442.5 in a TN or TT system, an earth fault in an IT system with distributed neutral, or a shortcircuit between a line conductor and a neutral conductor.

In practice there is usually little that installation designer and constructor can do to meet the requirements of these regulations beyond selecting and installing equipment with appropriate insulation voltage ratings, such as 600/1000 V cables for an installation of nominal voltage 230/400 V. The inspector should check that this has been done.

2.6.24 Verification of protection against overvoltages of atmospheric origin or due to switching

Section 443 The protection referred to in this section of the Guidance Note is the subject of Section GNI 443 of BS 7671. For more information, see IET Guidance Note l .

Table 44.4 Irrespective of whether the electrical designer has chosen to specify surge protective devices (SPDs), the inspector should check that all electrical equipment of the installation has been so selected and installed that, according to its product standards, it provides at least the applicable value of withstand voltage referred to in Table 44.3 of BS 7671. The values of impulse withstand voltage that table are given according to which Category, l, Il, Ill or IV, the equipment falls into and according to the nominal voltage of the installation. Table 44.4 of BS 7671 gives examples of equipment falling into each of the categories.

443.1.1 Where protection against overvoltages by the use of SPDs has been specified by the Section 534 designer, the inspector should check that they have been selected and installed in accordance with the designer's requirements or otherwise in accordance with Section 534 of BS 7671.

2.6.25 Verification of measures against electromagnetic disturbances

Sect 444 Inspectors should familiarise themselves with the section on avoidance and reduction

CNI of electromagnetic disturbances, Section 444 of BS 7671, which was introduced by Amendment No. 1: 2011. For more information, see IET Guidance Note 1.

It should be noted that compliance with EMC requirements in BS 7671 and in The Electromagnetic Compatibility Regulations 2006 is something that is not verified by testing. The ethos of achieving electromagnetic compatibility is in design (with possibly some of the mitigating effects) and compliance is shown by way of storing information on the design criteria.

Section 444 specifies additional mitigating methods for EMC applied to the design and installation of cables and equipment. Many of these mitigating methods concern the routing of cables and their distance from other cables, as well as providing equipotential bonding.

Thus, verification of EMC and compliance with Section 444 is as follows:

checking the EMC design with respect to cable routing, separation distances, enclosure etc.

inspection of cable sheath and screen terminations and, if considered necessary, continuity checking of these items carrying out continuity checks of any additional mitigating bonding network provided (for example, a local mesh network).

It should be noted that there are no requirements for either installers or inspectors to carry out electric field or magnetic field strength measurements.