IET

3

Guidance Note 3

Inspection & Testing

18th IET Wiring Regulations BS 7671:2018

Contents

Cooperating organisations

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It is strongly recommended that anyone involved in work on or near electrical installations possesses a copy of the latest version the *Memorandum of guidance on the Electricity at Work Regulations 1989* (HSR25) published by the Health and Safety Executive.

Copies of Health and Safety Executive documents and approved codes of practice (ACOP) can be obtained from:

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Preface

This Guidance Note is part of a series issued by the Institution of Engineering and Technology to explain and enlarge upon the requirements in BS 7671:2018, the 18th Edition of the IET Wiring Regulations.

From here on in BS 7671:2018 is referred to as BS 7671, and will only include a year after the standard where there is a need to refer to a requirement made in an earlier edition, such as BS 7671:2008.

Note that this Guidance Note does not ensure compliance with BS 7671. It is intended to explain some of the requirements of BS 7671 but readers should always consult BS 7671 to satisfy themselves of compliance.

The scope generally follows that of BS 7671; the relevant Regulations and Appendices are noted in the margin. Due to the introduction of CENELEC Harmonised Document (HD) 60364-6 in 2016 covering inspection and testing it has been necessary to align the clause numbering in BS 7671 with the HD clause numbering and this has resulted in Chapters 61 to 63 no longer being used, and the text of Part 6 of BS 7671:2018 starts at Chapter 64. Apart from RCD testing, the requirements for inspection and testing have not significantly changed. All of the Guidance Notes also contain references to other relevant sources of information.

Electrical installations in the United Kingdom that comply with BS 7671 are likely to satisfy the relevant parts of Statutory Regulations such as the Electricity at Work Regulations 1989. However, this cannot be guaranteed. It is stressed that it is essential to establish which Statutory and other Regulations apply and to install accordingly. For example, an installation in premises subject to licensing may have requirements different from or additional to, those of BS 7671 and these will take precedence.

The Regulations (BS 7671) apply to the design, erection and verification of electrical installations, also to additions and alterations to existing installations and to the inspection and testing of existing installations. Existing installations that have been installed in accordance with earlier editions of the Regulations may not comply with this edition in every respect, but this does not necessarily mean that they are unsafe for continued use or require upgrading, and the person or persons carrying out the inspection and testing of such an installation must decide as to whether the installation is safe and suitable for continued use.

Other related electrical installations such as emergency lighting, fire alarms and ICT systems also have their own installation requirement standards such as BS 5266, BS 5839 and BS 6701 that may have installation and inspection and testing and certification requirements over and above that required in BS 7671. It is essential that these further requirements are complied with in such installations.

The inspector is reminded that for a periodic inspection and test of an existing installation their duty is to assess the suitability of the existing installation for continued use, subject to any agreed exclusions. They must therefore make sufficient inspection and tests to enable them to make that assessment. Also the duty of the buildings or site "duty holder" to maintain their installation so it is safe and to undertake such maintenance so this can be achieved.

Introduction

This Guidance Note is concerned principally with Part 6 of BS 7671 – Inspection and testing.

Neither BS 7671 nor any of the IET's Guidance Notes are design guides. It is essential to prepare a design and specification prior to commencement or alteration of an electrical installation.

514.9 The documents should set out the design and provide sufficient information to enable electrically skilled persons and electrically instructed persons (where appropriate) to carry out the installation and to commission it. The specification must include a description of how the system is to operate and the design and operational parameters. It must provide for the commissioning procedures that will be required and for the provision of adequate operation and maintenance information to the user. This should be by means of an operational manual or schedule, and 'as fitted' drawings if necessary.

It must be noted that it is a matter of contract as to which person or organisation is responsible for, in turn, the design, specification, construction and verification of the installation and the provision of any operational information.

The persons or organisations who might be concerned in the preparation of the specification include:

The Designer (See the CDM Regulations 2015 for information on designers' duties)
The Installer (Contractor or contractors)
The Verifier
Specialist Commissioning Engineers
The Distributor of Electricity (DNO)
The Installation Owner and/or User
The Architect
The Fire Risk Assessor (a competent person for building inspection for fire risk and safety)
Specialist manufacturers or suppliers
Area Building Control bodies
Any Regulatory Authority
Any Licensing Authority
Any Specialist Insurers
The Health and Safety Executive

The revision of the CDM Regulations 2015 has given guidance on the duties required of a designer, as well as carrying out the actual design layout, calculations and specifying the materials and installation requirements. "Designers are those, who as part of a business, prepare or modify designs for a building, product or system relating to construction work.

When preparing or modifying designs, to eliminate, reduce or control foreseeable risks that may arise during:

1 construction; and
2 the maintenance and use of a building once it is built.

Provide information to other members of the project team to help them fulfil their duties."

133.1 Details of each item of equipment should be obtained from the manufacturer and/or
Sect 511 supplier and compliance with appropriate standards confirmed.

Health and safety of all installation and inspection and testing staff and any other persons in the premises is vital and a work plan including risk assessments and method statements must be agreed with all parties and put in place before any work is undertaken.

The installation operational manual must include a description of how the system as installed is to operate, maintenance provisions and all test and commissioning records. The manual should also include manufacturers' technical data for all items of switchgear, luminaires, accessories, etc. and any special instructions that may be needed. The *Health and Safety at Work etc. Act 1974* Section 6 and the *Construction (Design and Management) Regulations 2015* are concerned with the provision of information, and guidance on the preparation of technical manuals is given in BS EN 82079-1 *Preparation of instructions for use. Structuring, content and presentation. General principles and detailed requirements* and BS 4940 series *Technical information on construction products and services.* The size and complexity of the installation will dictate the nature and extent of the manual.

With regard to the inspection and testing of an existing installation, it is necessary to agree a detailed specification of the requirements of the client including any limitations.

General requirements 1

1.1 Safety

Before any work can begin a work programme should be agreed with the client and a Health and Safety plan including risk assessments and method statements agreed and put in place. It may be that work has to be carried out when the premises is operating and staff are present so they must not be exposed to any safety risks, work areas should be fenced off with temporary barriers and electrical equipment not left unattended when open. Escape routes must be kept open at all times or temporary alternatives arranged. Where supplies have to be isolated it is necessary that this must be planned in advance with the premises management.

Electrical inspection and testing inherently involves some degree of hazard. It is therefore the inspector's duty to ensure their own safety, and that of others, in the performance of the test procedures. The testing safety procedures detailed in Health and Safety Executive Guidance Note GS38 (fourth edition) '*Electrical test equipment for use on low voltage electrical systems*' should be observed. Where testing does not require the equipment or part of an installation to be live, it should be made dead and safely isolated. Guidance on live and dead working can be found in the Health and Safety Executive publication *Electricity at Work Regulations 1989*(HSR25). Guidance on safe isolation procedures can be found in *Best Practice Guide No.2 Guidance on the management of electrical safety and safe isolation procedures for low voltage installations,* published by the Electrical Safety First.

When using test instruments, safety can be achieved by precautions such as:

(a) understanding the equipment to be used, its rating and the characteristics of the installation it is proposed to use the equipment upon;

(b) checking that the instruments to be used conform to the appropriate British Standard safety specifications. These are BS EN 61010 *Safety requirements for electrical equipment for measurement, control, and laboratory use* and BS 5458:1977 (1993) *Specification for safety requirements for indicating and recording electrical measuring instruments and their accessories.* BS 5458 has been withdrawn, but is the standard to which older instruments should have been manufactured;

(c) checking any test equipment before use to see that it is complete and not damaged; and

(d) checking that test leads including any probes or clips used are in good order, are clean and have no cracked or broken insulation. Where appropriate, the guidance given in GS 38 should be observed for test leads, which recommends the use of fused test leads aimed primarily at reducing the risks associated with arcing under fault conditions.

Particular attention should be paid to the safety aspects associated with any tests performed with instruments capable of generating a test voltage greater than 50 V, or which use the supply voltage for the purposes of the test in earth fault loop testing and residual current device (RCD) testing. Note the warnings given in Section 2.6.16 through to Section 2.6.19 of this Guidance Note.

Electric shock hazards can arise from, for example, capacitive loads such as when cables become charged in the process of an insulation resistance test, or voltages on the earthed metalwork whilst conducting a loop test or RCD test. The test limits quoted in these guidelines are intended to minimise the chances of receiving an electric shock during tests.

1.2 Required competence

641.6 Persons carrying out the inspection and testing of any electrical installation must, as appropriate to their function, have a sound knowledge and experience relevant to the nature of the installation being inspected and tested, and of BS 7671 and other relevant technical standards. (Such persons are generally referred to in this Guidance Note as 'the inspector' and this may be one or more persons depending on the work being undertaken.)

Inspectors must also have relevant education and experience to enable them to perceive risks and avoid dangers that electricity can create, and be fully versed in the inspection and testing procedures. This can best be shown by the inspector holding a recognised inspection and testing qualification.

Furthermore, the inspector must employ suitable test equipment during the inspection and testing process and have sufficient inspection experience in interpreting the results with respect to the requirements of BS 7671.

It is worth noting that the person responsible for inspection and testing may be required to formally demonstrate competence by means of registration/certification under a recognised scheme or membership of a recognised trade body, or for example as a condition of contract and/or as a requirement of the Local Area Building Control (LABC).

It is the responsibility of the inspector, as appropriate for either the initial or periodic inspection and testing, to:

641.4 **(a)** prevent danger to any person or livestock and property damage;
641.3 **(b)** compare the inspection and testing results with the design criteria (where available), with BS 7671 and/or previous records, as appropriate;
(c) confirm compliance or non-compliance with BS 7671 that may give rise to danger; and
(d) take a view and report on the condition of the installation.

In the event of a dangerous situation being found, the inspector should recommend the immediate isolation of the defective item of equipment. The person ordering the work should be informed, in writing, of this recommendation without delay.

1.3 The client

1.3.1 Certificates and Reports

644.1 Following the initial verification of a new installation or changes to an existing installation,
653.1 an 'Electrical Installation Certificate', together with a 'Schedule(s) of inspections' and a 'Schedule(s) of test results', is required to be given to the person ordering the installation work.

Likewise, following the periodic inspection and testing of an existing installation, an Electrical Installation Condition Report, together with Schedule(s) of inspection and Schedule(s) of test results, are required to be given to the person ordering the inspection.

Sometimes the person ordering the work is not the user of the installation. In such cases it is necessary for the user (for example, employer or householder) to have a copy of the certificate (together with the records of inspections and test results). It is recommended that those providing documentation to the person ordering the work also recommend that a copy of the forms be passed to the user, including any purchaser of a domestic property.

Copies of any certificates or reports along with their associated schedules should be kept in the operating and maintenance documentation for the premises.

1.3.2 Rented domestic and residential accommodation

In England and Wales, the *Landlord and Tenant Act 1985*, Section 11 Repairing obligations in short leases sub-section (1)(b) implies that a landlord 'shall keep in repair and proper working order the installations in the dwelling-house for the supply of water, gas and electricity'.

A similar requirement can be found in the Housing (Scotland) Act 2014, Chapter 4, Section 13, which states that the electrical installation must be in a reasonable state of repair in order to comply with the Act. The legislation goes on to state that the installation must be maintained.

The above Acts do not directly specify periodic inspection and testing of an electrical installation. Periodic inspection and testing is a means of demonstrating compliance with the Acts. There are new proposals being considered by the government to require the electrical inspection and testing of rented properties but these are not yet enacted into legislation in England and Wales but the inspection and testing of rented properties is required in Scotland.

Any repairs must be carried out by an electrically skilled person or an electrically competent person under their supervision. The landlord is responsible for confirming the competency of any contractors carrying out such work.

There are requirements for houses of multiple occupancy (HMO) and these are required to be inspected and tested at intervals not exceeding five years, by a skilled person, competent in such work – see Chapter 3.

1.4 Additions and alterations

132.16

644.1 Every addition or alteration to an existing installation must comply with the current
641.3 edition of BS 7671 and must not impair the safety of the existing installation and the

relevant inspection and testing requirements of Chapter 64 also apply to additions and alterations. This applies especially to the replacement of a distribution board or consumer unit. In order to verify that the addition or alteration to an electrical installation complies with BS 7671, the relevant parts of an existing installation must be inspected and tested to confirm the safety of the addition or alteration, including for example:

(a) circuit ratings;
(b) circuit conductor sizes;
(c) means of earthing;
(d) protective conductor continuity; and
(e) earth fault loop impedance.

Whilst there is no obligation to inspect and test any part of the existing installation that does not affect and is not affected by the addition or alteration, any departures or non-compliances observed are required to be noted in the 'Comments on existing installation' section of an electrical installation certificates (single-signature or multiple-signature) or minor electrical installation works certificates.

1.5 Departures and non-compliance

These terms are now frequently used in certificates and reports and are defined in Part 2 of BS 7671.

Departure – deliberate decision not to comply fully with the requirement of BS 7671 for which the designer must declare that the resultant degree of safety is not less than that achievable by full compliance.

Non-compliance – a non-conformity that may give rise to danger.

1.6 Record keeping

132.13 514.9 It is a requirement that the appropriate documentation called for in Regulation 514.9, Part 6, and (where applicable) Part 7 is provided for every electrical installation.

Chapter 65 Appx 6 - guidance to recipients Records of all checks, inspections and tests, including test results, should be kept throughout the working life of an electrical installation. This will enable deterioration to be identified, and could also be used as a management tool to ensure that maintenance checks are being carried out and to assess their effectiveness.

For non-domestic installations, Regulation 12 of the *Construction (Design and Management) Regulations 2015* requires a record known as 'the health and safety file' to be prepared, reviewed, updated and revised from time to time to take account of the work and any changes that have occurred. This should contain any information relating to the project which is likely to be needed during any subsequent construction work to provide for the health and safety of persons. The CDM Regulations require that the health and safety file is passed on to the client on completion of the construction work.

The CDM Regulations also requires that once the construction work has been completed the health and safety file remains available for inspection by any person who might need it to comply with any relevant legal requirements. It also requires that the file is revised and updated as often as may be appropriate to incorporate any relevant new information.

Electrical installation certificates, minor electrical installations works certificates and electrical installation condition reports (as appropriate) would constitute relevant information in relation to this requirement.

For domestic installations the NHBC (National House-Building Council) guidance recommends that all instructions for services be passed to the building owner.

In both domestic and non-domestic cases there may also be insurance requirements that imply or specify records.

The *Electromagnetic Compatibility Regulations 2016* are statutory and require that the client keep the information provided by the installer relating to compliance with EMC criteria for the life of the installation.

Initial verification 2

2.1 Purpose of initial verification

Verification is defined in BS 7671 as: "All measures by means of which compliance of the electrical installation with the relevant requirements of BS 7671 are checked, comprising inspection, testing and certification."

641.1 642.2 643.1 Initial verification is carried out on a new installation before it is put into service. The purpose is to confirm by way of inspection and testing, during construction and on completion, that the installation complies with the design and construction aspects of BS 7671, in so far as is reasonably practicable.

Appx 6, 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, they cannot, and are not meant to, absolve responsibility for their work elements from the designer and installer.

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.

642.3 The inspector must have adequate information of the design details to check and inspect against and BS 7671 provides a format list in Regulation 642.3 of items to be verified, but this list is not exhaustive. These items are as follows:

(a) Installed electrical equipment is of the correct type and complies with an applicable British or Harmionized Standard, or a foreign national standard based on an IEC Standard.

(b) The fixed installation is correctly selected and erected, taking into account manufacturers' instructions.
(c) The fixed installation is not visibly damaged or otherwise defective so as to impair safety.
(d) The installation is ready and safe to be used.

Sect 642 **Inspections**

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

Sect 643 **Tests**

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

644.1 **Results**

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

643.1 **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 641.3, 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' section of the Electrical Installation Certificate or the 'Declaration' section 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 sections of the Electrical Installation Certificate, or make use of the single- signature Electrical Installation Certificate.

2.2 Certificates

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

(a) multiple-signature Electrical Installation Certificate
(b) Minor Electrical Installation Works Certificate.

Examples of typical forms are given in Chapter 5 of this Guidance Note.

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.

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

641.2 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

311.1 **(a)** the maximum demand, expressed in amps, kW or kVA (after diversity is taken into account);

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

312.2 **(c)** the type of system earthing used by the installation and any facilities provided by the distributor for the user;

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

(e) the nature of the current and supply frequency;

(f) the prospective short-circuit current at the origin of the installation;

(g) the earth fault loop impedance (Z_e) of that part of the system external to the installation; and

(h) the type and rating of the overcurrent protective device(s) acting at the origin of the installation.

Note: The statutory Electricity Supply, Quality and Continuity Regulations require that these characteristics should be available from the DNO for all sources of supply from the public supply network.

Diagrams, charts or tables

514.9.1 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:

(a) the type and composition of each circuit, including points of utilisation, number and size of conductors and type of wiring. This should include the reference method shown in Appendix 4 Section 7 'Methods of installation' of BS 7671

410.3.2 **(b)** the method used for compliance with the requirements for basic and fault protection and, where appropriate, the conditions required for automatic disconnection

(c) the information necessary for the identification of each device performing the functions of protection, isolation and switching, and its location

(d) any circuit or equipment vulnerable to the electrical tests specified in Part 6 of BS 7671.

2.4 Frequency of subsequent inspections

Note: The term 'periodic inspection' implies the inclusion of any necessary tests.

134.2.2 The time intervals between the recommended dates of periodic inspections need consideration.

301.1 The period to the first periodic inspection and test is required to be considered and
341.1 recommended by the installation designer and other relevant parties as noted in Regulations 301.1, and 341.1, as part of the design.

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

It has never been clarified whether the proposed period to a subsequent periodic inspection should be measured from the time of the previous inspection or from the time when any identified repairs have been completed (they may never be!). The inspector must take a view on this and it would perhaps be best to set it from the time of the previous inspection, especially if there are significant repairs identified or if the installation is poorly maintained.

652.1 An inspector must also use their experience and skill to identify a suitable period for a subsequent periodic inspection and they must be clear about their reasoning. Industry guidance is available but can only be general and each installation is different and can have different factors. Too frequent an inspection will cause unnecessary costs, but too long a period, especially if the installation is poorly maintained, may allow significant possible dangers to develop, especially as an installation gets older. Regulation 652.1 gives some guidance, but the inspector must make a reasonable and informed decision as they may need to justify it. Some installations such as those subject to local authority licensing are required to be inspected at set periods.

2.5 Initial inspection

2.5.1 General procedure

Inspection and, where required, 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.

641.1 It should be noted that Regulation 641.1 requires inspection and testing to be carried out during the erection stage of the installation, and this is to allow the review and inspection of work that may later be covered and inaccessible – but the inspector will require necessary design information from the designer before any such inspections during construction or installation.

A model Schedule of Inspections is shown in Chapter 5 of this Guidance Note.

2.5.2 Comments on individual items to be inspected

642.3 BS 7671 provides a list of items considered as a minimum to be inspected but the list is not exhaustive. The inspector where necessary will inspect and compare the items against data provided by the designer and installer and identify any non-compliances or departures but is not for the inspector to decide what installation items are required or necessary, or identify any repairs or modifications. The list is as follows:

Sect 526 **a Connection of conductors**

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

It is impractical for an inspector to physically inspect all connections but they should inspect a representative sample of connection types, especially larger connections such as on switchgear and busbars. (It is noted that in some cases such as high current busbar connections specialist resistance test may be required that are outside the scope of BS 7671).

b Identification of cables and conductors

Sect 514 It should be checked that each core or bare conductor is identified as necessary. The single colour green must not be used. The bi-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 over marked with another colour or alphanumeric symbols at terminations.

Again it is impractical for an inspector to physically inspect all identifications, but they should inspect a representative sample of types, especially on larger conductors such as to switchgear.

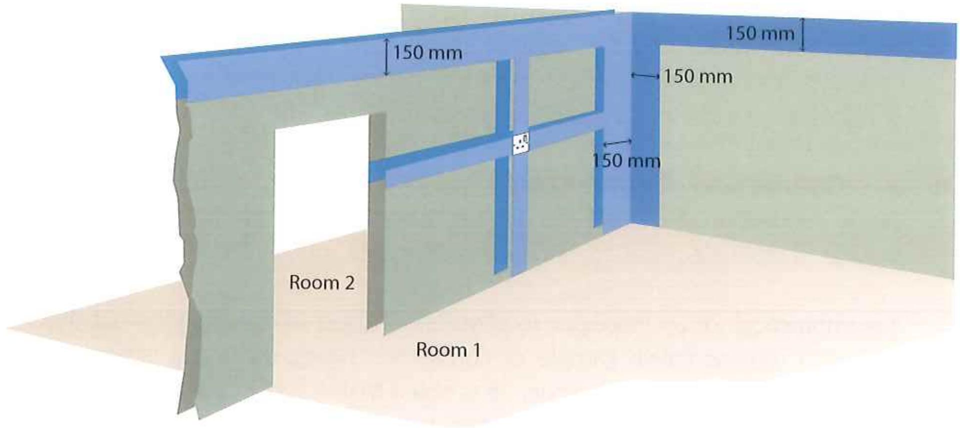
c Routing of cables

522.8 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.

522.6.201 A key requirement to note is for cables installed in a wall or partition at a depth of less
522.6.203 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 where cables are run within the prescribed cable zones described in Regulation 522.6.202.

522.6.202 Another requirement relates to cables installed in a wall or partition, the construction
522.6.203 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 provided 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.

Cables should be routed in prescribed zones in walls (as shown below), as identified in Regulation 522.6.202 (especially in dwellings) to assist in avoiding damage by penetration by nails and screws etc. It should be noted that the requirements can also apply to the other side of the wall.



Furthermore, where 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.

It will be far too late at the end of the construction to view and assess any of these things so it is vital that the inspector continually inspects the installation work during construction.

521.10.202 Cables routed in buildings must be fixed such that they cannot come away from their supports during fires and collapse to block escape routes or entangle firefighters searching the building in smoke filled conditions. Sadly such entanglements have led to fatalities in the past that could have been avoided with some forethought. Not all escape routes in a building are defined and signed – in open plan office areas there can be several possible routes away from a desk or meeting room across an open office area to an escape stair (see BS 9999) and all such routes should be kept clear from possible entanglement. An escape route is defined in the Wiring Regulations as being, "a path to follow for access to a safe area in the event of an emergency". The requirement for surface run wiring systems not to be subject to premature collapse in the event of a fire applies to all areas not just designated escape routes.

It is not difficult to look at a proposed installation and consider the possibilities of cables coming away from their fixings – have only plastic ties been used, is cable tray metal or plastic, is the tray upside down etc? If the cable supports are metal and the cables lay in or are cleated to them with metal fixings then the cable cannot go anywhere. Even if it is fixed with plastic ties or clips and could drop it may only require an occasional metal or fire resistant fixing to restrain it.

In larger industrial or commercial installations cable ladder or tray and other services may be suspended together from concrete structural elements by steel wires or "drop rods" screwed into the concrete. The inspector cannot physically assess the suitability or the loading of such fixings but may look at the design data provided to see that what is installed was as the design.

Where cables run around or down walls – say to a socket-outlet – and are contained in small section plastic trunking the cables should be fixed inside the trunking if it would be possible for the trunking to deform in heat and the lid come off thus releasing the cables.

The inspector must also assess any fire protection repairs and fire stopping where cables have been installed through a fire rated building structural element or wall.

132.7 d Selection of conductors

Sect 523 The specification of cables used – BS type and designation, temperature ratings, selection for environmental conditions, conductor category and material, certification to and compliance with required *Construction Product Regulations* requirements etc. must be checked based on the data supplied by the designer and installer.

Sect 523 BS 8519 requires cables for both primary and secondary supplies to safety services to
Sect 524 be fire resistant and to follow diverse routes through the building.

Sect 523 The cross-sectional area of conductors should be assessed against the overcurrent
Sect 524 protective arrangement and the requirements for limitation of voltage drop, based
Sect 525 upon information provided by the installation designer (where available) such as a cable schedule or schematic diagram.

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

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

530.3.2 It must be verified that single-pole devices for protection or switching are installed in line conductors only, and that ES lampholders are correctly connected.

f Accessories and equipment

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

553.1.3 Table 55.1 of BS 7671 sets out the three different types of plug and socket-outlet recognised, their ratings, and their 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.

559.5.1.204 Bayonet lampholders B15 and B22 should comply with BS EN 61184 and have a
559.5.1.205 temperature rating T2, as described in that standard. ES lampholders should have the live of the supply connected to their centre contact. Lighting circuits incorporating B15, B22, E14, E27 or E40 lampholders are only to be used in a lighting circuit rated up to 16 A.

Sect 527 g Selection and erection to minimize the spread of fire

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 built around services penetrations through a fire rated building element should be labelled by the specialist installer to state its fire rating and inspected to verify that it conforms to the manufacturer's erection instructions and required rating. 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.

A wiring system such as conduit, trunking or ducting that penetrates a building element that has a specified fire rating is to be sealed both internally and externally to the degree of fire resistance of the external element. Fire barrier requirements are detailed in Regulations 527.2.2 and 527.2.3.

Products classified as 'non-flame propagating' in accordance with BS EN 61386-1 or BS EN 50085 are liable to catch fire as a result of an applied flame, but in which the flame does not propagate, and which extinguishes itself within a limited time after the flame is removed. The test to classify products as 'non-flame propagating' is a self-extinguishing test, it is not a fire resistance test. The product cannot be assumed to protect the cable inside it from the effects of a fire. The cable should have its own fire/smoke classification. Both metallic and non-metallic products can be classed as 'non-flame propagating'.

Chapter 41 h Measures of protection against electric shock

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

410.3.2 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.

▼ **Protective measures** generally permitted

	Protective measure	Protective provisions	
		Basic protection by	Fault protection by
411	Automatic disconnection of supply	Basic insulation of live parts and/or barriers or enclosures	Protective earthing, protective equipotential bonding and automatic disconnection in case of a fault
		or Class II equipment	
412	Double or reinforced insulation	Basic insulation	Supplementary insulation
		or Reinforced insulation	
413	Electrical separation for the supply of one item of current-using equipment	Basic insulation of live parts and/or barriers or enclosures	Simple separation from other circuits and from Earth
Sect 414	Extra-low voltage provided by SELV or PELV	Limitation of voltage, protective separation and basic insulation	

▼ **Protective measures** for use only where access is controlled or supervised by skilled persons

	Protective measure	Protective provisions	
		Basic protection by	Fault protection by
417.1	Obstacles	Obstacles	None
417.2	Placing out of reach	Placing out of reach	None

▼ **Protective measures** for use only where the installation is controlled or under the supervision of skilled or instructed persons

	Protective measure	Protective provisions	
		Basic protection by	Fault protection by
418.1	Non-conducting location(1)	Basic insulation of live parts and/or barriers or enclosures	No protective conductor, insulating floor and walls, spacing/obstacles between exposed-conductive-parts and extraneous-conductive-parts
418.2	Earth-free local equipotential bonding(2)	Basic insulation of live parts and/or barriers or enclosures	Protective bonding, notices, etc.
418.3	Electrical separation for the supply of more than one item of current-using equipment	Basic insulation of live parts and/or barriers or enclosures	Simple separation from other circuits and Earth, to non-earthed protective bonding, etc.

Notes: (1) Not recognised for general application.
(2) To be used only in special circumstances.

416 (i) 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 previous tables.

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

411.3 The provision for fault protection is protective earthing, protective 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 **(a)** earthing conductor
Sect 543 **(b)** circuit protective conductors

Sect 544 **(c)** protective bonding conductors

Sect 544 **(d)** main bonding conductors. Regulation 411.3.1.2 allows that metallic pipes entering the building having an insulating section at their point of entry need not be connected to the protective equipotential bonding but there is no detail in BS 7671 as to what constitutes an "insulation section" or how this is to be installed. The inspector can only inspect and confirm that what has been specified by the installer is actually present. This should be noted on the installation inspection schedule.

(e) supplementary bonding conductors (where required).

312.2 The type of system earthing must be stated by the designer, for example:

(a) TN-C-S system (usually with protective multiple earthing (PME))
(b) TN-S system
(c) TT system (earth electrode(s) used as the means of earthing for the installation)

411.5 (TN) 411.5 (TT) 411.5 (TT) The earth fault loop impedance must be appropriate for the protective device, i.e. RCD or overcurrent device and within the values given in the tables in Chapter 41.

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 a single application of 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(s) being made that could impair the effectiveness of the measure.

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

413.1.1 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:

414.1.1 **(a)** the nominal voltage must not exceed 50 V AC or 120 V DC;
414.3 **(b)** an isolated source, for example, a safety isolating transformer to BS EN 61558-2-6 or BS EN 61558-2-8;
414.1.1 **(c)** protective separation from all non SELV or PELV circuits;
414.1.1 **(d)** for SELV, basic insulation between the SELV system and Earth; and
414.1.1 **(e)** SELV exposed-conductive-parts must have no connection with earth, exposed-conductive-parts or protective conductors of other systems.

(iii) Protective measures for use only where access is controlled or supervised by skilled persons

Obstacles

417.2 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

417.3 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 only permitted in areas where access is controlled or supervised by skilled persons. The dimensions of passageways should be checked against the information given in Appendix 3 of the HSE's guidance on *The Electricity at Work Regulations 1989* (HSR25) (see BS 7671 section 729).

Sect 729 Section 729 – Operating and maintenance gangways 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 7671; these must be confirmed with the installation isolated. However it must be noted that the Electricity at Work regulations take precedence in all cases and their requirements for accessible live conductors must be followed in ALL cases.

(iv) Protective measures for use only where the installation is controlled or under the supervision of 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.

418.1.2 Further, the exposed-conductive-parts of the installation should be so arranged that it is not possible for persons to make simultaneous contact with either two exposed-conductive-parts, or an exposed-conductive-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 live part.

418.1.3 The inspector should confirm the achievement of this and check that within the location there are no protective conductors (see also the specific test for this method in 2.6.12).

418.2 *Earth-free local equipotential 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-conductive-parts should be interconnected by local protective bonding conductors.

418.2.3 Measures must be taken to ensure that the local protective 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 to 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 of the separated circuit should be connected together by insulated, non-earthed protective 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.

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

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

418.3.7 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.

418.3.8 The product of the nominal voltage (volts) and length (meters) 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

415.1.1 It should be confirmed that an RCD selected to provide additional protection has a rated residual operating current ($I_{\Delta n}$) not exceeding 30 mA and complies with relevant standards.

Generally all socket-outlets up to and including 32 A rating should be provided with additional protection by a 30 mA RCD, but BS 7671 allows this to be omitted in non-domestic installations where a written risk assessment shows that such additional protection does not present a danger. It is not for the inspector to consider or approve the risk assessment, but the inspector should see the assessment to prove that it exists so the requirement of the regulation is fulfilled. The assessment should also be attached to the Electrical Installation or Minor Electrical Installation Works Certificate for future reference.

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 protective equipotential bonding

415.2.1 Where supplementary bonding is provided it should encompass all simultaneously accessible exposed-conductive-parts of fixed equipment, 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-conductive-parts and extraneous-conductive-parts fulfil the applicable one of the following condition.

- for AC systems, $R \leq 50\ V/I_a$
- for DC systems, $R \leq 120\ V/I_a$

where I_a is the operating current of the protective device in amps; for overcurrent devices, this is the 5 second operating current, and for RCDs, $I_{\Delta n}$.

Sect 515 i Prevention of mutual detrimental influence

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.

132.5.1 This however does not include the detrimental influence of other systems onto the electrical installation, such as water leaks or splashing, which are covered by the requirements of Regulation 132.5.1.

Sect 537 j Isolating and switching devices

BS EN 60947-1 *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.

▼ **Table 2.1** Examples of utilisation categories for alternating current installations

Utilisation category		
Frequent operation	**Infrequent operation**	**Typical applications**
AC-20a	AC-20b	Connecting and disconnecting under no-load conditions
AC-21a	AC-21b	Switching of resistive loads including moderate overloads
AC-22a	AC-22b	Switching of mixed resistive and inductive loads, including moderate overloads
AC-23a	AC-23b	Switching of motor loads or other highly inductive loads

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, for example, for a switch disconnector:

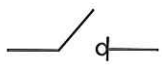


Table 537.4 Guidance on the suitability or otherwise of protective, isolation and switching devices to be employed for one or more of the functions of isolation, emergency switching and functional switching is given in Table 537.4 in BS 7671 and Guidance Note 2.

The inspector should carry out an isolation review to check that effective isolation can be achieved, but it is not the inspector's responsibility to resolve any apparent shortcomings or problems with the isolation and switching design. This review could include, where appropriate, locking-off and inspection or testing to verify that the circuit is dead and no other source of supply is present. It should also be identified by the designer where it may be necessary to isolate the neutral conductor.

Note (5) to Table 537.4 in BS 7671 points out that circuit-breakers and RCDs are not intended for frequent load switching or functional switching unless they are approved by the device manufacturer for this duty. The note gives further guidance relating to this and the inspector is at liberty to make a comment on this use if it is inappropriate.

BS 7671 does not allow a switching or isolating device to be placed in the earth or protective conductor other than a plug and socket-outlet.

k Presence of undervoltage protective devices

Sect 445 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.

Chap 43 l Protective and monitoring devices

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.

421.1.7 Arc Fault Detection Devices (AFDDs) have been introduced in the 18th edition of BS 7671 and they are designed to provide protection by monitoring the change of current flow in a final circuit due to a possible cable conductor fault that could cause an arc and possible fire. Their use is recommended in BS 7671 but it is for the designer to decide on their use and the inspector cannot comment if they are not installed. Some makes of AFDDs have a test button (like an RCD) and this should be pressed at commissioning to prove operation, but if there is no test button an operational commissioning test cannot be carried out.

Note: BEAMA have published a free guide to AFDDs that is available to download.

Sect 443 The guidance for the application of surge protection devices (SPDs) has been revised and expanded in the 18th Edition of BS 7671, providing for protection against switching surges and surges of atmospheric origin (lightning strikes). This is a complex area which will be designed and usually installed by specialist suppliers. The inspector can only review what is installed against the scheme documentation provided by the specialist suppliers, and review their test and commissioning documentation.

Sect 514 m Labelling of protective devices, switches and terminals

514.8.1 Each protective device must be arranged and identified so that the circuit protected
514.9.1 can be easily identified, and a diagram or chart indicating the function of each circuit 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.

512.2 n Selection of equipment and protective measures appropriate to
Sect 522 external influences

Equipment must be selected with regard to its suitability for the environment – ambient 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.

132.12 o Adequacy of access to switchgear and equipment

Sect 513 Every piece of equipment that requires operation or attention by a person must be 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.

Sect 514 p Presence of danger signs and other warning signs

Suitable warning signs, suitably located, are required to be installed to give warning of:

514.10 Voltage

- 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. Voltages exceeding 230 V to earth require warning labels. An example would be the use of a 690 V three-phase AC power transformer used on an American air base located in the UK.

514.11 Isolation

- 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.

AFDDs

- Where AFDDs are installed, those provided with a trip test button (as RCDs) should be tested every six months by pressing the button and a notice to this effect should be provided. A text similar to the RCD notice can be used.

Earthing and bonding connections

514.13.1
- The requirements for the label and its wording are given in Regulation 514.13.1.

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.

Non-standard colours

514.14.1
- For installations containing both pre-BS 7671:2001 (2004) (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 514.14.1.

Alternative supplies

514.15.1
- For installations with alternative or additional voltage sources, a 'multiple-supplies' 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

543.7.1.205
- For 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.

514.9.1 Presence of diagrams, instructions and similar information

- The presence of diagrams, charts or tables, or an equivalent form of information for the work being inspected should be verified. The form of information should be legible and durable, and should indicate all of the following:

  (a) The type and composition of each circuit (which includes the points of utilisation served, number and size of conductors, and the type of wiring).

  (b) The method used for compliance with Regulation 410.3.2 (that is, the protective measures used for basic and fault protection).

(c) The information necessary for the identification of each device performing the functions of protection, isolation and switching, and its location.
(d) Any circuit or equipment that is vulnerable to the electrical tests as required by Part 6.

For a simple installation, such as a dwelling or similar, the forgoing information can be given in the form of schedule, so an additional copy of the Schedule of circuit details' provided within or adjacent to each distribution board is likely to meet this requirement.

A complex installation would obviously require more comprehensive information in the form of record or "as built" drawings and operation and maintenance documents.

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.

521.10.201 Regulation 521.10.201 requires that cables are to be supported so they will not collapse and come away from their fixings in the event of a fire and impede the escape of persons from buildings. This can usually be achieved by installing a metal cable fixing at reasonable intervals.

2.5.3 Inspection checklist

Listed below are requirements to be checked when carrying out an installation inspection. The list is not exhaustive. The inspector can only check against the design and installation data provided by the designer and installer and report any non-compliances noted, but cannot make any requirements.

General

(a) Equipment complies with a product standard or equivalent (511.1)
(b) Equipment is installed using good workmanship (134.1.1)
(c) Equipment is accessible for operation, inspection and maintenance (513.1)
(d) Equipment is 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)
(e) Final circuits are separate, including the neutral conductors (314.4)
(f) Protective devices identified to indicate the circuits they protect (514.8.1)
(g) Protective devices adequate for intended purpose, including AFDDs and SPDs where installed (Ch. 53)
(h) Disconnection times for protection against electric shock likely to be met by installed protective devices (Ch. 41)
(i) All circuits identified (514.1, 514.8, 514.9)
(j) Main switch provided (462.1.201)
(k) Supplies to any safety services correctly installed, for example, fire alarms to BS 5839 and emergency lighting to BS 5266 (Ch. 56). This does not include any inspection of the safety systems which should be inspected and maintained by specialists.
(l) Auxiliary circuits are installed (557)
(m) Means of isolation labelled (514.1, 537.2.7)
(n) Provision for disconnecting the neutral (Ch 46; 537.2.8)

(o) Main switches to single-phase installations, intended for use by an ordinary person, for example, domestic, shop, office premises, to be double-pole (462.1.201)
(p) RCDs provided where required (411.3.3, 411.4, 411.5, 415.1, 422.3.9, 522.6.201, 522.6.202, 532.1, 701.411.3.3, 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, 710.411.3, 710.531.3.2, 711.410.3.4, 711.411.3.3, 712.411.3.2.1.2, 714.411.3.3, 717.411.1, 717.411.6.2, 717.413, 717.415.1, 721.415.1, 722.531.2.101, 740.410.3, 740.415.1, 753.411.3.2, 753.415.1)
(q) Selectivity between RCDs considered to avoid danger (314.1, 314.2, 531.3)
(r) Main earthing terminal provided (542.4.1), readily accessible and identified where separate from switchgear (514.13.1)
(s) Provision for disconnecting earthing conductor (542.4.2)
(t) Cables used comply with British or Harmonized Standards and Construction Products Regulations (Appendix 4 of BS 7671)
(u) Earth tail pots installed where required on mineral insulated cables (543.2.7)
(v) Non-conductive finishes on enclosures removed where necessary to ensure good electrical connection and, if necessary, made good after connecting (526.1)
(w) Adequately rated distribution boards (to the relevant parts of BS EN 60439 or BS EN 61439 (may require derating, see GN 6)
(x) Correct fuses or circuit-breakers installed (Sect 531, Sect 533)
(y) All connections secure (134.1)
(z) Protection provided against voltage disturbances, including overvoltages, where required (Ch. 44)
(aa) 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)
(af) Cables and wiring systems installed and supported such that they will not be liable to premature collapse in the event of a fire (521.10.202)
(ag) Suitable degree of protection ('IP Code') appropriate to external influences when installed in accordance with manufacturer's instructions (522.3.1, 559.3.1).

Switchgear

(a) Meets requirements of BS EN 61008, BS EN 61009, BS EN 60947-2, BS EN 60898, relevant parts of or BS EN 61439 where applicable, or equivalent standards (Sect 511)
(b) Securely fixed (134.1.1) and suitably labelled (514.1)
(c) Switchgear assemblies, including consumer units, are complete with, or additionally housed in, fire protecting enclosures (421.1.201).
(d) Non-conductive finishes on switchgear removed at protective conductor connections and if necessary made good after connecting (526.1)
(e) Suitable cable glands and gland plates used (526.1)
(f) Correctly earthed (Ch. 54)
(g) Environmental conditions likely to be encountered taken account of, i.e. suitable for the foreseen environment (512.2)
(h) Suitable as means of isolation as design, where applicable (Ch 46, 537.2)
(i) Need for isolation, mechanical maintenance, emergency and functional switching met where required by design (Ch 46, 537)
(j) Firefighter's switch provided where required and labelled for identification and operation (537.4)

(k) All connections secure (526)
(l) Cables correctly terminated and identified (514, 526)
(m) No sharp edges on cable entries, screw heads, etc., which could cause damage to cables (134.1.1, 522.8.11)
(n) Adequate access, lighting and working space (132.12 and 513.1).

General wiring accessories

(a) Complies with appropriate standards, for example, BS 5733 (general accessories) or BS EN 60670-22 (junction boxes) (511.1)
(b) Box or other enclosure securely fixed (134.1.1)
(c) Metal box or other enclosure earthed where required (Ch. 54)
(d) No sharp edges on cable entries, screw heads, etc. which could cause damage to cables (134.1.1, 522.8.11)
(e) Non-sheathed cables, and cores of cable from which sheath has been removed not exposed outside the enclosure (526.8)
(f) Conductors correctly identified (514.3)
(g) Bare protective conductors having a cross-sectional area of 6 mm^2 or less to be sleeved green-and-yellow (514.4.2, 543.3.201)
(h) Terminals tight and containing all strands of the conductors (526)
(i) Cable grip correctly used or clips fitted to cables to prevent strain on the terminals (522.8.5, 526.6)
(j) 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

(a) Light switches comply with BS 3676 or BS EN 60669-1 (511.1)
(b) Selected for external influences (512.2)
(c) Single-pole switches connected in line conductors only (132.14.1)
(d) Correct colour coding or marking of conductors (514.3)
(e) Earthing of exposed metalwork, for example, metal switch plate (Ch. 54)
(f) Adequate current rating allowing for any capacitive or inductive effects as given in the design cable ratings (512.1.2)
(g) 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)
(h) 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 a location containing a bath or shower (701.512.3)

Lighting points

(a) Lights connected via a recognised accessory (559.5.1), batten lampholders or pendent sets being in compliance with BS EN 60598
(b) Ceiling rose complies with BS 67 (559.5.1)
(c) Luminaire supporting couplers comply with BS 6972 or BS 7001 (559.5.1)
(d) Installation couplers comply with BS EN 61535 (559.5.1)
(e) Recognised connecting device used for luminaires that do not provide a device for connection of the supply (559.5.4)
(f) Track systems comply with BS EN 60570 (559.3.4 and 715.521.1)

(g) Systems for ELV lighting comply with BS EN 60598-2-23 (715.521.1)
(h) Bare conductors of ELV lighting installations comply with all requirements of Regulation 715.521.106 (715.521.1)
(i) Not more than one flex unless designed for multiple pendants (559.5.1.202)
(j) Flex support devices used and suitable for the mass suspended (559.5.2)
(k) Switch-lines identified (514.3.2 and Appendix 7 of BS 7671). For two-core switch wires, blue conductors are over marked with brown or L at terminations; for three-, four- or five-core cables, all non-brown line conductors of switch and intermediate strappers are over marked at terminations with brown or L
(l) Penetrations in fire-rated ceiling made good (527.2.1)
(m) Ceiling roses and similar not used for circuits having supply exceeding 250 V (559.5.1.201).
(n) Protection from UV radiation (if any) is provided to external wiring within or passing through a luminaire (559.5.6).

Socket-outlets

(a) Comply with BS 546, BS 1363-2 or BS EN 60309-2 (553.1.3) and shuttered for household and similar installations (553.1.201)
(b) 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 (722.55.101.0.201.1)
(c) Mounting height above the floor or working surface suitable (553.1.6) (Also complies with Building Regulations Part M and Scottish equivalent where relevant – see note on previous page.)
(d) Correct polarity (643.6)
(e) 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)
(f) Suitably protected against the expected external influences where mounted in a floor (512.2)
(g) Not used to supply a water heater having uninsulated elements (543.3.1)
(h) 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)
(i) Additional requirement provided by 30 mA RCD or risk assessment provided for specific non-domestic socket-outlets (411.3.3)
(j) Socket-outlets with integral USB socket provision comply with BS 1363-2:2016.

Junction boxes, joint box and terminations

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

Fused connection unit

(a) Correct rating and fuse (533.1)
(b) Complies with BS 1363-4 (Table 537.4, 559.5.1 vii).

Cooker control unit

(a) Sited to one side and low enough for accessibility and to prevent flexes trailing across radiant plates (522.2.1)
(b) Cable to cooker fixed to prevent strain on connections (522.8.5).

Conduit systems
General

(a) Securely fixed, box lids in place and adequately protected against mechanical damage (522.8)
(b) Draw points are accessible (522.8.6)
(c) 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)
(d) Solid elbows and tees used only as appropriate (522.8.1)
(e) Unused entries blanked off where necessary (416.2 and 522)
(f) Conduit system components comply with a relevant British Standard depending on performance requirements (511.1)
(g) Provided with drainage holes and gaskets as necessary (522.3.2)
(h) Radius of bends such that cables are not damaged (522.8.3).

Rigid metal conduit

(a) Complies with BS EN 61386-21 (521.6)
(b) Connected to the main earthing terminal (411.4.2, 411.5.1)
(c) Line, neutral and any additional protective conductors are contained in the same conduit (521.5.1)
(d) Conduit suitable for wet, damp or corrosive situations (522.3, 522.5)
(e) Fixed appropriately (522.8 and see Guidance Note 1 Appendix G)
(f) 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

(a) Complies with BS 4607, BS EN 60423 or the BS EN 61386 series (521.6)
(b) Ambient and working temperatures within permitted limits (522.1, 522.2)
(c) Provision made to allow for expansion and contraction (522.15.1)
(d) Boxes and fixings suitable for mass of luminaire suspended at expected temperature (559.5.2).
(e) Conduit to be 'non flame propogating' type (521.6).

Flexible metal conduit

(a) Complies with BS EN 61386 series (521.6)
(b) 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

(a) Complies with BS 4678 or BS EN 50085-1 (521.6)
(b) Securely fixed and adequately protected against mechanical damage (522.8)
(c) Selected, erected and routed to avoid ingress of water (522.3)
(d) Proximity to non-electrical services, i.e. sources of heat, smoke etc. cannot cause damage (528.3)
(e) Internal fire sealing provided where necessary (requires inspection during the erection stage) (527.2.2)
(f) Holes surrounding trunking made good (527.2.1)
(g) Band I circuits partitioned from Band II circuits or insulated for the highest voltage present (528.1)

(h) Circuits partitioned from Band I circuits or wired in mineral insulated metal-sheathed cables (528.1)
(i) Cables supported for vertical runs (522.8.5).

Metal trunking

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

Rigid non-metallic trunking

(a) Ambient and working temperatures within permitted limits (522.1, 522.2)
(b) Provision made to allow for expansion and contraction (522.15.1)
(c) Trunking to be 'non-flame propogating' type (521.6)
(d) Cables to be secured where necessary to prevent premature collapse in the event of a fire (521.10.202)

Busbar trunking and powertrack systems

(a) 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)
(b) 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

(a) Correct type and complies with relevant design Construction Products Regulations requirements (521)
(b) Correct current rating (523 and Appendix 4)
(c) Protected against mechanical damage and abrasion (522.8)
(d) Suitable for high or low ambient temperature as necessary (522.1)
(e) Non-sheathed cables are protected by enclosure in conduit, duct or trunking (except for protective conductors of 4 mm^2 and larger) (521.10 and 543.1)
(f) 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:
  (i) routed in prescribed zones and additional protection is provided by an RCD having a rated residual operating current, $I_{\Delta n}$, not exceeding 30 mA, or
  (ii) provided with mechanical protection complying with (522.6.204)
(g) Cables concealed in a partition containing metallic structural parts are
  (i) provided with additional protection by RCD having $I_{\Delta n}$ not exceeding 30 mA, or
  (ii) provided with adequate mechanical protection to suit both the installation of the cable and its normal use, or
  (iii) comply with the requirements set out in Regulation 522.6.203 (522.6.202)
(h) Cables exposed to direct sunlight are of a suitable type or are suitably shielded (522.11)
(i) Not run in lift or hoist shaft unless part of the lift installation and of the permitted type (528.3.5)
(j) Cables buried in the ground are correctly selected and installed for use (522.8.10)
(k) Cables installed overhead are correctly selected and installed for such use (522.8.4)

(l) Internal radii of every bend in a wiring system should be such so that it is not so tight that the cable and/or its conductors do not suffer damage and terminations are not in any way stressed (522.8.3 and Guidance Note 1 Appendix G)
(m) Correctly supported and secured where necessary to prevent premature collapse in the event of a fire (521.10.202, 522.8.4, 522.8.5)
(n) Not exposed to water, etc. unless suitable for such exposure (522.3)
(o) Metal sheaths and armour earthed (411.3.1.1)
(p) Conductors identified at terminations (514.3)
(q) Joints and connections electrically and mechanically sound and adequately insulated (526.1, 526.2)
(r) All wires securely contained in terminals, etc. without strain (522.8.5, 526)
(s) Enclosure of terminals (526)
(t) Glands correctly selected and fitted with shrouds and supplementary earth tags as necessary (526.1)
(u) Joints and connections mechanically sound and accessible for inspection, testing and maintenance purposes, except as permitted otherwise (526.1, 526.3).

Flexible cables (521.9)

(a) Correct type and complies with relevant design Construction Products Regulations requirements (521.9.1)
(b) Correct current rating (523 and Appendix 4)
(c) Protected where exposed to mechanical damage (522.6, 522.8)
(d) Suitably sheathed where exposed to contact with water (522.3) or corrosive substances (522.5)
(e) Protected where used for final connections to fixed apparatus, etc. (526.8)
(f) Selected for resistance to damage by external heat sources (522.2)
(g) Segregation of Band I and Band II circuits (528; see also BS 6701 and BS EN 50174 series)
(h) Fire alarm and emergency lighting circuits segregated (528; see also BS 5839, BS 5266)
(i) Cores correctly identified (514.3)
(j) Connections to have durable electrical continuity, adequate mechanical strength and be made using appropriate means (526.1, 526.2)
(k) Where used as fixed wiring, relevant requirements met and secured where necessary to prevent premature collapse in the event of a fire (521.9.1, 521.10.202)
(l) Final connections to current-using equipment properly secured and arranged to prevent strain on connections (526.6)
(m) Mass supported by cable so as not to impair safety of the installation (559.5.2).

Protective conductors

(a) Cables incorporating protective conductors comply with the relevant British or Harmonised Standard (511.1)
(b) Joints in metal conduit, ducting or trunking comply with Regulations for preservation of continuity (543.3)
(c) Flexible or pliable conduit is supplemented by a protective conductor (543.2.3)
(d) Minimum cross-sectional area of copper conductors (543.1)
(e) Copper conductors of 6 mm^2 or less protected by insulation (543.3.201)
(f) Circuit protective conductor at termination of sheathed cables protected by sleeving (543.3.201)
(g) Bare circuit protective conductor protected against mechanical damage and corrosion (543.3.1)

(h) Insulation, sleeving and terminations identified by the bi-colour combination green-and-yellow (514.4.2)
(i) Joints electrically and mechanically sound (526.1)
(j) Separate circuit protective conductors of not less than 4 mm^2 if not protected against mechanical damage and is not an integral part of a cable, not formed by conduit, ducting or trunking, nor contained in an enclosure formed by a wiring system (543.1.1)
(k) Main and supplementary protective bonding conductors of correct size (544).
(l) Cables to be secured where necessary to prevent premature collapse in the event of a fire (521.10.202)

Enclosures

General

(a) Suitable degree of protection ('IP Code' in BS EN 60529) appropriate to external influences when installed taking account of the manufacturer's instructions (416.2, 512.2, 522, Part 7).

2.6 Initial testing

643.1 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

644.1 Regulation 644.1 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 is provided to the person that ordered the work. Chapter 64 requires that:

644.3 **(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
644.3 **(b)** the schedule of test results shall include test results for every distribution and final circuit
644.5 **(c)** the Electrical Installation Certificate is signed or otherwise authenticated by a skilled person responsible for each facet of design, construction and inspection and test and competent to verify that the requirements of BS 7671 have been met.
644.1.1 **(d)** any defects or omissions revealed by the inspector are required to be made good by the installer, and as necessary inspected and tested again, before the Electrical Installation Certificate is issued; it is not the responsibility of the person or organisation carrying out the inspection and testing to make good defects or omissions.

Where the installation work does not extend to the installation of a new circuit a Minor Electrical Installation Works Certificate may be used instead of the full Electrical Installation Certificate. This simplifies the documentation for small works and also the required installation inspection and testing and tests are limited to the circuit being extended or modified, as detailed in Part 4 of the Certificate. See Chapter 5 for further details and guidance on the completion of this Certificate.

2.6.3 Model forms

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

643.1 2.6.4 The sequence of tests

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

(a) Continuity of protective conductors, including main and supplementary bonding (see following item 2.6.5 and Regulation 643.2.1);
(b) Continuity of ring final circuit conductors (2.6.6) (Regulation 643.2.1);
(c) Insulation resistance (2.6.7) (Regulation 643.3);
(d) Protection by SELV, PELV or by electrical separation (2.6.8, 2.6.9) (Regulations 643.4, 643.4.1, 643.4.2);
(e) Protection by barriers or enclosures provided during erection (2.6.11) (Regulation 643.3.3);
(f) Insulation resistance of non-conducting floors and walls (2.6.12) (Regulation 644.5);
(g) Polarity (2.6.13) (Regulation 643.6);
(h) Protection by automatic disconnection of the supply (2.6.15) (Regulations 643.7, 643.7.1);
(i) Earth electrode resistance 2.6.14) (Regulation 643.7.2);
(j) Earth fault loop impedance (2.6.16) (Regulation 643.7.3);
(k) Prospective fault current (2.6.17) (Regulation 643.7.3.201);
(l) Additional protection (2.6.19) (Regulation 643.8);
(m) Check of phase sequence (2.6.18) (Regulation 643.9);
(n) Functional testing (2.6.19, 2.6.20) (Regulation 643.10);
(o) Verification of voltage drop (2.6.21) (Regulation 643.11).

643.2 2.6.5 Continuity of protective conductors, including main and supplementary bonding

411.3.1.1 Regulation 411.3.1.1 requires installations that provide protection against electric 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 to this is made for a lampholder having no exposed-conductive-parts and suspended from such a point.

Regulation 643.2.11 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, where applicable, all supplementary bonding conductors.

Regulation 643.2.1 also requires that a continuity check be carried out on each conductor of every ring final circuit, which includes the line, neutral and protective conductors.

There are two widely used test methods that have evolved for checking protective 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 1, detailed in this item, as well as checking the continuity of the protective conductor, also measures ($R_1 + R_2$) which, when added to the external impedance (Z_e), enables the earth fault loop impedance (Z_s) to be checked against the design (see 2.6.16). ($R_1 + R_2$) is the sum of the resistances of the line conductor, R_1, and the circuit protective conductor, R_2.

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 always be aware of the possible existence of parallel earth return paths. These may take the form of metallic cable management products, extraneous-conductive-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 or to the building fabric, and luminaires fitted in grid ceilings. Such parallel paths exist in domestic, commercial and industrial installations.

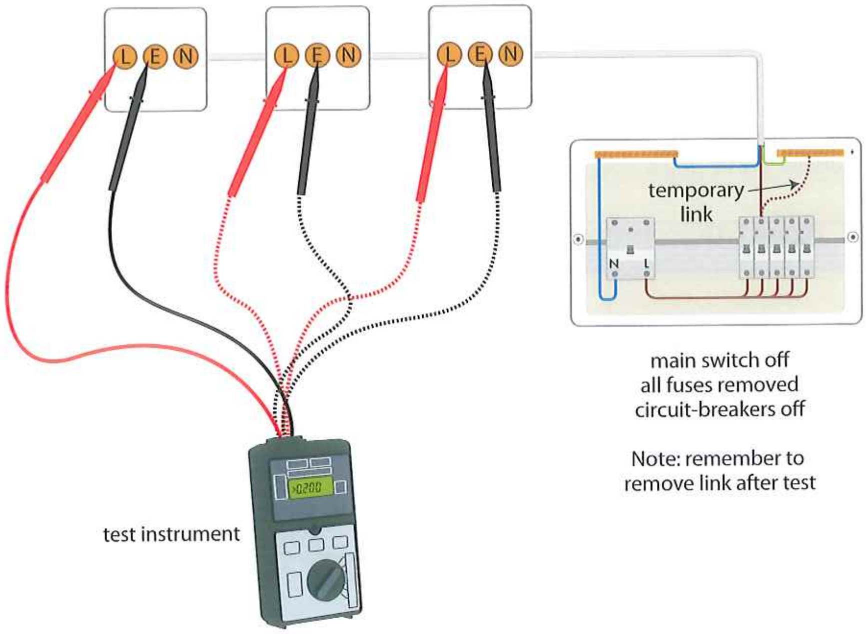
The effect of parallel earth return paths is that the measured value of protective conductor continuity, R_2, tends towards a zero value. It is often impractical and in some cases impossible to carry out testing with some or all of the parallel paths disconnected and the inspector must be aware of this.

Test method 1 (for circuits)

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 measured and deducted from the readings obtained, or auto-nulled by the test instrument, which most modern instruments are able to do.

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 ($R_1 + R_2$), i.e. the resistance of the line conductor, R_1, plus the resistance of the protective conductor, R_2, 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 ($R_1 + R_2$) obtained at the circuit's extremity, namely the furthest circuit distance from the distribution board.

▼ **Figure 2.1a** Connections for testing continuity of protective conductors: method 1



Expected results for test method 1

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 the fabric of the building 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 (R_1 + R_2). 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 mm^2 line and protective conductors should have an (R_1 + R_2) resistance as follows:

Length of circuit is 55 m

Resistance of a 2.5 mm^2 conductor is 7.41 mΩ/m (at 20 °C) from Table B1

Theoretical minimum DC resistance = $(55 \times 2 \times 7.41)/1000 = 0.82\ \Omega$

When verifying this circuit, the inspector should be looking for a reading somewhere in the order of, say, 0.8 to 1.2 Ω would be acceptable. If the circuit had several outlets, thus meaning that the circuit conductors were 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)

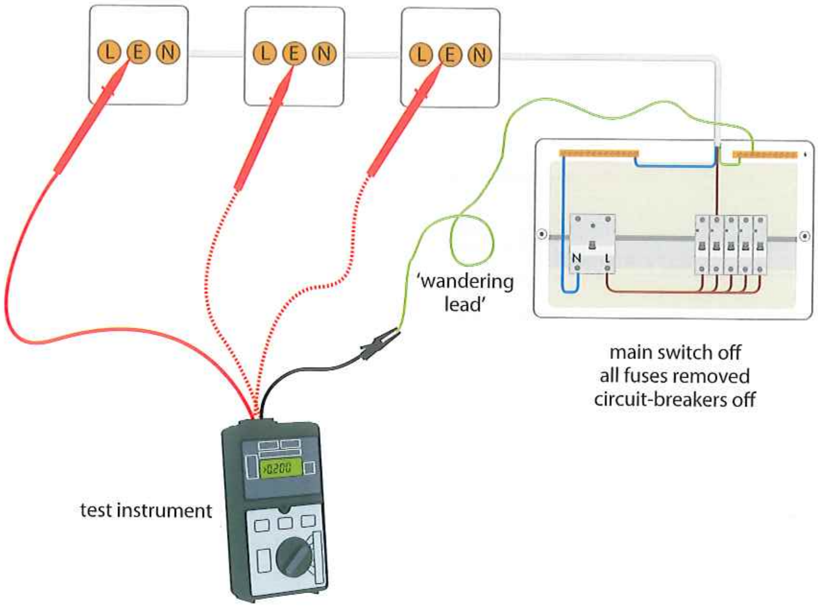
Instrument: Use a low-resistance ohmmeter for this test. Refer to Section 4.3.

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, for example, luminaires, switches, fused connection units, etc. as shown in Figure 2.1b.

The resistance of the wandering lead and the test leads are either measured and deducted from the readings obtained, or auto-nulled by the test instrument, which most modern instruments are able to do these days

This test measures the continuity resistance of the circuit protective conductor, R_2, which should be recorded on the Schedule of Test Results (see earlier note regarding 'Parallel earth paths and effects on test readings').

▼ **Figure 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 the fabric of the building or other elements that may be earthed, then the measurement will equate to the protective conductor resistance, R_2. 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 mm^2 copper protective conductor should have an R_2 resistance as follows:

Length of circuit is 55 m

Resistance of a 2.5 mm^2 conductor is 7.41 mΩ/m (at 20 °C) from Table B1

Theoretical minimum DC resistance $= (55 \times 7.41)/1000 = 0.41\ \Omega$

When verifying this circuit, the inspector should be looking for a reading somewhere in the order of, say 0.4 to 0.5 Ω. 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

To confirm the continuity of these protective conductors, **test method 2** may be used. Account should be taken of the possibility of test readings being affected by parallel paths as mentioned earlier in this section. For this reason it may be necessary to carry out the test with the protective conductor disconnected at one end, where practicable.

This method can also be used to confirm a bonding connection between extraneous-conductive-parts where it is not possible to see a bonding connection, for example, where bonding clamps have been 'built in'. The test would be done by connecting the leads of the test instrument between any two points, such as metallic pipes, and looking for a low reading of the order of 0.05 Ω, but do keep in mind that such a reading for a single core 6.0 mm^2 or 10.0 mm^2 conductor, equates to 15 m and 25 m, respectively. (It should be noted that not all low-resistance ohmmeters can read this low, see Section 4.3.) It should be noted that this is not the R2 resistance measured from the Main Earthing Terminal to the bonding clamp or adjacent pipework.

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

(a) Inspect the enclosure along its length for soundness of construction
(b) 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 Ω taking into account both the resolution of the instrument, its accuracy at low values and contact resistance.

2.6.6 Continuity of ring final circuit conductors

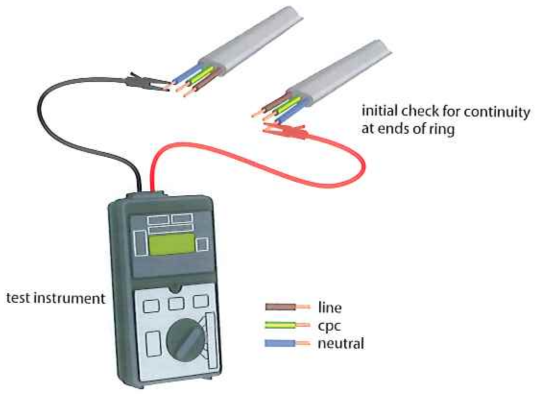
643.2.1 A three-step test is required to verify the continuity of the line, neutral and protective conductors and the correct wiring of every ring final circuit. The test results show if the ring has been interconnected to create an apparently continuous ring circuit, which is in fact broken or connected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

▼ **Figure 2.2a** Connections for testing step 1



These resistances are referred to as r_1, r_n and r_2 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 length, csa and material. If the protective conductor has a smaller csa, the resistance r_2 of the protective conductor loop will be proportionally higher than that of the line or neutral loop, for example, 1.67 times for 2.5/1.5 mm^2 cable. If the resistance readings are not as expected this could mean the following:

(a) *readings lower than the expected resistance*[1], 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

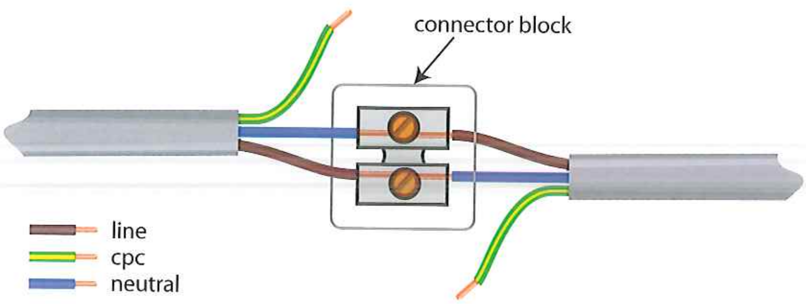
(b) *readings higher than the expected resistance*[1], would suggest that one or more of the conductor terminations is poorly made

Note 1: The 'expected resistance' mentioned above is that found from the tabulated DC resistance for the conductor csa per metre multiplied by the installed length and corrected for measured temperature. A small allowance should be made for instrument errors. Table B1 gives values of DC 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).

▼ **Figure 2.2b** Connections for testing step 2



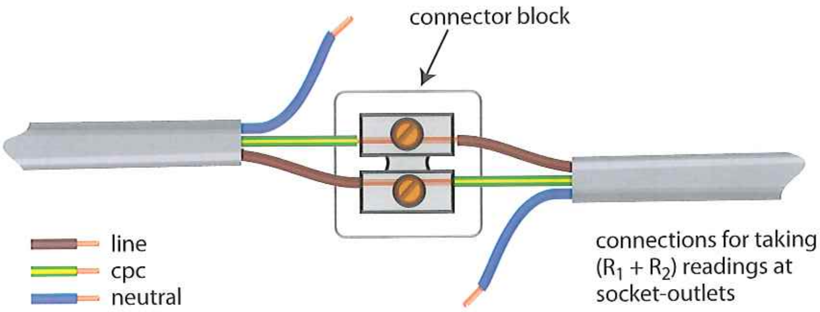
The resistance between line and neutral conductors is measured at each socket-outlet. The readings at each of the sockets wired into the ring should be substantially the same and the value will be approximately one-quarter of the resistance of the line plus the neutral loop resistances, i.e. $(r_1 + r_n)/4$ (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.

Note 1: Where single-core cables are used, care should be taken to verify that the line and neutral conductors of **opposite** ends of the ring circuit are connected together. An error in this respect will be apparent from the readings taken at the socket-outlets, progressively increasing in value as readings are taken towards the midpoint of the ring, then decreasing again towards the other end of the ring.

Step 3

The open ends of the line conductor and cpc are then cross-connected (see Figure 2.2c).

▼ **Figure 2.2c** Connections for testing step 3



The resistance between line and cpc is measured at each socket-outlet. The readings obtained at each of the socket-outlet wired in the form of a ring will be substantially the same and the value will be approximately one-quarter of the resistance of the line plus cpc loop resistances, i.e. $(r_1 + r_2)/4$ (the explanation for this being similar to step 2). A higher resistance value will be recorded at any socket-outlets wired as spurs. The highest value recorded represents the maximum $(R_1 + R_2)$ of the circuit and is recorded on the Schedule of Test Results. The value can be used to determine the earth fault loop impedance (Z_s) of the circuit to verify compliance with the loop impedance requirements of the Regulations (see Section 2.6.15).

Where every socket-outlet on a ring final circuit is connected in the form of a ring (i.e. no spurs), the following formula is true: $R_1+R_2=(r_1+r_2)/4$. The inspector is again reminded to take note of the effects of possible parallel return paths on these continuity tests, described in 2.6.5.

▼ **Figure 2.3** Explanation of the maths for step 2

Figures 2.3**a** to **e** explain the expected results for a correctly wired ring circuit.

a

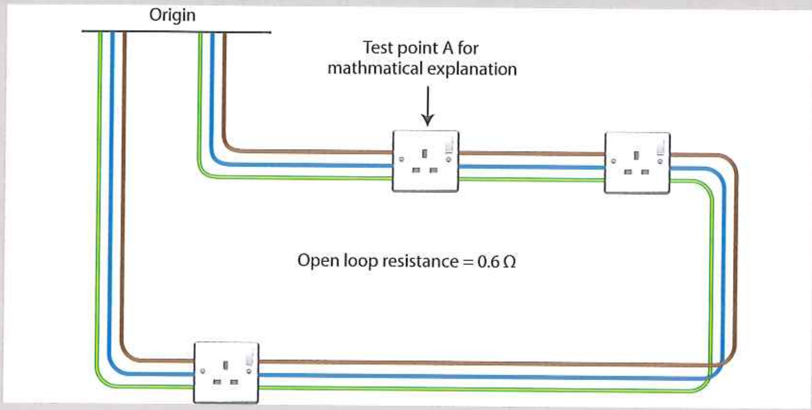
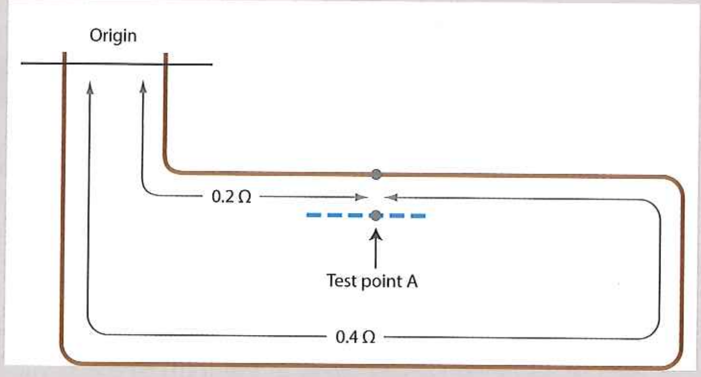


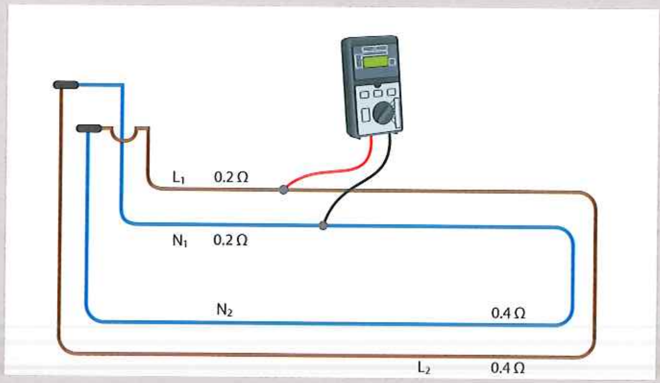
Figure **a** above is an example of a correctly wired ring, the open loop resistances from step 1 being 0.6 Ω. A test point about a third distance round the ring is used to illustrate the maths as explained below.

b



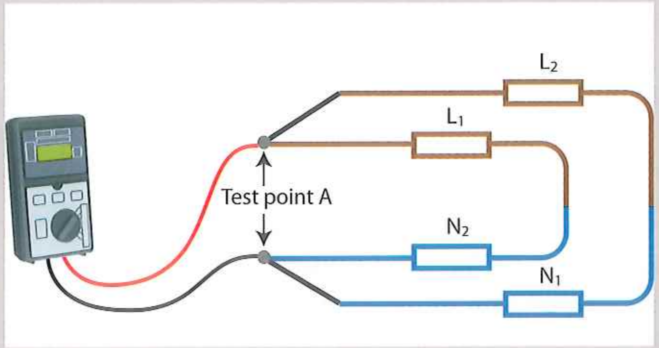
Figures **b** and **c** show the resistances of each leg of the ring as a test is applied at this point as per step 2 (line–neutral).

c



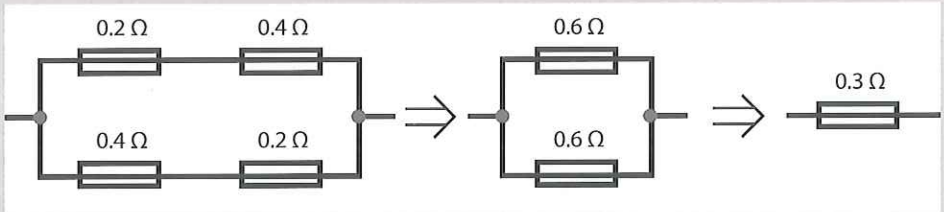
The equivalent connects are then represented in figure **d**.

d



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

e



Thus, in summary the open loop resistances are 0.6 ohm for both line and neutral, giving an $(r_1 + r_n)$ 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 $(r_1 + r_n)$ value, or:

643.3

$$R_{\text{step 2 test}} = \frac{(r_1+r_n)}{4},\ \text{in this case}\ \frac{1.2}{4} = 0.3\,\text{ohm}$$

2.6.7 Insulation resistance

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.

643.3 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 how the procedure currently worded 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 (which was actually only the cpc, such as a single core conductor, or 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 (such as armouring) 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:

(a) 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
(b) pilot or indicator lamps, and capacitors are disconnected from circuits to avoid an inaccurate test value being obtained (see note below)
(c) 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.
(d) the incoming neutral has been disconnected/isolated, where necessary, so that there is no connection to Earth.

(Great care should be taken when removing neutral conductors or neutral links on installations as the moment the neutral is removed it may become live if there is a "borrowed neutral" on the installation. Insulated tools should be used for this task.)

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.

Table 64 Insulation resistance tests should be carried out using the appropriate DC test voltage specified in Table 64 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 64, reproduced here as Table 2.2.

▼ **Table 2.2** Minimum values of insulation resistance

Circuit nominal voltage	Test voltage DC (V)	Minimum insulation resistance (MΩ)
SELV and PELV	250	0.5
Up to and including 500 V with the exception of SELV and PELV but including FELV	500	1.0
Above 500 V	1000	1.0

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 (i.e. in their 'on' positions), 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. An insulation resistance test of L&N connected together to E will ensure that all the circuit conductors are tested. Where there are special lighting controls such as contactor switching all the circuit wiring, including such switch lines, must be included in the testing.

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 1 MΩ would comply with the requirements of the Regulations, a new installation should not yield a test result this low and in new installations a value below 20 MΩ should be investigated.

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

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

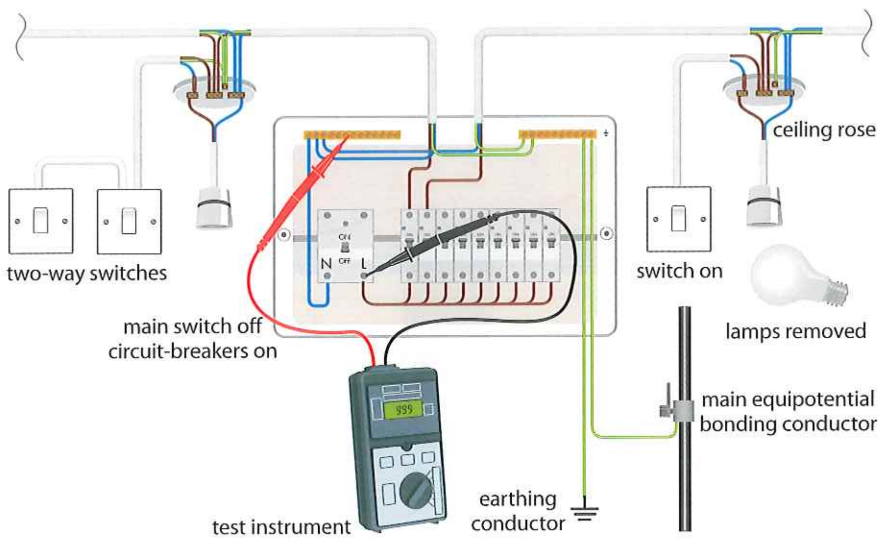


Figure 2.4a shows an example of testing a whole consumer unit (i.e. installation) in one test (only the L-N test is shown). The tests required are a test between the live conductors (L-N) and tests between the live conductors and earth (L-E and N-E).

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

For circuits and/or equipment that is vulnerable to the test voltage, the line and neutral conductors can be linked/connected together and a test made between the linked conductors and protective Earth (as in L&N - E). It is essential that the incoming earth connection is connected to the main earthing terminal of the installation (and that this is connected to the means of earthing) for these tests.

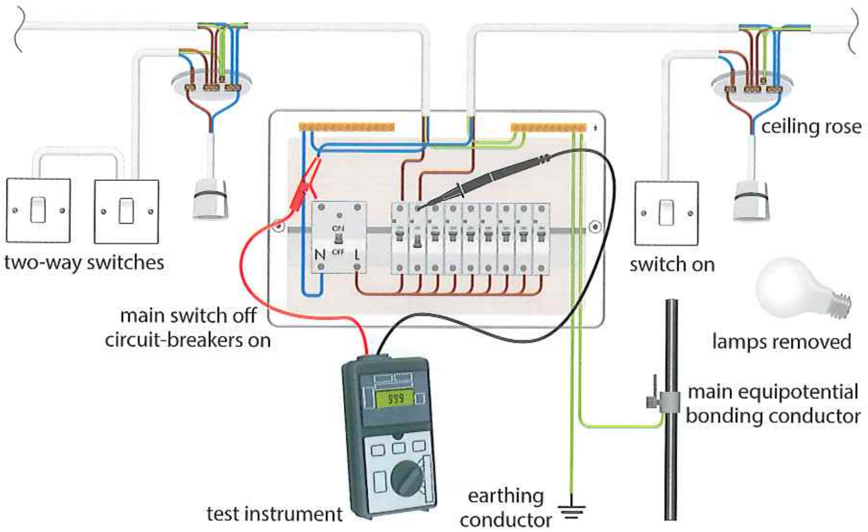
Example (ii) - Insulation resistance test of a final circuit

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 (L-N) and tests between the live conductors and earth (L-E and N-E).

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

For circuits and/or equipment vulnerable to the test voltage, the line and neutral conductors can be linked/connected together and a test made between the linked conductors and protective Earth (as in L&N - E). It is essential that the incoming earth connection is connected to the main earthing terminal of the installation (and that this is connected to the means of earthing) for these tests.

▼ **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.

▼ **Table 2.3** Insulation resistance test on 4-core power cable

Test 1	L_1 to L_2	The lowest value of these tests is recorded as 'between live conductors'
Test 2	L_1 to L_3	
Test 3	L_2 to L_3	
Test 4	$L_1 + L_2 + L_3$ (connected together) to neutral	
Test 5	$L_1 + L_2 + L_3$ (connected together) to earth	The lowest value of these tests is recorded as 'between live conductors and earth'
Test 6	neutral to earth	

Note 1: It is essential for tests 5 and 6 that the protective conductor of the cable is connected to the installation's earthing arrangement.

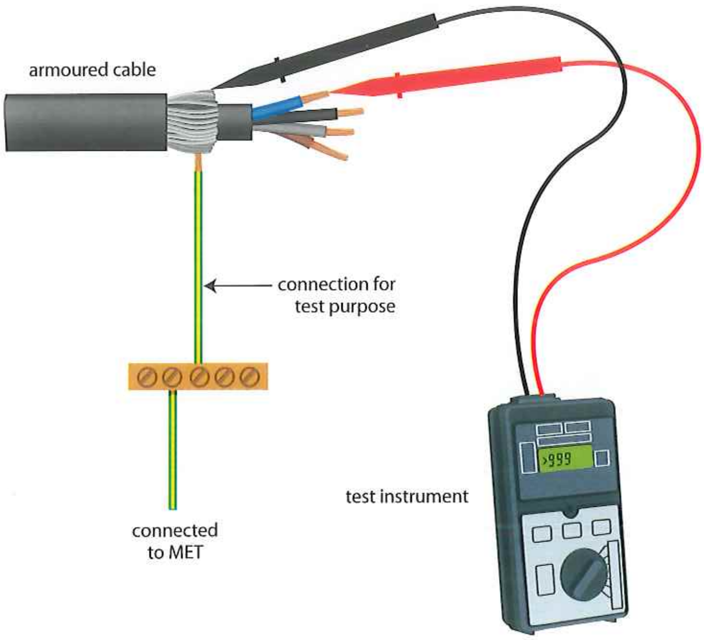
Note 2: Tests 4 and 5 can be done individually L core by core to N and E.

For experienced inspectors and testers, Table 2.3a shows how it is possible to reduce the number of steps for insulation resistance to four, but should any test yield a reading lower than referred to in Table 2.2, it will be necessary to follow the sequence stated in Table 2.3 to identify which conductors are affected.

▼ **Table 2.3a** Four step insulation resistance test on 4-core power cable

Test 1	$L_1 + L_2 + L_3$ + N to E	All live conductors linked together to Earth
Test 2	$L_1 + L_2 + L_3$ to N	All line conductors to Neutral
Test 3	$L_1 + L_2$ to L_3	L_1 and L_2 linked together to L_3
Test 4	L_1 to L_2 (connected together) to neutral	L_1 to L_3

▼ **Figure 2.4c** Insulation testing of a 4-core 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.

643.3 2.6.8 Confirming SELV or PELV circuits by insulation resistance testing

Sect 414 In order to establish which insulation resistance tests are required for verifying a SELV or PELV system, the requirements of Section 414 of BS 7671 must first 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:

414.4.5
- up to 12 V AC or 30 V DC in wet areas
- up to 25 V AC or 60 V DC in dry areas

Part 7 However, for locations containing a bath or shower, or in 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 resistance tests on these circuits as a matter of course.

Where SELV or PELV is used as a protective measure and insulation resistance 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.

643.3.2 ▼ **Table 2.4** SELV insulation resistance tests

Test type	Description	Test voltage DC (V)	Minimum acceptable resistance (MΩ)
Basic insulation	Between live conductors and all other circuits including other SELV and PELV and low voltage circuits	250	0.5
Live to Earth	Between all SELV live parts and Earth	250	0.5

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 V DC and the insulation resistance shall be not less than 1 MΩ.

643.4.2 ▼ **Table 2.5** PELV insulation resistance tests

Test type	Description	Test voltage DC (V)	Minimum acceptable resistance (MΩ)
Basic insulation	Between live conductors and all other circuits including other SELV and PELV and low voltage circuits	250	0.5

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 V DC and the insulation resistance shall be not less than 1 MΩ.

643.4.3 2.6.9 Testing of electrically separated circuits

413.3.2 The source of supply should be inspected to confirm compliance with the Regulations. 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 detailed in Table 2.6.

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

▼ **Table 2.6** Tests made to verify electrical separation

Test type	Description	Test voltage DC (V)	Minimum acceptable resistance (MΩ)
Basic separation	Between the electrically separated live conductors and the transformer secondary live conductors	500	1.0
Basic insulation of the separated conductors	Between the electrically separated live conductors and their corresponding exposed-conductive-parts	500	1.0
Basic insulation of any exposed-conductive-parts associated with separated conductors	Between any exposed-conductive-parts associated with the electrically separated circuits and any protective conductor, other exposed-conductive-parts or Earth	500	1.0

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

418.3.4 **(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 DC insulation resistance test between it and the protective conductor or exposed-conductive-parts of other circuits, or to extraneous- conductive-parts. The insulation resistance should be not less than 1.0 MΩ. *Instruments*: Use a low-resistance ohmmeter and an insulation resistance tester for these tests. Refer to Chapter 4 of this Guidance Note.

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 system.

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

418.3.7 Table 41.2 Table 41.3 Table 41.1 **(d)** Operation of the protective device must be verified by measurement of the fault loop impedances (i.e. between live conductors) to the various items of connected equipment. These values should then be compared with the maximum Z_S 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 Z_S 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.

643.3.2 Regulation 643.3.2 requires that FELV circuits shall meet the test requirements for low voltage circuits (such as 'mains voltage' circuits). This includes the testing of:

643.2 **(a)** continuity of protective conductors (see 2.6.5);
643.3 **(b)** insulation resistance (see 2.6.7), the test voltage being 500 V DC and the minimum insulation resistance being 1 MΩ;
416.2 **(c)** basic protection by a barrier or enclosure provided during erection of the installation (see 2.6.11); and
643.6 **(d)** polarity (see 2.6.13).

It should also be checked by inspection that:

411.7.2 **(a)** the exposed-conductive-parts of the FELV system are connected to the 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
411.7 **(b)** the source of the FELV system is one that meets the requirements of Regulation 411.7.4, and
411.7.5 **(c)** plugs, socket-outlets, LSCs, DCLs and cable couplers in a FELV system are required to have a protective conductor contact (connected to the protective conductor) and not be 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.

642.3 2.6.11 Protection by barriers or enclosures provided during erection

416.2.1 416.2.2 416.2.1 This test is not applicable to barriers or enclosures of factory-built equipment and these will have been tested and certified by the manufacturer. It is applicable to those constructed on site during the course of assembly or erection and therefore is seldom necessary.

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

418.1.2 643.5 2.6.12 Proving and testing of non-conducting location (insulation resistance/impedance of floors and walls)

Where fault protection is provided by a non-conducting location, which should be remembered as a measure of protection not recognised for general application, the following should be verified, prior to carrying out insulation testing:

418.1.3 **(a)** Exposed-conductive-parts should be inspected to confirm that under ordinary circumstances no one can come into simultaneous contact with:
418.1.3 **(i)** two exposed-conductive-parts, or
(ii) an exposed-conductive-part and any extraneous-conductive-part

if these parts are liable to be at different potentials through failure of the basic insulation of a live part.

418.1.4 **(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.

418.1.5 643.3 Following these checks, the insulation resistance between the insulating floors and 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, for example, 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 1 or test electrode 2 (see Figures 2.5a and 2.5b) and the main protective conductor of the installation.

Appx 13 Measuring insulation resistance of floors and walls

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 DC 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.

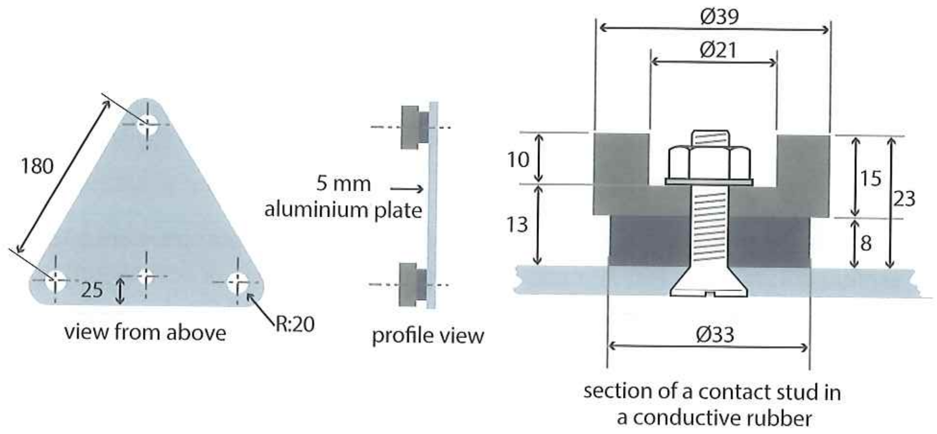
It is recommended that the test be made before the application of the surface treatment (varnishes, paints and similar products).

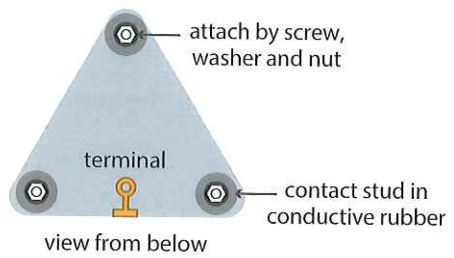
Test electrode 1

The test electrode shown in Figure 2.5a comprises a metallic tripod of which the parts resting on the floor form the points of an equilateral triangle. Each supporting part is provided with a flexible base ensuring, when loaded, close contact with the surface being tested over an area of approximately 900 mm^2 and having a combined resistance of less than 5000 Ω 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 ▼ **Figure 2.5a** Test electrode 1

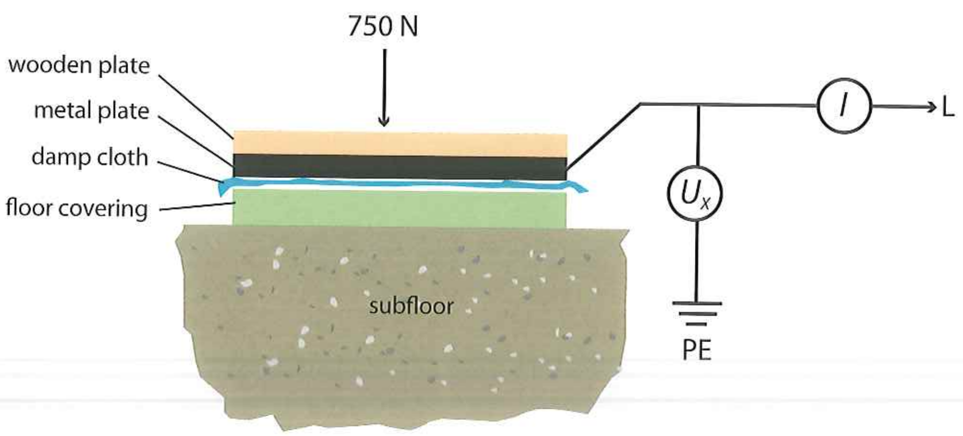




Test electrode 2

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 or cloth, as applicable, 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.

Fig 13B ▼ **Figure 2.5b** Test electrode 2



Expected results

The floors and walls are considered to be non-conducting where the measured resistances are at least 50 kΩ (where the system voltage to Earth does not exceed 500 V).

643.5 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 2 kV AC rms test and measures the leakage current (which should not exceed 1 mA).

643.6

2.6.13 Polarity testing

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.

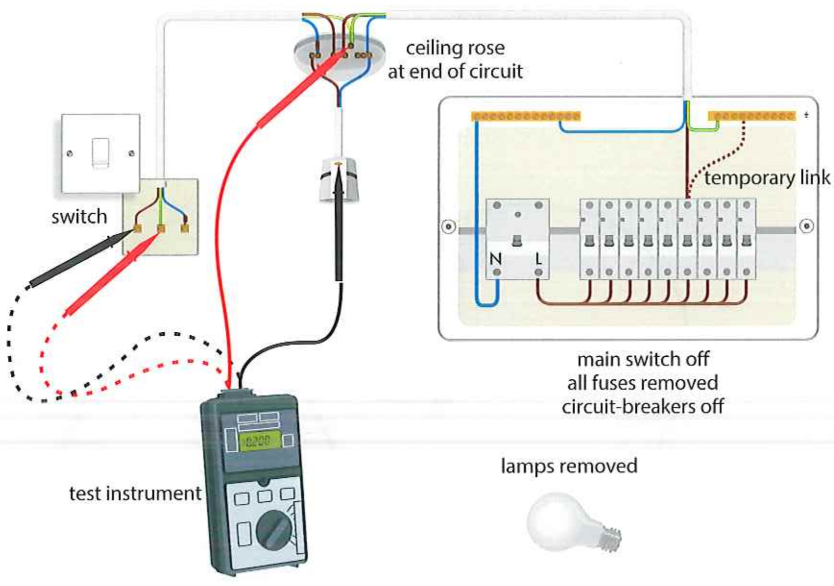
Alternatively, polarity can be verified by visually checking core colours at terminations, thus verifying the installer's connections. Whatever method is used, polarity checks are required at all points on a circuit.

Instrument: Use a low-resistance ohmmeter for these tests – see Section 4.3.

A test for polarity is necessary to ensure 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) so this needs to be verified as does the correct connection of all non-reversible plugs and socket-outlets.

Note: The continuity test (see 2.6.5) and ring final circuit continuity test (see 2.6.6) helps to confirm polarity.

▼ **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.

643.7.2 2.6.14 Earth electrode resistance testing

542.1 Three methods of measuring the resistance of an earth electrode are described in this
542.2 section. Test method E1 uses a dedicated earth electrode tester (fall of potential, three- or four-terminal type), test method E2 uses a dedicated earth electrode tester (stakeless or probe type) and test method E3 uses an earth fault loop impedance tester.

Test method E1: Measurement using dedicated earth electrode tester (fall of potential, three- or four-terminal type)

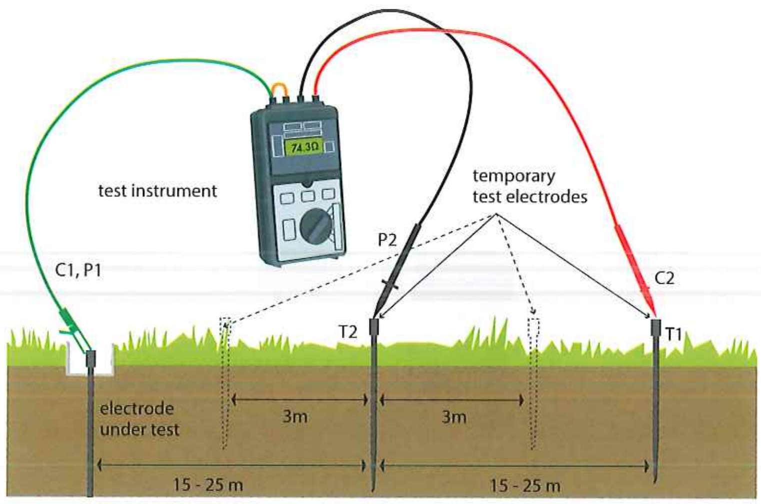
For safety reasons, it is essential to ensure that the installation is securely isolated from the supply. It is also necessary to disconnect the earthing conductor from the earth electrode/MET. **Caution: If this is the only earth electrode this may leave the installation unprotected against earth faults 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 parallel paths. The installation must remain isolated from the supply until all testing has been completed and the earth electrode connection reinstated.

Ideally, the test should be carried out when the ground conditions are least favourable, such as when the soil is frozen or very dry. Refer to Annex C of IEC 60364-6 for further guidance.

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 C1 and P1 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 linked together 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.

▼ **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, for example, 30 m for a 3 m long rod electrode.

Three readings are taken:

(a) firstly, with the potential spike, T2, inserted midway between the electrode under test and the current spike, T1
(b) secondly, with T2 moved to a position 10 % of the overall electrode-to- current spike distance back towards the electrode under test
(c) last, with T2 moved to a position 10 % of the overall distance towards the current spike, from its initial position between the electrode under test and T1.

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 %, and inadvisable to accept readings that differ by more than 5 %. 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 AC or reversed DC 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, BEFORE THE INSTALLATION IS ENERGISED (OR RE-ENERGISED).

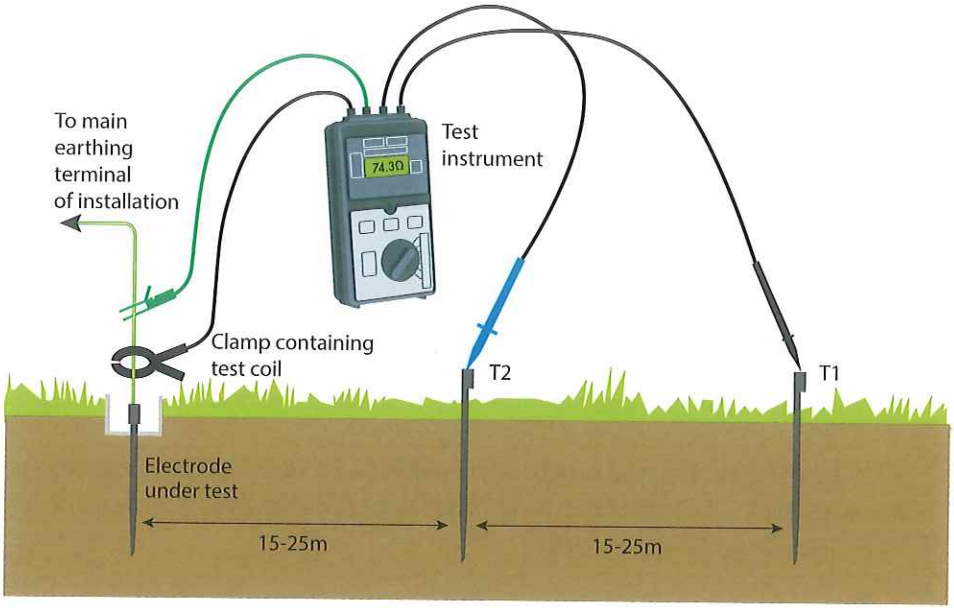
Test method E2: Measurement using dedicated stakeless or clamp based earth electrode tester

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

Instrument using one test coil

The instrument described here uses a method of measurement similar to the fall of potential method (Method E1, 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.

▼ **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.

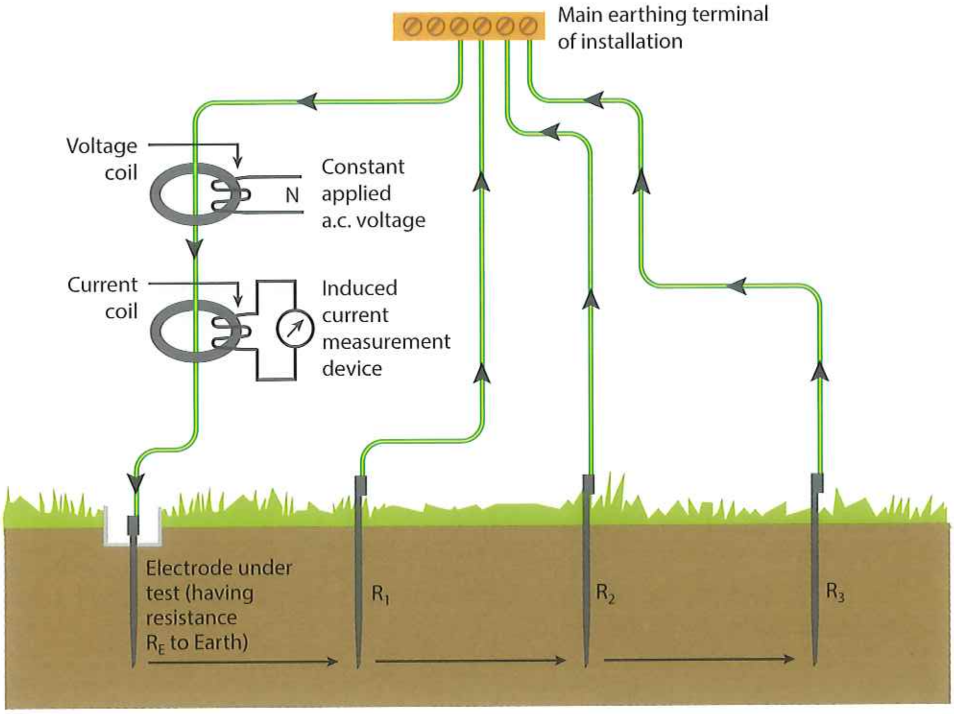
The resulting level of accuracy is similar to that given by 'fall of potential' method.

Instrument using two test coils

The instrument 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.

▼ **Figure 2.9** Instrument using two test coils



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.

$$R_{reading} = R_E + \frac{1}{\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}+...+\frac{1}{R_n}}$$

Where:

- $R_{reading}$ is the resistance reading given by the test instrument
- R_E is the actual resistance of the earth electrode under test
- R_1, R_2 etc. are the resistances of the other 'earth electrodes'

The accuracy of the test reading ($R_{reading}$) 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 Ω, their combined resistance would be 10 Ω. If the resistance of the earth electrode under test was 100 Ω, the total resistance, $R_{reading}$, measured by the test instrument would be 100 Ω +10 Ω =110 Ω. Consequently, the measured value ($R_{reading}$) would be 110 % of the actual value (R_E), 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, $R_{reading}$, measured by the test instrument would be 100 Ω + 40 Ω =140 Ω. Consequently $R_{reading}$ would then be 140 % of the actual value (R_E), 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. However, it is recognised that the results may not be as accurate as using a dedicated earth electrode tester.

FOR SAFETY REASONS, THE INSTALLATION MUST BE ISOLATED FROM THE SUPPLY BEFORE DISCONNECTING 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 via the earthing conductor, and a test performed. The impedance reading taken is treated as the electrode resistance.

ON COMPLETION OF THE TEST ENSURE THAT THE EARTHING CONDUCTOR IS RECONNECTED BEFORE THE SUPPLY IS ENERGISED (OR RE-ENERGISED).

Results of earth electrode testing

For TN-S systems and generator supplies, electrode resistance values may not have been specified, as there is a separate metallic earth conductor and 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, Regulation 411.3.2.3 or 411.3.2.4, and
(b) $R_A \times I_{\Delta n} \leq 50$ V

where:

The maximum disconnection time required by Table 41.1 of BS 7671 (for final circuits rated at not more than either 63 A with one or more socket-outlets or 32 A supplying fixed current using equipment only) at a nominal voltage to Earth, U_0, of 230 V is 0.2s 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.

R_A	is the sum of the resistances of the earth electrode and the protective conductor(s) connecting it to the exposed-conductive-parts (in ohms)
$I_{\Delta n}$	is the rated residual operating current of the RCD (in amps).

For a nominal voltage, U_0, of 230 V, Table 2.7 gives maximum values of Z_s for non-delayed RCDs, which may be substituted for R_A in equation (b), above.

▼ **Table 2.7** Maximum values of earth fault loop impedance (Z_s) for non-delayed RCDs to BS EN 61008-1 and BS EN 61009-1 for U_0 of 230 V

Table 41.5

RCD rated residual operating current, $I_{\Delta n}$ (mA)	Maximum value of earth fault loop impedance, Z_s (Ω)
30	1667
100	500
300	167
500	100

Where a time-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 given above.

The table indicates that the use of a suitably rated RCD will theoretically allow much higher values of R_A, and therefore of Z_S, than could be expected by using the circuit overcurrent devices for fault protection.

*It is advised though, in Note 2 of Table 41.5, that earth electrode resistance values above 200 Ω may not be stable, as soil conditions change due to factors such as soil drying and freezing.

643.7 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:

(a) measurement of earth fault loop impedance (as described in 2.6.16 below);
(b) confirmation by visual inspection that overcurrent devices have suitable short-time or instantaneous tripping setting for circuit-breakers, or current rating (I_n) and type for fuses; and
(c) 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:

(a) measurement of the resistance of the earthing arrangement of the exposed-conductive-parts of the equipment for the circuit in question;
(b) confirmation by visual inspection that overcurrent devices have suitable short-time or instantaneous tripping setting for circuit-breakers, or current rating (I_n) and type for fuses; and
(c) 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).

643.7.3 2.6.16 Earth fault loop impedance verification

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 fault loop:

(a) the circuit protective conductor;
(b) the main earthing terminal and earthing conductor;
(c) for TN systems, the metallic return path or, in the case of TT and IT systems, the earth return path;
(d) the path through the earthed neutral point of the transformer;
(e) the transformer winding (or the equivalent in another source of energy); and
(f) the line conductor from the 'source' to the point of fault.

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

(a) measurement of total earth fault loop impedance (Z_S) using an earth fault loop impedance tester, where it is safe to do so; and
(b) measurement of ($R_1 + R_2$) 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_e).

The latter is preferred when determining Z_S for final circuits and distribution circuits.

Measurement of total earth fault loop impedance (Z_s) using an earth fault loop impedance tester

Measurement of Z_S 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 ($R_1 + R_2$) during continuity testing of a circuit and addition to the earth fault loop impedance external to that circuit (Z_e)

This procedure is described in Section 2.6.5 and, for ring circuits, Section 2.6.6, and the ($R_1 + R_2$) 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:

$$Z_S = Z_e + (R_1 + R_2)$$

where:

Z_S	is the total earth fault loop impedance in ohms
Z_e	is the external earth fault loop impedance, 'external' to the installation
$(R_1 + R_2)$	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, confusion can arise over the term 'external earth fault loop impedance' (Z_e) and some prefer to write or note the earth fault loop impedance at the distribution board as Z_{db}. As this value is not external to the installation, the formula is modified to:

$$Z_S = Z_{db} + (R_1 + R_2)$$

Circuit-breakers and residual current devices

The test (measuring) current of earth fault loop impedance testers may trip some types of 6 A Type B circuit-breakers and any RCD protecting the circuit. So, 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 DC biasing (this technique saturates the core of the RCD prior to applying the test).

Measurement of external earth fault loop impedance, Z_e

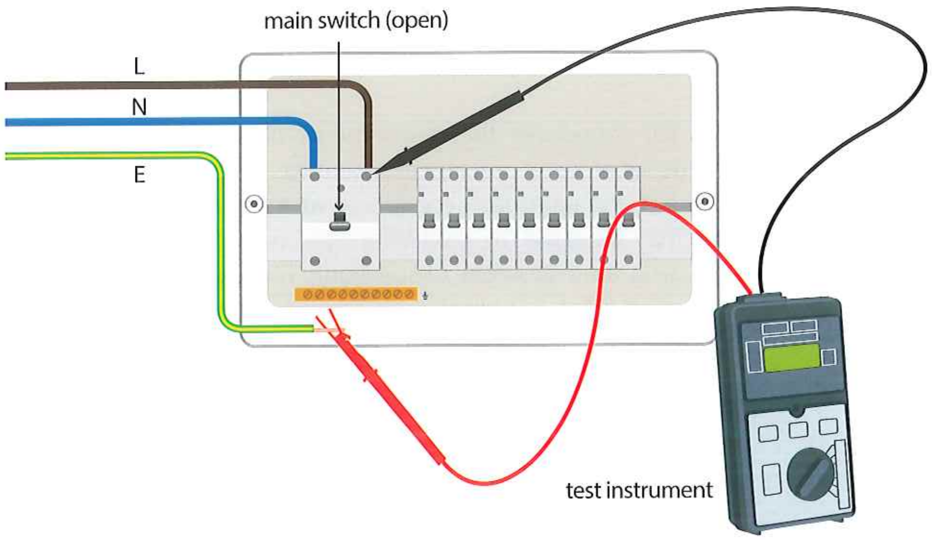
542.4.2 The external earth fault loop impedance, Z_e, is measured using an earth fault loop
643.7.3 impedance tester at the origin of the installation. The impedance measurement is made between the line conductor of the supply and the means of earthing *with the main switch open or with all the circuits isolated.* The means of earthing must be disconnected from the installation MET 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 RECONNECTED BEFORE THE INSTALLTION IS ENERGISED (OR RE-ENERGISED).

See Figure 2.10 for test method connections.

Instrument: Use an earth fault loop impedance tester for this test – see Section 4.5.

▼ **Figure 2.10** Example test of Z_e at the origin of a small installation



As previously mentioned, the measured Z_e can be used to add to circuit (R_1 + R_2) values.

Determining external earth fault loop impedance, Z_e, by enquiry

The external earth fault loop impedance, Z_e, 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 to verify that the intended means of earthing is present and of the expected value or a test lamp.

Verification of earth fault loop impedance test results

643.1 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 Z_S should be compared with one of the following:

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

Table 41.2 Table 41.3 Table 41.4 **(b)** 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)

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

(d) using a factor of 0.8, see Appendix A2.

Appendix A provides a formula for making temperature adjustments, together with a worked example.

643.7.3.201

2.6.17 Prospective fault current, I_{pf}

434.1 Regulation 434.1 requires the prospective fault current to be determined at every relevant point of an installation for design purposes, and Regulation 643.7.3.201 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 for confirmation.

Regulation 643.7.3.201 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 be measured directly using an instrument (inspection). 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. Appendix 14 provides some further guidance on these requirements.

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. Any fault current contribution from a generator must be included if the generator can operate in parallel with the supply. If a generator or other source can supply the installation in place of the normal supply generally fault currents will be significantly lower and the protection may take longer to clear a fault making it possible that the I^2t contribution could cause thermal damage to some cables or equipment.

434.5.1 Part 2 Regulation 434.5.1 requires that, except where back-up protection is provided by 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.

Where an instrument is rated for the higher voltage a more accurate prospective fault current measurement, for a 3 phase installation, can be obtained by measuring the line to line fault current and dividing the measured result by 0.87.

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 Electrical Installation Certificate, Electrical Installation Condition Report and the Schedule of Test Results as appropriate.

If the measured value of prospective fault current appears to exceed the fault current rating for the equipment or protective device further consideration must be given to the current limiting effect of any upstream protective devices and the ability for the source of supply to deliver the indicated prospective fault current. The maximum value of prospective fault current for an installation will be with the installation unloaded and the conductors at ambient temperature.

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 low value impedance 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 fault loop impedance instrument.

Whilst earth fault loop testers should have a resolution of at least 0.01 Ω this should not be confused with accuracy.

Displayed test result less than about 0.1 Ω, or about 1.0 Ω when on the lower current range (such as 15 mA), could be prone to significant errors. So, such errors can significantly affect the calculation of prospective fault current.

Should more accurate measurements be needed on large installations with very low impedance supplies specialist high current 4 wire earth fault loop impedance testers are available.

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.

Table 2.8 Rated short-circuit capacities of protective devices

Device type	Device designation	Rated short-circuit capacity (kA)
Semi-enclosed fuse to BS 3036 with category of duty	S1A	1
	S2A	2
	S4A	4
General-purpose fuse to BS 88-2		
System E (bolted) type		80 kA at 400 V
System G (clip in) type		50 kA at 230 V or
		80 kA at 400 V
Domestic fuse to BS 88-3		
Fuse system C		
type I		16 kA
type II		31.5 kA
BS 88-6		16.5 at 240 V
		80 at 415 V
Circuit-breakers to	I_{cn}	I_{cs}
BS EN 60898* and RCBOs to BS EN 61009*	1.5	(1.5)
	3.0	(3.0)
	6	(6.0)
	10	(7.5)
	15	(7.5)
	20	10.0)
	25	(12.5)
BS 1361 Fuses (BS 1361 has been withdrawn, so refer to BS 88-3 fuse system C)		
Domestic fuse to BS 1361		
type 1		16.5
type 2		33.0
Circuit-breakers to BS 3871 (replaced by BS EN 60898)	M1	1
	M1.5	1.5
	M3	3
	M4.5	4.5
	M6	6
	M9	9

* Two short-circuit capacity ratings are defined in BS EN 60898 and BS EN 61009:

I_{cn} the rated short-circuit capacity (marked on the device)

I_{cs} the service short-circuit capacity.

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

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

I_{cs} is the maximum fault current that the device can interrupt safely without loss of performance.

The I_{cn} value is marked on the device in a rectangle, for example, 6000 and 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 I_{cn} will equal I_{cs}. (For domestic installations the DNO may specify a higher fault current value – perhaps up to 16 kA – but this level is rapidly reduced through the impedance of the supply cables.)

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. For non-domestic installations on the public supply network this information will have to be obtained from the local DNO.

The terminology to define the short-circuit rating of an assembly is given in the BS EN 61439 series of standards as follows:

(a) rated short-time withstand current I_{cw}
(b) rated peak withstand current I_{pk}
(c) rated conditional short-circuit current I_{cc}.

Further details are provided in IET Guidance Note 2.

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:

(a) the consumer unit complies with BS EN 61439-3:2012
(b) the consumer unit is supplied through a type II fuse to BS 1361:1971 rated at not more than 100 A, on a single-phase supply with a nominal voltage up to 250 V .

Recording the prospective fault current

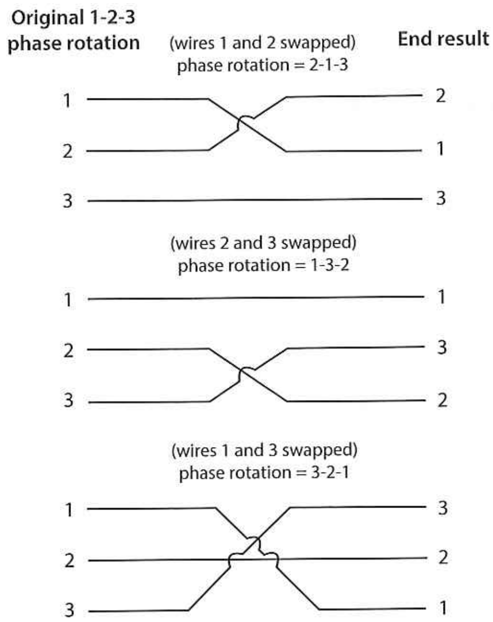
Both the Electrical Installation Certificate and the Electrical Installation Condition Report contain a section headed Nature of Supply Parameters, which requires the prospective fault current at the origin to be recorded. The value to be recorded is the greater of either the short-circuit current (between 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

643.9 Regulation 643.9 verification 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. Whilst the Regulation requires phase sequence to be maintained throughout the installation this should not be confused with phase rotation.

Phase sequence may be confirmed, with the installation/circuits isolated using continuity testing as carried out for continuity of conductors. This may be carried out using the same method as $R_1 + R_2$ testing.

▼ **Figure 2.11** All possibilities of swapping any two wires



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

(a) rotating disc type; or
(b) 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.

Some Approved Voltage Testers have a phase rotation facility built in to them. They offer an increase in safety over standard 3 wire phase rotation testers as they do not require the inspector to attach the wires to the installation as they only require 2 phases to be probed with the hand held probes.

With the indicator lamp type either the L1/L2/L3 (formerly R/Y/B) lamp or the L1/L3/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:

643.7.1 **(a)** where they are relied on for disconnection for compliance with Chapter 41
643.8 **(b)** 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. (As noted previously, such specification details must be provided to the inspector before the start of the inspection and testing work.)

Operation of residual current devices

411.4.5 411.5.3 For each of the tests, readings should be taken on both positive and negative half-cycles and the longer operating time recorded.

Prior to these RCD tests it is essential, for safety reasons, that the earth fault 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 of the 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 stated in Table 41.1 (Regulation 411.4.5) for final circuits and 5 seconds for distribution circuits unless supplementary bonding has been applied in accordance with Regulation 419.3.

▼ **Table 2.9** Operational tripping times for various RCDs

Device type	Non-time delayed maximum operating time at 100 % rated tripping current, $I_{\Delta n}$ (ms)	Time delay operating time at 100 % rated tripping current, $I_{\Delta n}$ (ms)	Notes
BS 4293	200	{(0.5 to 1.0) × time delay} + 200	
BS 61008	300	130 to 500	S type
BS 61009 (RCBO)	300	130 to 500	S type
BS 7288 (integral socket-outlet)	200	non-applicable	

Additional protection

415.1 643.7 Where an RCD with a rated residual operating current, $I_{\Delta n}$, not exceeding 30 mA is 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 $I_{\Delta n}$. 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

643.10 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:

(a) the continuity of the earthing conductor or the associated circuit protective conductors, or

(b) 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

643.10 Other equipment, including switchgear, controls and interlocks, should also be functionally tested - that is, operated to confirm that they work and are properly installed, mounted and adjusted.

The settings on all adjustable relays and controls etc should be checked to see that they align with the designers proposed requirements. RCD test buttons should be operated to see that the RCD trips.

Arc fault detection devices (AFDDs) have been introduced in the 18th edition of BS 7671 (532.6). There are two general types – some have a test button and the others do not. Functional testing can only be carried out by pressing the test button, there is no means of functionally testing the other type.

Circuit breakers should not be used as lighting switches on a regular basis (as in some warehouses) unless they are approved by the manufacturers for such use.

2.6.21 Verification of voltage drop

Verification of voltage drop is not normally required during initial verification and it is usually sufficient to check that voltage drop calculations have been undertaken and the design voltage drops are within the limits required in BS 7671.

643.11
Sect 525 Where it may be necessary to verify that voltage drop does not exceed the limits stated in relevant product standards of installed equipment, BS 7671 provides guidance 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.

Accurate 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. An indication of volt drop can be obtained to ensure that it is not excessive for the proper functioning of the equipment by simple voltage measurement at the equipment terminals with the installation fully loaded.

Voltage drop may be determined by measurement of the combined live conductor resistance and calculation using this value and the full load current of the equipment with compensation for conductor temperature difference for measured and operating conductor values. This will determine voltage drop within the circuit, which can then be used to verify compliance.

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 a public 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
710.64
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
GN1
The protection referred to in this section of the Guidance Note is the subject of Section 442 of BS 7671. For more information, see IET Guidance Note 1.

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 11 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
442.2.2
Where the low voltage installation is supplied from a privately-owned substation, the 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:

- **(a)** 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
- **(b)** that the high voltage earthing and low voltage arrangements are interconnected or, where appropriate, separated, according to the designer's requirements
- **(c)** 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
- **(d)** that the rated currents and settings of protective devices are as intended by the designer.

Temporary overvoltages due to a low voltage system fault

442.3 442.4 442.5 Regulations 442.3, 442.4 and 442.5 require consideration to be given to the stress voltages that would occur in an installation in the event of loss of the neutral conductor in a TN or TT system, an earth fault in an IT system with distributed neutral, or a short-circuit 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 GN1 The protection referred to in this section of the guidance note is the subject of Section 443 of BS 7671. For more information, see IET Guidance Note 1.

Table 443.2 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 rated impulse voltage referred to in Table 443.2 of BS 7671. The values of rated impulse withstand voltage that table are given according to which Category, I, II, III or IV, the equipment falls into and according to the nominal voltage of the installation. Table 443.2 of BS 7671 gives examples of equipment falling into each of the categories.

443.1.1 Section 534 Where protection against overvoltages by the use of SPDs has been specified by the 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.

The inspector needs to verify that SPDs have not become expired or defective by ensuring that indicator lights are correctly illuminated or the coloured flag or flags on the device indicate they are serviceable.

2.6.25 Verification of measures against electromagnetic disturbances

Sect 444 GN1 Inspectors should familiarise themselves with the section on avoidance and reduction of electromagnetic disturbances, Section 444 of BS 7671. 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 2016* 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 product conformity, along with good installation practice, This is shown by way of storing information on the design criteria. The information that would need to be retained for the "design file" (which needs to be retained by the "responsible person", which under the 2016 EMC Regulations is the Installer) might include:

(a) For a small or simple installations consisting solely of CE-marked equipment complying with the EMC Regulations 2016:

- **(i)** Product manuals and installation instructions – and evidence of CE marking of products.
- **(ii)** Notes on what was done where instructions could not be followed (if relevant).

(b) For a large or complex installation, or where the above does not apply:

- **(i)** Manufacturer/importer declarations of conformity, or statements of EMC standards compliance etc.
- **(ii)** Cable and product manufacturer's installation instructions and specifications
- **(iii)** Design drawings and reports demonstrating:
  - design conformity to relevant installation standards, which might include:
    - BS 7671
    - BS EN 50310
    - BS EN 50174 series
    - BS IEC 61000-5-2
    - Etc. (for systems such as emergency lighting, fire alarm and so on that may have additional EMC requirements as part of their system standards)
  - Evidence that manufacturer instructions have been followed, or mitigation measures where they could not be.
  - Product selection relevant for the EM environment (see PD IEC/TR 61000-2- 5)
    - For larger installations / multi-use premises, EM environment zoning
    - Statement of mitigations and residual risk for equipment installed outside target EM environment

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:

(a) checking the EMC design has been followed with respect to cable routing, separation distances, enclosure etc.
(b) inspection of cable sheath and screen terminations and, if considered necessary, continuity checking of these items
(c) carrying out continuity checks of any additional mitigating bonding network provided (for example, a local mesh network).

BS IEC 61000-5-2 contains guidance on inspection items for good installation practices to achieve EMC. BS EN 50310:2016 contains requirements for electrical tests to be carried out for bonding networks in buildings containing information technology and telecommunications systems.

It should be noted that there are no specific requirements in BS 7671 for either installers or inspectors to carry out electric field or magnetic field strength measurements, however, designs for certain installations may require such measurements to be made, based on assessments carried out at the design stage.

Periodic inspection and testing 3

3.1 Purpose of periodic inspection and testing

651.1 The purpose of periodic inspection and testing is to provide an engineering view on whether or not the installation is in a satisfactory condition where it can continue to be used safely.

A detailed visual examination of the installation is required, together with appropriate tests. The tests are mainly to confirm that the disconnection times stated in Chapter 41 are met.

The periodic inspection and testing is carried out, so far as is reasonably practicable, for:

(a) the safety of persons and livestock against the effects of electric shock and burns;
(b) protection against damage to property by fire and heat arising from an installation defect;
(c) confirmation that the installation is not damaged or deteriorated so as to impair safety; and
(d) the identification of installation defects and departures from the requirements of BS 7671 that may give rise to danger.

652.2 For an installation under effective supervision in normal use, periodic inspection and testing may be replaced by an adequate regime of continuous monitoring and maintenance of the installation and all its constituent equipment by skilled persons competent in such work. It is important in such regimes that maintenance records, with references to inspection and testing, are recorded and stored. Such records should be available for scrutiny and need not be in the standard IET Electrical Installation Condition Report format.

3.2 Necessity for periodic inspection and testing

Periodic inspection and testing is necessary because all electrical installations deteriorate due to a number of factors such as damage, wear, tear, corrosion, excessive electrical loading, ageing and environmental influences. Consequently:

(a) legislation requires that electrical installations are maintained in a safe condition, and this lends itself to periodic inspection and testing – see also Tables 3.1 and 3.2
(b) licensing authorities, public bodies, insurance companies, mortgage lenders and

others may require periodic inspection and testing of electrical installations, as is for example the case for houses in multiple occupation – see Tables 3.1 and 3.2

(c) additionally, periodic inspection and testing should be considered in the following circumstances:
- **(i)** to assess compliance with BS 7671
- **(ii)** on a change of occupancy of the premises (especially rented domestic accommodation)
- **(iii)** on a change of use of the premises
- **(iv)** after additions or alterations to the original installation
- **(v)** where there is a significant change (increase) in the electrical loading of the installation
- **(vi)** where there is reason to believe that damage may have been caused to the installation, as might be the case for example after flooding.

"Reference to legislation and other documents is made below and it is vital that these requirements are ascertained before undertaking periodic inspection and testing."

3.3 Electricity at Work Regulations

Regulation 4(2) of the *Electricity at Work Regulations 1989* requires that:

As may be necessary to prevent danger, all systems shall be maintained so as to prevent, so far as is reasonably practicable, such danger.

Guidance on *The Electricity at Work Regulations 1989*(HSR25), published by the Health and Safety Executive, advises that this regulation is concerned with the need for maintenance to ensure the safety of the system rather than being concerned with the activity of doing the maintenance in a safe manner, which is required by Regulation 4(3). The obligation to maintain a system arises if danger would otherwise result. There is no specific requirement to carry out a maintenance activity as such; what is required is that the system be kept in a safe condition. The frequency and nature of the maintenance must be such as to prevent danger so far as is reasonably practicable.

There have been many debates as to what "reasonably practicable" means, and eventually after an accident a court would have to decide the issues. However in essence, making sure a risk has been reduced as low as reasonably practicable is about weighing the risk against the sacrifice needed to further reduce it. The decision should be weighted in favour of health and safety because the presumption is that the duty-holder should implement the risk reduction measure. To avoid having to make this sacrifice, the duty-holder must be able to show that it would be grossly disproportionate to the benefits of risk reduction that would be achieved. Thus, the process is not one of balancing the costs and benefits of measures but, rather, of adopting measures except where they are ruled out because they involve grossly disproportionate sacrifices.

Ultimately under the Electricity at Work Regulations it is the duty holder who is responsible for the safety of an electrical installation at work, and this leads to the question of who is the duty holder. In the instance of HSWA, s.4, it refers to a person "who has, to any extent, control of premises", who may be an identified person with that specific responsibility within an organisation – a landlord, or perhaps a manager or supervisor.

Regular inspection of equipment including the electrical installation is an essential part of any preventive maintenance programme. This regular inspection may be carried out as required without dismantling (or with partial dismantling, as required) and supplemented by appropriate testing.

There is no specific requirement to test the installation on every inspection. Where testing requires dismantling, the inspector should consider whether the risks associated with dismantling and reassembling are justified. Dismantling, and particularly disconnection of cables or components, introduces a risk of unsatisfactory reassembly.

It is however easy to decide that it is impractical to dismantle an item of equipment or that it would introduce a risk of unsatisfactory reassembly but this needs to be considered against the possible later electrical dangers of not doing so, (for example, inspecting inside switchgear for signs of overheating). Where irreparable damage would ensue it can be justified not to inspect (for example, lifting floor tiles to inspect cables under a floor) but where it is just a matter of a little extra work or inconvenience (for example, a visual inspection of cables etc in a domestic dwelling loft void) it could be difficult to justify.

3.4 Design

341.1 When carrying out the design of an installation and particularly when specifying the equipment, the designer should take into account the quality of the maintenance to be reasonably expected, including the frequency of routine checks and the period between subsequent inspections (supplemented as necessary by testing).

Information on the requirements for routine checks and inspections should be provided in accordance with Section 6 of the *Health and Safety at Work etc. Act 1974* and as required by the *Construction (Design and Management) Regulations 2015*. Duty holders and users of premises should seek this information as the basis on which to make their own assessments. The Health and Safety Executive advise in their guidance on *The Electricity at Work Regulations 1989*(HSR25), that practical experience of an installation's use may indicate the need for an adjustment to the frequency of checks and inspections. This is a matter of judgement for the duty holder. In fact, BS 7671 requires the designer of an electrical installation to recommend the interval to the first periodic inspection and insert the date of that recommendation on the Electrical Installation Certificate. However, as stated in regulation 341.1 wider consideration should be given to the expected maintainability of an installation and the client should be involved, and perhaps the installer too, so any designer would take the advice of other relevant persons into account. Then, after the first, and further periodic inspections and tests, the inspector, in conjunction with the client, taking into account test results and the observations found, will then advise on the period until the next inspection. However, whatever inspection and testing periods are decided upon must be justifiable as they may be requested to be justified in the case of an accident etc. It would not be unreasonable for the inspector to write supporting reasons for the period that has been advised on to the inspection and test report.

3.5 Routine checks

Electrical installations should not be left without any attention for the periods of years that are normally allowed between formal inspections. In domestic premises it is presumed that the occupier will soon notice any breakages or excessive wear and arrange for precautions to be taken and repairs to be carried out.

Commercial and industrial installations come under the *Electricity at Work Regulations 1989* and formal arrangements are required for maintenance and interim routine checks (as well as periodic inspections); there should also be facilities to receive wear-and-tear reports from users of the premises.

The frequency and type of these routine checks will depend entirely upon the nature of the premises and should be set by the electrical duty holder. Routine checks should include the items listed in Table 3.1. Table 3.2 (Section 3.7) provides guidance on the frequency , which may need to be increased as an installation ages.

▼ **Table 3.1** Routine checks

Activity	Check
Defects reports	All reported defects have been rectified
Inspection	Look for: breakages wear/deterioration signs of overheating missing parts (covers, screws) loose fixings Confirm: switchgear accessible (not obstructed) doors of enclosures secure adequate labelling in place
Operation	Operate: switchgear (where reasonable) equipment – switch on and off including RCDs (using test button)

Note that routine checks need not be carried out by an electrically skilled person but should be undertaken by somebody who is able to safely use the installation and recognise defects.

There is a general on-going requirement to manage health and safety at work, and electrical safety is just one area. To ensure that regular routine checks are made on the electrical installation it may be advantageous in larger premises to combine these with other regular checks such as emergency lighting and fire alarm inspections, general fire safety inspections, emergency exit route inspections etc on security patrols. All results should be noted on a simple form and filed for any future reference.

3.6 Required information

It is essential that the inspector knows and agrees with the client the extent of the installation to be inspected and any criteria regarding the limit of the inspection. This should be recorded.

514.9 Enquiries should be made to the person responsible for the electrical installation with regard to the provision of diagrams, design criteria, type of electricity supply (and any alternative supply) and earthing arrangements.

Where they exist, diagrams, charts or tables should be available to indicate the type and composition of circuits, identification of protective devices for shock protection, isolation and switching and a description of the method used for fault protection. Unfortunately most such records are not kept up to date with changes and additions/removals and an inspector will initially need to verify the accuracy of any such information provided.

Where there are no records, in all but the simplest domestic installation an inspector may first need to spend time tracing installation systems and circuits and producing basic drawings and schedules before starting any inspection and testing work.

3.7 Frequency of periodic inspections

The time intervals between the recommended dates of periodic inspections and testing require careful consideration. The date for the first periodic inspection and test is required to be considered and recommended by the installation designer, based on their design philosophy and maintenance advice from other parties (Regulation 341.1). The period for each subsequent periodic inspection is required to be considered and recommended by a competent inspector as part of carrying out a periodic inspection and test.

652.1 In advising a dutyholder about the time interval for the period for the next recommended periodic inspection and test, the inspector is required to take into consideration the individual characteristics of the type of installation and equipment, its condition, use and operation, any damage and deterioration, any known maintenance and the external influences to which it is subjected. The results and recommendations of any previous periodic inspection reports should also be considered.

Typical installation types with suggested initial frequencies for the first periodic inspection and testing are provided in Table 3.2. The table sets out a suggested initial frequency for the various routine checks on electrical installations and equipment. It gives suggested starting intervals for a duty holder to consider when implementing a maintenance plan for a particular installation. It must be remembered that "routine checks" and "periodic inspection and testing" by a competent inspector are only a part of the requirement for maintenance and the duty holder has a continuing on-going responsibility for the safety of an installation

Note: Dutyholders are reminded of the requirements of Regulation 4(2) of The Electricity at Work Regulations, 1989 – undertaking routine inspection and testing of their installations will assist in meeting this duty.

The suggested initial frequencies for inspection and testing given in Table 3.2 are recommendations and not legal requirements. It is the dutyholders responsibility to determine when the next periodic inspection is undertaken. Dutyholders should take appropriate advice from specialists where necessary, to assess the conditions affecting their installation which may lead to defects, potential damage and/or deterioration that will affect safety when making this decision. Such advice may include routine checks; manufacturers' or engineers' advice and guidance, periodic inspection and testing reports etc, and this information should assist the dutyholder to determine the maintenance plan for their installation. Over time, and with practical maintenance experience, it may be possible to extend periodic inspection and testing intervals if results of routine checks, inspections or tests show that few faults are found and the installation is not subject to excessive deterioration. However, if faults are common it may be necessary to reduce intervals or take other action to improve maintenance and reduce risk. Routine checks and periodic inspection and testing by a competent inspector are only a part of the requirement for maintenance and the duty holder has a continuing on-going responsibility for the safety of an installation.

The competent inspector carrying out subsequent periodic inspections may recommend that the interval to the next inspection be increased or decreased as a result of the findings of their current inspection. For example, the inspector may recommend an interval greater in instances where an installation has not suffered from damage or deterioration which would detract from its overall suitability for continued use. Conversely, it would be appropriate to recommend that the next inspection is carried out sooner where an installation has clearly not withstood the adverse effects of its environment and usage well and is not subject to adequate and appropriate maintenance.

In short, the inspector, being a skilled person, should apply sound engineering judgement and experience when deciding upon intervals between inspecting and testing an installation based upon the criteria in Regulation 652 of BS 7671. It must also be noted that in the event of an accident or dangerous occurrence, the inspector may be required to justify their decision.

In the case of domestic and commercial premises, a change in occupancy of the premises may necessitate additional inspection and testing.

651.1 The formal periodic inspection and testing should be carried out in accordance with Regulation 642 supplemented by tests as detailed in Regulation 643. This requires an inspection comprising a detailed examination of the installation, carried out without dismantling or with partial dismantling as required, together with the appropriate tests of Regulation 643 as required to comply with Regulation 651.2.

652.2 Where there is an effective management system in place for inspection and preventative maintenance of the installation (for example where there are competent permanent on-site maintenance staff) periodic inspection and testing can be replaced by an adequate regime of continuous monitoring and maintenance of the installation and its constituent equipment. However appropriate records must be maintained on site to show that an inspection and preventative maintenance plan is in place and is being adhered to.

Although periodic inspection and testing is primarily aimed at keeping an electrical installation in a safe state it can also have other financial benefits such as identifying possible upcoming equipment failures that could interrupt production, providing advice on energy saving and reducing running costs. It must also be noted that whilst this Guidance Note is concerned with periodic inspection and testing for the maintenance of safety of general electrical installations there are other specialist parts of an electrical installation such as plant controls, fire alarms and emergency lighting that also require separate periodic inspection and testing by specialists for the maintenance of safety.

▼ **Table 3.2** Recommended initial frequencies of inspection of electrical installations

Type of installation	Routine check see section 3.5	Maximum period between inspections and testing (note 8)	Notes
General installation			
Domestic accommodation - general	–	Change of occupancy/10 years	
Domestic accommodation - rented houses and flats	1 year	Change of occupancy/5 years	1, 2, 10
Residential accommodation (Houses of Multiple Occupation) - halls of residence, nurses accommodation, etc.	1 year	Change of occupancy/5 years	1, 2, 10, 11
Commercial	1 year	Change of occupancy/5 years	1, 2, 3, 4
Educational establishments	6 months	5 years	1, 2, 6
Industrial	1 year	3 years	1, 2
Offices	1 year	5 years	1, 2
Shops	1 year	5 years	1, 2
Laboratories	1 year	5 years	1, 2
Hospitals and medical clinics			
Hospitals and medical clinics - general areas	1 year	5 years	1, 2
Hospitals and medical clinics - medical locations	6 months	1 year	9
Buildings open to the public			
Cinemas	1 year	1-3 years	2, 6
Church installations	1 year	5 years	2
Leisure complexes (excluding swimming pools)	1 year	3 years	1, 2, 6
Places of public entertainment	1 year	3 years	1, 2, 6
Restaurants and hotels	1 year	5 years	1, 2, 6
Theatres	1 year	3 years	2, 6, 7
Public houses	1 year	5 years	1, 2, 6
Village halls/community centres	1 year	5 years	1, 2
Special and specific installations (for medical locations see above)			
Agricultural and horticultural	1 year	3 years	1, 2
Caravans	1 year	3 years	7
Caravan parks	6 months	1 year	1, 2, 6
Highway power supplies	as convenient	6-8 years	
Marinas	4 months	1 year	1, 2
Fish farms	4 months	1 year	1, 2
Swimming pools	4 months	1 year	1, 2, 6
Emergency lighting	daily/monthly	3 years	2, 3, 4
Fire alarms	daily/weekly	1 year	2, 4, 5
Launderettes	monthly	1 year	1, 2, 6
Petrol filling stations	1 year	1 year	1, 2, 6
Construction site installations	3 months	3 months	1, 2

Notes:

1 Particular attention must be taken to comply with *Electricity Safety, Quality and Continuity Regulations* (as amended).

2 Electricity at Work Regulations 1989, Regulation 4 and Memorandum of guidance (HSR25) published by the HSE.

3 See BS 5266-1:2016 *Emergency lighting. Code of practice for the emergency escape lighting of premises.*

4 Other intervals are recommended for testing operation of batteries and generators.

5 See BS 5839-1:2017 *Fire detection and fire alarm systems for buildings. Code of practice for design, installation, commissioning and maintenance of systems in non-domestic premises.*

6 Local Authority Conditions of Licence.

7 It is recommended that a caravan is inspected and tested every three years, reduced to every year if it is used frequently (see Regulation 721.514.1 and Fig 721 – Instructions for electricity supply).

8 The person carrying out subsequent inspections may recommend that the interval between future inspections be increased or decreased as a result of the findings of their inspection.

9 Medical locations shall have their isolating transformer equipment inspected and tested for functionality as well as alarms etc.; every third year the output leakage current of the IT isolating equipment shall be measured.

10 The Landlord & Tenant Act 1985 requires that properties under the Act have their services maintained. Periodic inspection and testing is the IET recognised method of demonstrating this.

11 The *Management of Houses in Multiple Occupation (England) Regulations* and the *Management of Houses in Multiple Occupation (Wales) Regulations.*

Any landlord (House in Multiple Occupation (HMO) or other occupancy) may be considered to have duties under the *Electricity at Work Regulations* due to their responsibilities under Section 3 of the Health & Safety at Work Act (for example the common areas of a set of flats). In Scotland the private rented sector has legal requirements to maintain the electrical installation. Landlords are required by law to ensure that the electrical installation in a rented property is safe when tenants move in and maintained in a safe condition throughout its duration and that a HMO has a periodic inspection carried out on the property every five years.

(The definition of a HMO is difficult but it hinges on whether the persons living in the house are related – as in a large family residence – or completely separate as in a block of flats.)

3.8 Requirements for periodic inspection and testing

3.8.1 Scope

The purpose of periodic inspection and testing is to provide an engineering view on whether or not the installation is in a satisfactory condition where it can continue to be used in a safe way.

The periodic inspection and test comprises a detailed examination of the installation together with appropriate tests. The inspection is carried out without taking apart or dismantling equipment as far as is possible. The tests made are mainly to confirm that the disconnection times stated in Chapter 41 are met, as well as highlighting other defects.

It is important that the competency of the skilled person carrying out the periodic inspection and test is of the appropriate level, having gained sufficient education, training or practical skills, and knowledge to be fully conversant with the type of installation being inspected and the aspects required of carrying out such an important inspection. The inspector will, for example, need to be able to inspect switchgear, determine the age of installation components and recognise signs of their deterioration. As well as having sufficient visual inspection skills, they will also need to possess good testing skills and experience of older installations and knowledge of what the resulting data means in the context of the ongoing safety of the installation.

651.2 The requirement of BS 7671 for periodic inspection and testing is for a detailed inspection comprising an examination of the installation without dismantling, or with partial dismantling as required, together with the tests of Chapter 64 considered appropriate by the person carrying out the inspection and testing. The scope of the periodic inspection and testing must be decided by a suitably skilled person, competent in such inspection and testing work, taking into account the information and guidance contained in this section.

3.8.2 Process – prior to carrying out inspection and testing

Prior to carrying out the inspection, the inspector will need to meet with the client or the client's representative to agree the scope and nature of the work required and the programme and to highlight likely items that require isolation.

Consultation with the client or the client's representative prior to the periodic inspection and testing work being carried out is essential to determine the access and any disruption to the normal work in the premises, health and safety requirements (dangerous processes may be being carried out), security and access requirements and fire safety requirements, as well as the degree of electrical disconnection which will be acceptable before planning the detailed inspection and testing. To assist with this planning any existing drawings, schedules and documentation of the installation should be available, and some initial validation of these will be necessary. Also, the extent of previous maintenance, routine tests and documentation, including the original design and Electrical Installation Certificate and Certificates for any other electrical works that have been carried out in the premises, should be provided to the inspector if they are available.

For safety, it is necessary to carry out a visual inspection of the installation before testing or opening enclosures, removing covers, etc. So far as is reasonably practicable, the visual inspection must verify that the safety of persons, livestock and property is not endangered.

3.8.3 General procedure

Note: The following advice is not applicable to domestic or simple installations as the extent and method of inspection and testing is rudimentary in such installations in comparison with more complex installations.

Although there are various approaches to carrying out inspection and testing, one suggested method is to first obtain an overview of the installation, ideally from diagrams and charts as well as from a simple 'walk round' survey prior to starting the full inspection. This will enable the inspector to be able to plan the inspection and identify items that require isolation etc. Most importantly, this initial survey will enable the inspector to set sample sizes, see Section 3.8.4.

651.1 Where diagrams, charts or tables are not available, a degree of exploratory work may be necessary so that inspection and testing can be carried out safely and effectively; this may include a survey to identify switchgear, controlgear and the circuits they control.

Indeed, for more involved installations without diagrams or charts the client should be advised that such diagrams require producing prior to the inspection and testing commencing. Alternatively, the inspection can commence in cases where the inspector considers that it is safe to proceed (this may be limited to visual inspection); the production of diagrams and charts can be called for on the Electrical Installation Condition Report.

651.2 Note should be made of any known changes in environmental conditions, building structure, and additions or alterations which have affected the suitability of the wiring for its present load and method of installation.

651.4 During the inspection, the opportunity should be taken to identify dangers which might arise during the testing. Any location and equipment for which safety precautions may be necessary should be noted and the appropriate steps taken.

A thorough inspection should be made of all electrical equipment which is not concealed, and should include the accessible internal condition of a sample of the equipment. The external condition should be noted and if damage is identified or if the degree of protection has been impaired, this should be recorded on the Schedule of Inspections appended to the Report. The inspection should include a check on the condition of electrical equipment and material, taking into account any available manufacturer's information, with regard to the following:

(a) safety;
(b) age;
(c) damage and defects;
(d) corrosion and external influence(s);
(e) overloading (signs of);
(f) wear and tear and environment;
(g) change of use of location; and
(h) suitability for continued use.

The assessment of condition should take account of known changes in conditions influencing and affecting electrical safety, for example plumbing or structural changes.

Where parts of an electrical installation are excluded from the scope of a periodic inspection and test, they should be identified in the 'Extent and limitations' section of the Report.

Periodic inspection and testing should be undertaken in such a way as to minimise disturbance of the installation and inconvenience to the user. Where it is necessary to disconnect part or the whole of an installation in order to carry out a test, the disconnection should be made at a time agreed with the user and for the minimum period needed to carry out the test. Where more than one test necessitates a disconnection, where possible they should be made during one disconnection period.

643.3.2 A careful check should be made of the type of equipment on site so that the necessary precautions can be taken, where conditions require, to disconnect or short-out electronic and other equipment which might be damaged by testing. Special care must be taken where control and protective devices contain electronic components.

3.8.4 Setting inspection and testing samples

The inspector must be familiar with setting both inspection and testing sample sizes as carrying out 100 % inspection or testing in many installations is unrealistic, uneconomical and unachievable. Information is provided in this section and the relevant sampling table, Table 3.3.

As pointed out in 3.8.3, one recommended procedure is for the inspector to carry out an initial walk-round survey to establish initial sample sizes at various points throughout the installation. The detailed inspection is then started and the sample size is adjusted upwards if necessary, depending upon the results obtained. Samples should be selected that are representative of the whole installation. Parts of the installation that, in the inspector's experience, are more likely to be problematic, should be prioritized.

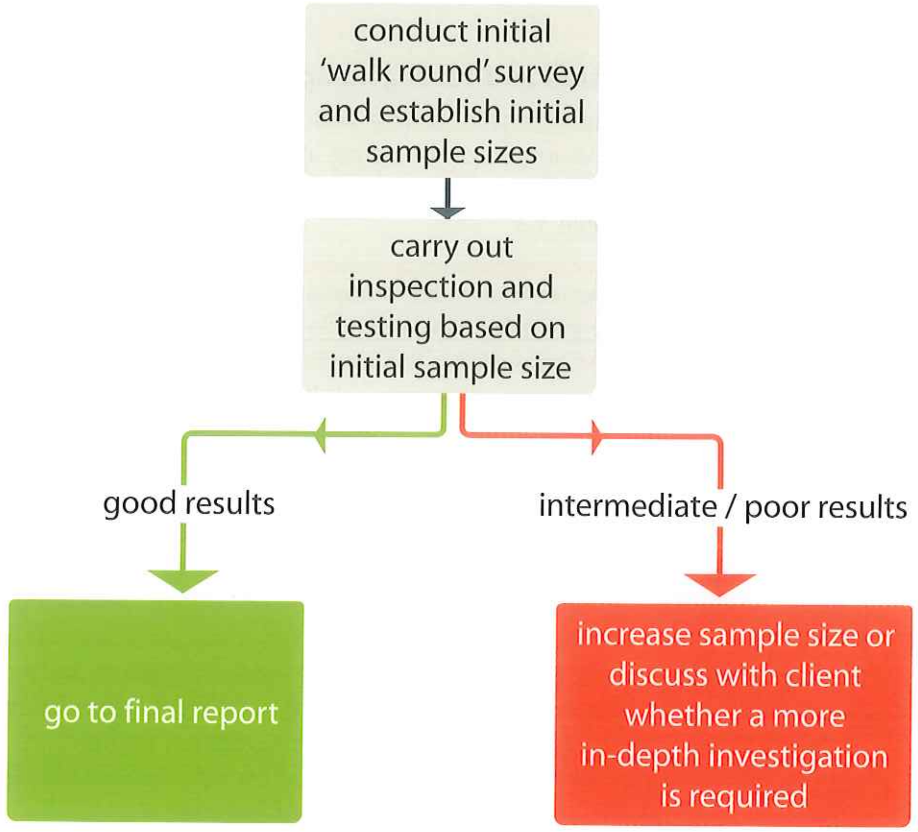
Discussions of sampling and sample size selection are generally simplified and tend to be rather simplistic, and in practice matters are usually quite different. As discussed previously an initial survey of the premises must be carried out, and quite likely, as with most buildings, different things will have been done to it at various times in its life, and any samples selected MUST be representative of the whole installation, and it may be necessary to take seperate samples of the same thing in different areas. For example, in a factory the condition of a fluorescent luminaire installation in the office area is unlikely to be representative of the condition of a fluorescent luminaire installation in the production area, even if they are the same type of luminaire.

Inspectors will require all of their experience in setting sample locations and sizes and should consider:

(a) approximate age and probable condition of the electrical installation in the area being inspected;
(b) any electrical installation work carried out since the last inspection and test;
(c) any differences in the installation in the area (part of it may have been refurbished or taken from another area);
(d) type and usage of the installation or part thereof in that area (part of it may have been used for another purpose previously);
(e) ambient environmental conditions in the area and any differences in the ambient environmental conditions over the area;
(f) the apparent effectiveness of ongoing maintenance, if any;
(g) period of time elapsed since previous inspection/testing;
(h) the size of the installation and any differences in the ambient environmental conditions over the area;
(i) consultation with the installation owner; and
(j) the quality of records such as electrical installation certificates, minor electrical installation works certificates, previous periodic inspection reports, maintenance records, site plans/drawings and data sheets relating to installed equipment.

It should be noted that the initial sample size is based only on a walk-round and consultation of records. Further, that what may at first appear to be good, for example, the quality of maintenance may turn out to be poor during the detailed inspection and testing.

▼ **Figure 3.1** Suggested procedure for setting initial and adjusted sample sizes



Where the inspection or testing of a sample yields poor or unacceptable results this would suggest that similar problems might exist elsewhere in uninspected or untested items. The inspector will then need to either increase the sampling or refer back to the client; it may be that the inspector recommends that 100 % testing is carried out in that area.

The principle of this is indicated in Figure 3.1.

As an example, consider the testing of final circuits at a distribution board with a sample size of 10 % of the lighting circuits. Suppose that more than one of these circuits was found to have an unacceptably high earth fault loop impedance, with a relatively low earth fault loop impedance at the incoming terminals to the distribution board itself, and that there were no apparent factors to suggest why the final circuit values were high. It would be remiss to complete the Electrical Installation Condition Report by using just this 10 % sample and stating that improvements were required for these circuits. It would be far more appropriate to increase the sample size or to recommend that all circuits at the distribution board were tested, based on the initial findings.

If relatively small sample sizes are chosen it is important that these are representative of the complete installation. Similarly, if a repeat periodic inspection is undertaken using a sampling system then a different sample, again representative of the complete installation, must be chosen. Therefore, previous periodic inspection and test records should be consulted prior to commencement of a sample inspection and test. Suggested sample sizes for visual inspections are provided in Table 3.3; suggested sample sizes for testing are discussed in Section 3.10.1 and shown in Table 3.4.

▼ **Table 3.3** Range of samples for inspection

Item	Suggested minimum sample size (notes 1, 2)	Typical checks
Main switchgear external inspection	100 %	Signs of damage, overheating or ageing.
Main switchgear internal sections and cable terminations	Ideally 100 % but not less than 20 % (note 2)	Signs of overheating, ageing, check tightness of cable connections
Main switchgear internal inspection of circuit-breaker connections and control sections	Ideally 100 % but not less than 20 %	Signs of overheating, ageing, check tightness of cable connections
Final circuit distribution boards	Ideally 100 % but not less than 25 % (note 4)	Signs of overheating, ageing, check of cable connections
Final circuit accessories	Between 10 % to 100 % (note 3)	Damage, signs of overheating
Earthing and protective bonding conductors	100 %	Presence and tightness

Notes:

1. Where the inspection of a sample yields poor or unacceptable results this would suggest that similar problems may exist elsewhere in the uninspected items. The inspector will then need to either increase the sampling or refer back to the client; it may be that the inspector recommends that 100 % inspection is carried out in that area.
2. 100 % where practicable.
3. Generally, it is less appropriate to apply small sample sizing to the inspection of socket-outlets compared to samples for lighting, as it is more likely that user equipment will be hand-held and therefore of greater potential risk from electric shock.
4. Do not 'sample samples', resulting in a very low overall sampled installation. Samples must be representative. If it is decided to sample, for example, submain cables at 10 %, then further sampling should not be applied to the final circuit distribution boards on these circuits.
5. One easy way to remember sampling is to reflect on the fact that where just 10 % of final circuits have been inspected, this actually means that 90 % have **not** been inspected.

Whenever samples are taken and whatever sample size is utilized the inspector must remember that the requirement of the report is to say whether or not the electrical installation being inspected (subject to any agreed limitations) is suitable or not for continued use. The inspector MUST carry out sufficient inspection and testing to allow them to make that judgement.

3.9 Periodic inspection

3.9.1 Example checklist of items that require inspection

Appx 6 The following is a copy of the checklist in Appendix 6 of BS 7671, which lists items at various locations within an installation that may require inspection. The items in this checklist are examples; the list in not exhaustive.

ELECTRICAL INTAKE EQUIPMENT – visual inspection only as this is DNO equipment

- Service cable
- Service head
- Distributor's earthing arrangement
- Meter tails – Distributor/Consumer
- Metering equipment
- Isolator

PARALLEL OR SWITCHED ALTERNATIVE SOURCES OF SUPPLY

- Presence of adequate arrangements where generator to operate as a switched alternative (551.6)
  1. Dedicated earthing arrangement independent of that of the public supply (551.4.3.2.1)
- Presence of adequate arrangements where generator to operate in parallel with the public supply system (551.7)
  1. Correct connection of generator in parallel (551.7.2)
  2. Compatibility of characteristics of means of generation (551.7.3)
  3. Means to provide automatic disconnection of generator in the event of loss of public supply system or voltage or frequency deviation beyond declared values (551.7.4)
  4. Means to prevent connection of generator in the event of loss of public supply system or voltage or frequency deviation beyond declared values (551.7.5)
  5. Means to isolate generator from the public supply system (551.7.6)

AUTOMATIC DISCONNECTION OF SUPPLY

- Protective earthing/protective bonding arrangements (411.3; Chap 54)
- Presence and adequacy of
  1. Distributor's earthing arrangement (542.1.2.1; 542.1.2.2), or installation earth electrode arrangement (542.1.2.3)
  2. Earthing conductor and connections (Section 526; 542.3; 543.1.1; 542.3.2)
  3. Main protective bonding conductors and connections (Section 526; 544.1; 544.1.2)
  4. Earthing/bonding labels at all appropriate locations (514.13)
- Accessibility of
  1. Earthing conductor connections
  2. All protective bonding connections (543.3.2)
- FELV – requirements satisfied (411.7; 411.7.1)

OTHER METHODS OF PROTECTION

(Where any of the methods listed below are employed details should be provided on separate pages)

BASIC AND FAULT PROTECTION

where used, confirmation that the requirements are satisfied:

- SELV (Section 414)
- PELV (Section 414)
- Double insulation (Section 412)
- Reinforced insulation (Section 412)

BASIC PROTECTION:

- Insulation of live parts (416.1)
- Barriers or enclosures (416.2; 416.2.1)
- Obstacles (Section 417; 417.2.1; 417.2.2)
- Placing out of reach (Section 417; 417.3)

FAULT PROTECTION:

- Non-conducting location (418.1)
- Earth-free local equipotential bonding (418.2)
- Electrical separation (Section 413; 418.3)

ADDITIONAL PROTECTION:

- RCDs not exceeding 30 mA as specified (411.3.3; 415.1)
- Supplementary bonding (Section 415; 415.2)

SPECIFIC INSPECTION EXAMPLES

as appropriate to the installation

DISTRIBUTION EQUIPMENT

- Security of fixing (134.1.1)
- Insulation of live parts not damaged during erection (416.1)
- Adequacy/security of barriers (416.2)
- Suitability of enclosures for IP and fire ratings (416.2; 421.1.6; 421.1.201; 526.5)
- Enclosures not damaged during installation (134.1.1)
- Presence and effectiveness of obstacles (417.2)
- Components are suitable according to manufacturers' assembly instructions or literature (536.4.203)
- Presence of main switch(es), linked where required (462.1; 462.1.201)
- Operation of main switch(es) (functional check) (643.10; 462.1.201)
- Manual operation of circuit-breakers and RCDs to prove functionality (643.10)
- Confirmation that integral test button/switch causes RCD(s) to trip when operated (functional check) (643.10)
- RCD(s) provided for fault protection, where specified (411.4.204; 411.5.2; 531.2)
- RCD(s) provided for additional protection, where specified (411.3.3; 415.1)
- Confirmation overvoltage protection (SPDs) provided where specified (534.4.1.1)
- Confirmation of indication that SPD is functional (651.4)
- Presence of RCD six-monthly test notice at or near the origin (514.12.2)
- Presence of diagrams, charts or schedules at or near each distribution board, where required (514.9.1)
- Presence of non-standard (mixed) cable colour warning notice at or near the appropriate distribution board, where required (514.14)
- Presence of alternative supply warning notice at or near (514.15)
  1. The origin
  2. The meter position, if remote from origin
  3. The distribution board to which the alternative/additional sources are connected
  4. All points of isolation of ALL sources of supply
- Presence of next inspection recommendation label (514.12.1)
- Presence of other required labelling (Section 514)
- Selection of protective device(s) and base(s); correct type and rating (411.3.2; 411.4, .5, .6; Sections 432, 433, 434)
- Single-pole protective devices in line conductors only (132.14.1, 530.3.2, 643.6)
- Protection against mechanical damage where cables enter equipment (522.8.1; 522.8.5 522.8.11)
- Protection against electromagnetic effects where cables enter ferromagnetic enclosures (521.5.1)
- Confirmation that ALL conductor connections, including connections to busbars, are correctly located in terminals and are tight and secure (526.1)

The use of individual components in a distribution board or consumer unit assembly complying with their respective product standard(s) does not indicate their compatibility when installed with other components in a low voltage switchgear and controlgear assembly.

Incorporated components inside the assembly can be from different manufacturers. It is essential that all incorporated components should have their compatibility for the final enclosed arrangements verified by the original manufacturer of the assembly and be assembled in accordance with their instructions, for example, the consumer unit, distribution board manufacturer. The original manufacturer is the organisation that carried out the original design and the associated verification of the low voltage switchgear and controlgear assembly to the relevant part of the BS EN 61439 series. If an assembly deviates from its original manufacturer's instructions, or includes components not included in the original verification, the person introducing the deviation becomes the original manufacturer with the corresponding obligations. The inspector may wish to note such assemblies for further investigation.

Consumer unit standards have also evolved over the years to provide coordinated "conditional ratings".

1. BS 5486-13: 1979 had a 6 kA, 10 kA, or 16 kA conditional rating as part of a British Standard. So need to check label or instructions for CM6, CM10 or CM16
2. BS 5486-13: 1989 had a 16 kA conditional rating as part of a British Standard. BS 5486-13 was withdrawn and replaced by BS EN 60439-3: 1991
3. BS EN 60439-3: 1991 had UK National deviation Annex ZA 16 kA conditional rating. BS EN 60439-3: 1991 was withdrawn and replaced by BS EN 60439-3: 2012
4. BS EN 61439-3: 2012 has UK National deviation Annex ZB 16 kA conditional rating.
5. BS EN 61439-3: 2012 (Incorporating corrigenda September 2013 and December 2015) is the only current version for new installations but the older equipment may still be in use in installations.

CIRCUITS

- Identification of conductors (514.3.1)
- Cables correctly supported throughout (522.8.5; 521.10.202)
- Examination of cables for signs of mechanical damage during installation (522.6.1; 522.8.1; 522.8.3)
- Examination of insulation of live parts, not damaged during erection (522.6.1; 522.8.1)
- Non-sheathed cables protected by enclosure in conduit, ducting or trunking (521.10.1)
- Suitability of containment systems (including flexible conduit) (Section 522)
- Correct temperature rating of cable insulation (522.1.1; Table 52.1)
- Adequacy of cables for current-carrying capacity with regard for the type and nature of installation (Section 523)
- Adequacy of protective devices: type and fault current rating for fault protection (434.5)
- Presence and adequacy of circuit protective conductors (411.3.1; 543.1)
- Coordination between conductors and overload protective devices (433.1; 533.2.1)
- Wiring systems and cable installation methods/practices with regard to the type and nature of installation and external influences (Section 522)
- Cables concealed under floors, above ceilings, in walls/partitions, adequately protected against damage (522.6.201, .202, .204)
- Provision of additional protection by RCDs having rated residual operating current ($I_{\Delta n}$) not exceeding 30 mA
  1. For circuits used to supply mobile equipment not exceeding 32 A rating for use outdoors (411.3.3)
  2. For all socket-outlets of rating 20 A or less, unless exempt (411.3.3)
  3. For cables concealed in walls at a depth of less than 50 mm (522.6.202, .203)
  4. For cables concealed in walls/partitions containing metal parts regardless of depth (522.6.202; .203)
  5. Circuits supplying luminaires within domestic (household) premises (411.3.4)
- Provision of fire barriers, sealing arrangements so as to minimize the spread of fire (Section 527)
- Band II cables segregated/separated from Band I cables (528.1)
- Cables segregated/separated from non-electrical services (528.3)

- Termination of cables at enclosures (Section 526)
  1 Connections under no undue strain (526.6; 522.8.5)
  2 No basic insulation of a conductor visible outside enclosure (526.8)
  3 Connections of live conductors adequately enclosed (526.5)
  4 Adequately connected at point of entry to enclosure (glands, bushes etc.) (522.8.5)
- Suitability of circuit accessories for external influences (512.2)
- Circuit accessories not damaged during erection (134.1.1)
- Single-pole devices for switching or protection in line conductors only (132.14.1, 530.3.2; 643.6)
- Adequacy of connections, including cpcs, within accessories and at fixed and stationary equipment (Section 526)

ISOLATION AND SWITCHING

- Isolators (537.2)
  1 Presence and location of appropriate devices (462; 537.2)
  2 Capable of being secured in the OFF position (537.2.4)
  3 Correct operation verified (functional check) (643.10)
  4 The installation, circuit or part thereof that will be isolated clearly identified by location and/or durable marking (537.2.7)
  5 Warning notice posted in situation where live parts cannot be isolated by the operation of a single device (537.1.2; 514.11.1)
- Switching off for mechanical maintenance (464; 537.3.2)
  1 Presence of appropriate devices (464.1; 537.3.2)
  2 Acceptable location – state if local or remote from equipment in question (537.3.3.6)
  3 Capable of being secured in the OFF position (464.2)
  4 Correct operation verified (functional check) (643.10)
  5 The circuit or part thereof to be disconnected clearly identified by location and/or durable marking (537.3.2.4)
- Emergency switching/stopping (465; 537.3.3; 537.4)
  1 Presence of appropriate devices (465.1; 537.3.3; 537.4)
  2 Readily accessible for operation where danger might occur (537.3.3.6)
  3 Correct operation verified (functional check) (643.10)
  4 The installation, circuit or part thereof to be disconnected clearly identified by location and/or durable marking (537.3.3.6)
- Functional switching (537.3.1; 463.1)
  1 Presence of appropriate devices (537.3.1.1; 537.3.1.2)
  2 Correct operation verified (functional check) (537.3.1.1; 537.3.1.2; 643.10)

CURRENT-USING EQUIPMENT (PERMANENTLY CONNECTED)

- Suitability of equipment in terms of IP and fire ratings (416.2; 421.1; 421.1.201; 526.5)
- Enclosure not damaged/deteriorated during installation so as to impair safety (134.1.1)
- Suitability for the environment and external influences (512.2)
- Security of fixing (134.1.1)
- Cable entry holes in ceilings above luminaires, sized or sealed so as to restrict the spread of fire (527.2)
- Provision of undervoltage protection, where specified (Section 445)
- Provision of overload protection, where specified (Section 433; 552.1)
- Recessed luminaires (downlighters)
  1 Correct type of lamps fitted (559.3.1)
  2 Installed to minimize build-up of heat (421.1.2; 559.4.1)
- Adequacy of working space/accessibility to equipment (132.12; 513.1)

PART 7 SPECIAL INSTALLATIONS OR LOCATIONS

Particular requirements for special locations are fulfilled.

3.10 Periodic testing

3.10.1 General

651.1 The periodic testing is supplementary to the inspection of the installation, see 3.8.1.

The same range and level of testing as for initial testing is not necessarily required, or indeed possible. Installations that have been previously tested and for which there are comprehensive records of test results may not need the same degree of testing as installations for which no such records exist.

651.5 Periodic testing may cause danger if the correct procedures are not applied. Persons carrying out periodic testing must be competent in the use of the instruments employed and have adequate knowledge and experience of the type of installation, see 3.8.1.

The inspector will need to set a sample size for testing. Notes on the principle of this are included in 3.8.4, which should be studied together with the guidance on suggested tests in Table 3.4.

Where a sample test indicates results significantly different from those previously recorded, further investigation is necessary. Also, if during the course of testing a sample, significant errors are found that suggest that the same problems might exist in untested items, the inspector should take appropriate action by either increasing the sampling or referring back to the client regarding the matter; it may be that the inspector recommends that 100 per cent testing is carried out in that area. This principle is mentioned earlier, in Figure 3.1.

3.10.2 Tests to be made

651.2 The tests considered appropriate by the person carrying out the inspection should be carried out in accordance with the recommendations in Table 3.4 and considering Sections 3.8.1 to 3.8.4 of this Guidance Note.

See Section 2.6 of this Guidance Note for test methods, noting that alternative methods may be used provided they give reliable results.

▼ **Table 3.4** Testing to be carried out where practicable on existing installations (see notes 1 and 2)

Test	Recommendations
Continuity of protective conductors	Accessible exposed-conductive-parts of current-using equipment and accessories (notes 4 and 5)
Continuity of bonding conductors	▶ Main protective bonding conductors to extraneous-conductive-parts ▶ Supplementary bonding conductors
Continuity of ring final circuit conductors	Where there are records of previous tests, this test may not be necessary unless there may have been changes made to the ring final circuit

Test	Recommendations
Polarity	At the following positions: ▶ origin of the installation ▶ distribution boards ▶ accessible socket-outlets ▶ extremity of radial circuits
Earth fault loop impedance	At the following positions: ▶ origin of the installation ▶ distribution boards ▶ accessible socket-outlets ▶ extremity of radial circuits
Insulation resistance	If tests are to be made: ▶ between live conductors (connected together, where applicable) and Earth at main and final distribution boards (note 6)
Earth electrode resistance	If tests are to be made: ▶ test each earth electrode or group of electrodes separately, with the test links removed, and with the installation isolated from the supply source
Functional tests RCDs	Tests as required by Regulation 643.1, followed by operation of the integral test button
Functional tests of circuit-breakers, isolators and switching devices	Manual operation to confirm that the devices disconnect the supply

Notes:

1 The person carrying out the testing should decide which of the above tests are appropriate by using their experience and knowledge of the installation being inspected and tested and by consulting any available records, see 3.8.4 of this Guidance Note.

2 Where sampling is applied, the percentage used is at the discretion of the inspector, see 3.8.4 of this Guidance Note (a percentage of less than 10 % is inadvisable).

3 The tests need not be carried out in the order shown in the table.

4 The earth fault loop impedance test may be used to confirm the continuity of protective conductors at socket-outlets and where it is safe to do so, at accessible exposed-conductive-parts of current-using equipment and accessories.

5 Generally, accessibility may be considered to be within 3 m from the floor or from where a person can stand.

6 Where the circuit includes surge protective devices (SPDs) or other electronic devices which require a connection to earth for functional purposes, these devices will require disconnecting to avoid influencing the test result and to avoid damaging them.

7 Where an installation is fully loaded and the conductors are at their normal operating temperatures measured loop impedance values can be directly compared to the maximum values of earth fault loop impedance set out in the Tables in Chapter 41 of the Regulations. Loop impedance data for unloaded conductors at 20 °C can be found in the IET *On-site Guide.*

3.10.3 Additional notes on periodic testing

This section provides some notes on the practicalities of carrying out the periodic tests, particularly within an installation where only partial isolation is practicable.

a Continuity of protective earthing and bonding conductors, and earth fault loop impedance testing

If an electrical installation is isolated from the supply, it is permissible to disconnect protective earthing and bonding conductors from the main earthing terminal in order to verify their continuity.

Where it is not practicable to isolate an electrical installation from the supply, the protective earthing or bonding conductors should not be disconnected as, under fault conditions, the exposed-conductive-parts and extraneous-conductive-parts could be raised to a dangerous voltage relative to Earth potential. Also, measurement of earth fault loop impedance at various parts of the installation is, for practical reasons, carried out with the protective earthing and bonding conductors connected.

A convenient way to carry out the above periodic tests in a large installation could be to use the wandering lead method to test continuity (see 2.6.5, test method 2) noting that the conductors were not disconnected for these tests, and to directly measure earth fault loop impedance at the same time. With the earthing and bonding conductors connected the tests confirm connection but not the continuity of the conductors involved.

Motor circuits

Loop impedance tests on motor circuits can only be carried out on the supply side of isolated motor controlgear. A continuity test between the circuit protective conductor and the motor is then necessary.

b Insulation resistance

Insulation resistance tests should be made on electrically isolated circuits with any electronic equipment which might be damaged by application of the test voltage disconnected, or only a measurement to protective earth made with the live conductors connected together.

For most installations the most practical test is an insulation resistance test between live conductors (connected together) and earth; in practice time does not usually allow for a line to neutral test.

Check that information/warnings are given at the distribution board of circuits or equipment likely to be damaged by testing. Any diagram, chart or table should also include this warning.

The results of insulation testing should be compared with previous results where possible. Table 2.2 of this Guidance Note (Table 64 of BS 7671) requires a minimum insulation resistance of 1 MΩ, but strictly speaking this value applies only to initial verification. It can, however, be used as a guide for periodic testing.

Where equipment is disconnected for these tests and the equipment has exposed-conductive-parts required by the Regulations to be connected to protective conductors, the insulation resistance between the exposed-conductive-parts and all live parts of the equipment should be measured separately and ought to comply with the requirements of the appropriate British Standard for the equipment.

There is a range of possible outcomes when carrying out insulation testing. Tests are typically made between all live conductors connected together and Earth at a test voltage of 500 V DC

The inspector will need to measure the values of insulation resistance for a given distribution board and then take a view based on his or her engineering judgement as to whether the results obtained are acceptable. It should be noted that distribution boards with large numbers of final circuits will generally give a lower insulation resistance value than distribution boards with fewer final circuits.

c Polarity

It should be established whether there have been any additions or alterations to the installation since its last inspection. If no additions or alterations have been made, the polarity test is a good example of where sampling can be applied.

For example, the following sampling could be used:

10 % of all single-pole and multi-pole control devices and of any centre-contact lampholders, together with 100 % of all readily-accessible socket-outlets. If any incorrect polarity is found then a full test should be made in that part of the installation supplied by the particular distribution board concerned, and the sample testing increased for the remainder of the installation (say to 25 %); if additional cases of incorrect polarity are found in the 25 % sample, a full test of the complete installation should be made, see Figure 3.1.

d Operation of overcurrent circuit-breakers

643.10 Where protection against overcurrent is provided by circuit-breakers, the manual operating mechanism of each circuit-breaker should be operated to verify that the device opens and closes satisfactorily.

It is not normally necessary or practicable to test the operation of the automatic tripping mechanism of circuit-breakers. As such, a test would need to be made at a current substantially exceeding the minimum tripping current in order to achieve operation within a reasonable time. For circuit-breakers to BS EN 60898 a test current of not less than two and a half times the rated tripping current of the device is needed for operation within one minute, and much larger test currents would be necessary to verify operation of the mechanism for instantaneous tripping.

For circuit-breakers of the sealed type, designed not to be maintained, if there is doubt about the integrity of the automatic mechanism it will normally be more practicable to replace the device than to make further tests. Such doubt may arise from visual inspection, if the device appears to have suffered damage or undue deterioration, or where there is evidence that the device may have failed to operate satisfactorily in service.

Circuit-breakers with the facility for injection testing may be so tested and, if appropriate, relay settings confirmed.

e Operation of devices for isolation and switching

Where means are provided in accordance with the requirements of the Regulations for isolation and switching, the devices should be operated to verify their effectiveness and checked to ensure adequate and correct labelling.

It should be verified by inspection that easy access to such devices is maintained and that effective operation is not be impaired by any material placed near the device. Access and operation areas may be required to be marked to ensure they are kept clear.

For isolating devices in which the position of the contacts or other means of isolation is externally visible, visual inspection of operation is sufficient and no testing is required.

The operation of every safety switching device should be checked by operating the device in the manner normally intended to confirm that it performs its function correctly in accordance with the requirements of BS 7671.

Where it is a requirement that the device interrupts all the supply conductors, the use of a proprietary test lamp, or two-pole voltage detector connected between each line and the neutral on the load side of the switching device is essential to confirm isolation. Reliance should not be placed on a simple observation that the equipment controlled has ceased to operate.

Where switching devices are provided with detachable or lockable handles in accordance with the Regulations, a check should be made to verify that the handles or keys are not interchangeable with any others available within the premises.

643.10 Where any form of interlocking is provided, such as between a main circuit-breaker and an outgoing switch or isolation device, the integrity of the interlocking must be verified; this may be beyond the scope of the inspector and something that is referred to a manufacturer or specialist.

Where switching devices are provided for isolation or for mechanical maintenance switching, the integrity of the means provided to prevent any equipment from being unintentionally or inadvertently energised or reactivated must be verified.

f Operation of RCDs

643.7 ***Fault protection***

Where an RCD is provided for Fault Protection the operating time should generally be no greater than those stated in Table 41.1 (Regulation 411.4.5) for final circuits and 5 seconds for distribution circuits. Unless supplementary bonding has been applied in accordance with Regulation 419.3.

Additional protection

643.8 Where an RCD with a rated residual operating current not exceeding 30 mA is 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 effectiveness is deemed to have been verified where an RCD meeting the requirements of Regulation 415.1.1 disconnects within 40 ms when tested at a current equal to or higher than five times its rated residual operating current ($5\ I\Delta n$) The maximum test time should not exceed 40 ms, unless the protective conductor potential rises by less than 50 V – the instrument manufacturer will advise on compliance.

3.11 Electrical Installation Condition Report

653.1 A model of the report, entitled 'Electrical Installation Condition Report', is provided in Appendix 6 of BS 7671 together with some model Schedules of Inspections and

Schedules of Test results. Typical completed forms are given in Chapter 5 of this Guidance Note.

The full Electrical Installation Condition Report documentation comprises the following:

Electrical Installation Condition Report

and

Schedule of inspections (one or more)

and

Schedule of test results (one or more)

On completion of periodic inspection and testing, the Electrical Installation Condition Report and its accompanying schedules of inspections and schedules of test results must be given to the client or person who ordered the inspection.

653.2
Part 2
A most important point to remember is that any damage, deterioration, defects, dangerous conditions and non-compliance with BS 7671 that may give rise to danger (*danger* being a risk or injury to persons or livestock) must be recorded on the report.

There are classification codes C1 to C3 for danger and non-compliances with BS 7671, these being explained in Table 3.5.

Each separate item entered in the Section K Observations section of the Report should be coded C1, C2 or C3 as appropriate, or, exceptionally, FI. Only one classification code is to be recorded against each observation.

Where an installation defect or non-compliance with the Regulations has attracted a Code C1, C2 or FI the overall assessment of the report must be "unsatisfactory".

Table 3.5 Classification of danger and non-compliances (for use during periodic inspection and testing)

Classification of danger or non-compliance	Description	Notes and guidance
C1	Danger present. Risk of injury. Immediate remedial action required	To be attributed for matters that cannot be left. It is suggested that these are rectified or possibly, isolation may be recommended or necessary. Examples include accessible bare live parts, badly damaged equipment with risk of access to live parts, incorrect polarity, and/or arcing or burning found in switchgear.
C2	Potentially dangerous – urgent remedial action required	To be attributed for issues that, whilst urgent, do not require immediate remedial action. Examples include a non-earthed installation (this requires a further fault to result in danger), fundamentally undersized cables, earth fault loop impedance values greater than required by BS 7671, a 'borrowed' neutral, equipment with inappropriately selected IP (this may warrant C1 if severe), insulation readings under 1 MΩ, connections not housed within appropriate enclosures.
C3	Improvement required	To be attributed where C1 or C2 do not apply. Examples include the absence of most warning notices, absence of the required diagrams and charts, no or incorrect marking of conductors at terminations, absence of an RCD specified for additional protection (where the circuit otherwise tests as normal).
FI	Further investigation required without delay	To be attributed where the inspection has revealed an apparent deficiency that could not, due to the limitations or extent of the inspection, be fully identified and further investigation may reveal a Code C1 or C2 item. An example could be where characteristics of electricity supply (such as voltage or external earth fault loop impedance) do not conform to supply industry norms.

3.12 Periodic inspection of installations constructed to an earlier edition of BS 7671 or the IEE Wiring Regulations

People often ask what standard should be applied when carrying out the periodic inspection of an installation constructed in accordance with an earlier edition of BS 7671, or an even earlier edition of the IEE Wiring Regulations or to an unknown standard. Each edition of the Wiring Regulations has provided for an increase of safety to the users of installations. Particular installation practices and methods that were compliant with earlier editions would be considered to be unacceptable now, such as the use of a public water pipe as a means of earthing, which would be considered as potentially dangerous now.

In all cases the inspection should be carried out against the current edition of BS 7671. It is likely that there will be items that do not comply with that edition but this does not necessarily mean that the installation is unsafe. If the inspector considers that an item, although not warranting Code C1 or C2, requires improvement, it should be given code C3 on the Electrical Installation Condition Report. If the item does not require improvement it does not need to be recorded as an observation.

Reference is made to existing installations both in the second paragraph of the Introduction to BS 7671:2018 and in the Note by the Health and Safety Executive which follows the Preface to BS 7671:2018.

Test instruments and equipment 4

4.1 Instrument standard

BS EN 61010 *Safety requirements for electrical equipment for measurement, control, and laboratory use* is the basic safety standard for electrical test instruments.

The basic instrument standard is BS EN 61557 *Electrical safety in low voltage distribution systems up to 1000 V a.c. and 1500 V d.c. Equipment for testing, measuring or monitoring of protective measures.* This standard includes performance requirements and requires compliance with BS EN 61010.

In Section 1.1 of this Guidance Note, reference was made to the use of test leads conforming to HSE Guidance Note GS 38. The HSE always advise only to carry out live tests that are actually useful and informative so as to minimise danger, so always consider whether any particular live test is necessary before undertaking it. The safety measures and procedures set out in GS 38 should be observed for all instruments, leads, probes and accessories. It should be noted that some test instrument manufacturers advise that their instruments be used in conjunction with fused test leads and probes. Other manufacturers advise the use of non-fused leads and probes when the instrument has in-built electrical protection, but it should be noted that such electrical protection does not extend to the probes and leads.

BS 7671 Appendix 14 also recommends that "the measurement should always be made on the output terminals of a suitably rated protective device. If such a device is not present then a temporary one should be fitted. Measurement should never be made where overcurrent protection is not present between the point of connection and the transformer. Fused test leads alone do not meet this requirement". When unsure a risk assessment should be carried out to establish if fused test leads should be used.

4.2 Instrument accuracy

The accuracy of a new or repaired instrument should be established to provide a point of reference. Accuracy is usually confirmed by calibration, but a calibration certificate may not be supplied with the instrument unless specifically requested. A certificate of conformity may be provided. This indicates that the instrument's accuracy was verified as part of the manufacturing process. Such verification follows the same procedure as calibration, but individual calibration data is not issued.

A basic measurement accuracy of 5 % is usually adequate. In the case of analogue instruments, a basic accuracy of 2 % of full-scale deflection will provide the required accuracy measurement over a useful proportion of the scale.

It should not be assumed that the accuracy of the reading taken in normal field use will be as good as the basic accuracy. The 'operating accuracy' is always worse than the basic accuracy, and additional errors derive from three sources:

(a) *Instrument errors*: basic instrument accuracy applies only in ideal conditions; and the actual reading accuracy can also be affected by:

(i) Digital instruments
Sources of error: test leads, fused leads, battery condition, ambient temperature, electrical noise etc.

(ii) Analogue instruments

Orientation of the instrument on older instruments hand cranked units, cranking speed can also affect performance.

(b) *Loss of calibration*: instruments should be periodically calibrated following manufacturer's recommendations and procedures traceable to National Standards. Intermediate checks can be made to ensure there are no major errors in measurement by comparing readings to those obtained from other instruments, or by the use of a proprietary 'check box' having clearly defined characteristics.

In all cases the type and frequency of recalibration or checking required should be as specified by the instrument manufacturer. However, the user should take into account ambient environmental and usage factors as appropriate. For example, if an instrument is left in storage at a constant temperature in a dry environment for long periods and/or is used infrequently, the user may be able to extend the recalibration interval. However, if an instrument is roughly handled and is regularly transported and stored in vehicles, and hence is subjected to fluctuations in temperature and humidity caused by changes in time of day/night and time of year, then more frequent confirmation of accuracy would be appropriate.
Instruments should also be subjected to regular checks before use so that errors caused by deterioration of leads, probes, connectors etc. do not result in inaccurate readings being recorded when, for example, schedules of test results are compiled.

It is essential that an instrument is inspected for damage and the safety and the accuracy of an instrument is confirmed after any incidences of mechanical or electrical mishandling.

(c) *Field errors*: the instrument reading accuracy will also be affected by external influences as a result of working in the field environment. These influences can take many forms, and some sources of inaccuracy are described in the appropriate sections.

BS EN 61557 requires a maximum operating error of no more than ±30 % of reading over the stated measurement range, taking into account worst case environmental, supply and battery conditions.

To achieve satisfactory in-service performance, it is essential to be fully informed about the test equipment, how it is to be used, and the accuracy to be expected.

Typically, in analogue instruments this corresponds to making measurements very near to the zero point on the scale, where inaccuracies and non-repeatability are not at all evident with this type of electromechanical movement.

Traceability to National Standards can be assured by using a calibration laboratory accredited by a National Accreditation Body. In the UK this is the United Kingdom Accreditation Service (UKAS). A list of accredited laboratories can be found at www.ukas.com or a search for sources of calibration by instrument can be made at www.ukas.org/calibration

4.3 Low-resistance ohmmeters

643.2.1 The continuity of conductors and connections to exposed-conductive-parts and extraneous-conductive parts, if any, shall be verified by a measurement of resistance on:

(a) protective conductors, including protective bonding conductors; and
(b) in the case of ring final circuits, live conductors.

The instrument used for low-resistance tests may be either a specialised low-resistance ohmmeter or the continuity range of an insulation and continuity tester. The test current may be DC or AC It is recommended that it be derived from a source with no-load voltage between 4 V and 24 V, and a short-circuit current of not less than 200 mA.

The measuring range should cover the span 0.2 Ω to 2 Ω, with a resolution of at least 0.01 Ω for digital instruments.

Instruments conforming to BS EN 61557-4 will meet the above requirements.

Field effects contributing to in-service errors include probe or crock-clip contact resistance, test lead resistance, AC interference and thermocouple effects in mixed metal systems.

Whilst contact resistance cannot be eliminated with two-terminal testers, and can introduce errors, the effects of lead resistance can be eliminated by measuring this prior to a test, and subtracting the resistance from the final value or using the test instrument's 'nulling' feature built-in to most modern instruments. Interference from an external AC source (interference pick-up) cannot be eliminated, although it may be indicated by vibration of the pointer of an analogue instrument or unstable digital readout. Thermocouple effects can be eliminated by reversing the test probes and averaging the resistance readings taken in each direction.

4.4 Insulation resistance testers

The instrument used should be capable of developing the test voltage required across the load.

The test voltage required is:

Table 64 **(a)** 250 V DC for SELV and PELV circuits with equipment such as SPDs that may influence test results or be damaged – but the insulation resistance is to be at least 1 MΩ (643.3.2);
(b) 500 V DC for all circuits rated up to and including 500 V except SELV and PELV circuits; and

(c) 1000 V DC for circuits rated above 500 V up to 1000 V.

Instruments conforming to BS EN 61557-2 will fulfil all the above instrument requirements.

When the current is applied by an insulation resistance test what we see as total current comprises of three parts. When an insulation resistance test is applied to a test subject, the measurement may be influenced by different circuit characteristics, for example:

(a) capacitive charging;
(b) absorption or polarisation of the insulation; and
(c) conduction or leakage currents.

These factors can be reduced or eliminated by extending the test time for which the test voltage is applied, and can be seen as a steady insulation reading on the instrument, after an initial rapid increase in value.

Capacitance may be as high as 5 μF, and the instrument should have an automatic discharge facility capable of safely discharging such a capacitance. Following an insulation resistance test, the instrument should be left connected until the capacitance within the installation has been fully discharged.

4.5 Earth fault loop impedance testers

Loop impedance testing is the practice of measuring the impedance of a live circuit. Typically the circuit voltage, either Line-Neutral, Line-Earth or Line-Line, is first measured to acquire the off-load voltage. A load is then applied and the new circuit voltage is measured. The volt drop is used to calculate the impedance of the circuit. Exactly how this is done differs between manufactures. However all methods can be presented with electrical conditions that present a challenge to the measurement. Sources of error can include:

(a) electrical noise and transients;
(b) external load switching;
(c) harmonics;
(d) RCD uplift;
(e) test lead contact resistance;
(f) proximity to the source transformer; and
(g) instrument resolution.

Three types of measurement are typically available, listed in order of preference:

(a) two-wire high current test;
(b) three-wire non-trip test; and
(c) two-wire non-trip test.

Two-wire high current test:

This is the test that should always be employed unless there is an RCD or RCBO in the circuit. The load used usually generates between 2 A and 15 A. This is sufficient to create a measurable voltage drop and consequently a stable and accurate result. The test usually lasts for no more than 3-4 seconds in total, with the load being present for no more than 40ms on two consecutive half cycles.

Test currents higher than 15 A risk tripping some low current MCBs.

Three-wire non-trip test:

Where there are RCDs or RCBOs present, the Line-Earth fault loop impedance may be carried out using a non-trip loop impedance test. The load current is significantly small enough not to trip the RCD. Typically this is around 15 mA. However 15 mA does not create a significant volt drop. Consequently many more test cycles are performed, the test runs for significantly longer, and the results are far more susceptible to variation.

Two wire non-trip test:

The third option on some instruments is a two wire non-trip test. This has the advantage of not requiring the third test lead to be connected, and is especially useful on some lighting circuits.

The drawback is that it is the most technically difficult test for the instrument and can be susceptible to more errors than the three wire test, and should only be used as a last resort.

Safety

To minimise electric shock hazard from the potential of the protective conductor during Line-Earth impedance tests, the test duration should be within safe limits. For two-wire high current tests, the instrument should cut off the test current after 40 ms or a time determined by the safety limits derived from the information contained within DD IEC/TS 60479-1 *Effects of current on human beings and livestock. General aspects*, if the voltage rise of the protective conductor exceeds 50 V during the test. On some installations this threshold may be 25 V, especially where livestock are present.

For low current (non-trip) tests the instrument must monitor the earth voltage and disconnect the test should the earth voltage be exceed.

Sources of error

The lower the load current employed in the test, the more variation and error is likely in the result as the volt drop is proportionally lower. Distortion or noise on the supply will also compromise accuracy and repeatability, as the instrument cannot easily differentiate between a volt drop created by the applied load or a voltage change induced by noise or harmonics etc. For this reason the test with the higher load currents should always be used where possible.

Repeating a test is advised if there is concern for the validity of the result, especially on noisy supplies.

RCD uplift

This is a phenomenon frequently encountered when performing a two or three wire Non-trip test. During the test the RCD internal impedance may sometimes be measured, increasing the overall circuit impedance. This may be as high as 0.5 Ω or more.

RCD uplift can be avoided by choosing an instrument that declares immunity to this effect. Alternatively, if uplift is suspected, measuring on the source and load sides of the RCD will identify any additional impedance within the RCD. This can then be deleted from the measurement.

This phenomenon is not encountered with high test currents, but these tests will trip the RCD during the test, preventing their use.

Transformer impedances can also affect results, as the impedance close to source can be very reactive rather than resistive. This is only a real issue when measuring close to the source transformer, but the instrument resolution and accuracy becomes very significant in this location.

Test lead errors

Test leads can induce errors from:

(a) internal lead resistance;
(b) contact resistance of the probes or clips; and
(c) internal fusing of the test leads.

As with the low resistance ohmmeter section earlier, the test lead resistance can be 'nulled' or may already be accounted for in the instrument. If not, the lead resistance should be measured and deducted from future measurement values.

Contact resistance can add significantly to the circuit impedance – ensure probes are sharp and clips grip tightly.

Fused leads can add significantly to lead resistance. A 500 mA fuse can add as much as 1.8 Ω in a test lead pair. If fused leads are used for loop impedance testing they will be need to be fused with higher rating fuses, typically 7 A or 10 A fuses, to prevent the test current rupturing the fuse.

Leads compliant to the HSE document GS38 should be adequate.

Instrument accuracy

Instrument resolution can compromise measurement accuracy, especially at the lower loop impedances found near the source transformer. When measuring loop impedances below 0.1 Ω, caution should be exercised in the interpretation of the results, as the instrument accuracy significantly affects measurement values close to the lowest end of the range.

For example: When attempting to measure a loop impedance of 0.03 Ω, an instrument that declares a ±5 % ±3 digits on a digital display could give an answer between zero and 0.06 Ω and be within its declared accuracy.

Instruments conforming to BS EN 61557-3 will fulfil the above requirements under most situations.

These instruments may also offer additional facilities for deriving prospective fault current. The basic measuring principle is the same as for earth fault loop impedance testers. The current is calculated by dividing the loop impedance value into the nominal mains voltage. Instrument accuracy is determined by the same factors as for Earth Fault Loop Impedance testers. In this case, instrument accuracy decreases as scale reading increases, because the loop value is divided into the mains voltage. It is important to note these aspects, and the manufacturer's documentation should be consulted.

4.6 Earth electrode resistance testers

There are three general methods referred to in Chapter 2:

(a) method E1, using a dedicated earth electrode tester (fall of potential, three- or four-terminal type);
(b) method E2, using a dedicated earth electrode tester (stakeless or probe type); and
(c) method E3, using an earth fault loop impedance tester.

The most accurate of these is method E1.

As mentioned in Chapter 2, method E2, the stakeless or probe tester, cannot be used to measure the resistance of a single earth electrode.

4.7 RCD testers

The trip times of RCDs are required to be verified, to ensure adequate disconnection under fault conditions.

RCDs are tested by applying a test load to the RCD, inducing a calibrated test current to flow in the Line-Earth circuit. This creates an imbalance in the Line-Neutral currents in the RCD and the device trips. The time it takes to trip is then displayed.

The test instrument should be capable of applying the full range of test current to an in-service accuracy as given in BS EN 61557-6. This in-service reading accuracy will include the effects of voltage variations around the nominal voltage of the tester.

The range of RCD operating currents supported is generally limited to between 10 mA and 1 A – exceeding these limits presents severe design and cost implications to the instrument design.

As with loop impedance testing, the Earth voltage is monitored and prevented from exceeding the touch voltage limit, either 50 V or 25 V, depending on the requirements of the location.

RCDs are usually tested to ensure:

(a) they do not trip with fault currents less than 50 % of their operation rating;
(b) they trip in the required time at fault current of 100 % of their operational rating; and
(c) they trip in the required time at fault current of 500 % of their operational rating.

In addition to trip time testing, instruments offer the ability to test the RCD's tripping current threshold. For this test, a RAMP current is applied from less than 50 % of the RCD rating to 110 %. The current at which the RCD trips is then displayed – this identifies if the RCD is overly sensitive and may cause nuisance tripping.

Instruments conforming to BS EN 61557-6 will fulfil the above requirements.

4.8 Phase rotation instruments

BS EN 61557-7 gives the requirements for measuring equipment for testing the phase sequence in three-phase distribution systems whether indication is given by mechanical, visual and/or audible means.

BS EN 61557-7 includes requirements that:

(a) indication shall be unambiguous between 85 % and 110 % of the nominal system voltage or within the range of the nominal voltage and between 95 % and 105 % of the nominal system frequency;
(b) the measuring equipment should be suitable for continuous operation;
(c) the measuring equipment should be so designed that when either one or two measuring leads are connected to earth and the remaining measuring lead(s) remain connected to their corresponding line conductors, the resulting total current to earth should not exceed 3.5 mA rms;
(d) the measuring equipment should not be damaged nor should the user be exposed to danger in situations where the measuring equipment is connected to 120 % of the rated system voltage or to 120 % of its rated maximum voltage range; and
(e) portable measuring equipment should be provided with permanently attached leads or with a plug device with live parts not accessible, whether plugged or unplugged.

4.9 Thermographic equipment

Although thermographic surveying is not recognised by BS 7671 as a test instrument, such equipment can be invaluable in assisting electrical inspections especially in the early identification of possible points of overheating in circuits. Therefore some notes are included here on this type of equipment. It must, however, be remembered equipment must be operating and "thermally transparent" for a thermographic survey to be able to see temperature changes.

Important note: It is recommended that persons refer to the requirements of the Electricity at Work Regulations 1989 and the HSE's guidance published in *The Electricity at Work Regulations 1989* (HSR25), prior to undertaking any work activity which places themselves or those under their control in close proximity to live parts.

It is relatively easy to make arrangements to disconnect small installations such as at domestic premises from the supply to facilitate periodic inspection and testing.

However, as the size and complexity of an installation increases, isolation from the supply becomes increasingly difficult. This is particularly true where continuity of supply has health implications, as may be the case in hospitals and similar premises, or financial implications as would be the case in banks, share-dealing and commodities markets and the like. Nevertheless, it remains necessary to confirm the continuing suitability of such installations for use. Therefore they must still be subjected to planned and preventive maintenance or regular periodic assessment of their condition.

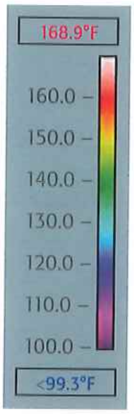
It may well be possible to carry out a thorough visual inspection of such installations without subjecting the inspector or others in the building to any danger, and such an inspection may identify many common defects caused by use/abuse. Furthermore, experience of such installations may provide a valuable insight into commonly occurring cases of wear and tear.

Some defects though cannot be discovered by visual inspection alone. For example, incorrectly tightened connections can result in a high resistance joint which can then cause a high temperature to occur locally to the connection. If left uncorrected over time further deterioration of the connection may well occur, leading to a continuing increase in temperature which may subsequently present a risk of fire. This fire risk will be significantly increased in installations where a build-up of dust or other flammable materials can occur in close proximity to the source of heat. It should also be remembered that increased heat at terminations can result in accelerated deterioration of the insulation locally. Heating effects symptomatic of a fault or other problem within an electrical installation can also occur as a result of cyclical-load operations, use of conductors of inadequate current-carrying capacity, incorrect load balancing and more mechanically related issues such as incorrect alignment of motor drive couplings and overtightened belt-drives.

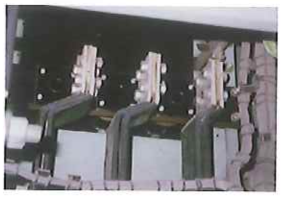
A number of manufacturers offer infrared imaging equipment which can be used to identify such 'hot spots'. Infrared thermography works on the principle that all materials emit electromagnetic radiation in the infrared region which can be detected by a thermal imaging camera.

The amount of radiated energy detected can be presented in a readily usable form, typically being shown as differences in colour that vary with the temperature being detected. Figure 4.1 shows a colour/temperature correlation indicator such as those that may accompany images. Such scales will aid the person ordering the inspection or responsible for maintenance activities in their interpretation of the thermal images.

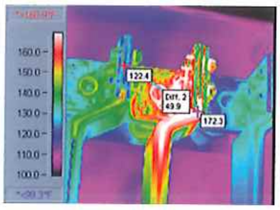
▼ **Figure 4.1** A colour/temperature correlation indicator



▼ **Figure 4.2** Bolted connections at a busbar as seen by the eye



▼ **Figure 4.3** Bolted connections at a busbar viewed using thermal imaging



▼ **Figure 4.4** Thermal image of contactor showing termination on right is too hot

▼ **Figure 4.5** Thermal image of contactor after loose termination has been tightened

In terms of visual inspection, the busbar connections in Figure 4.2 appear to be satisfactory.

However, if the same connections are viewed using a thermal imaging camera (Figure 4.3), it is evident that the connections to the centre are running significantly hotter than those to either side.

This higher temperature may indicate a loose connection or connections, but in this case is probably due to the centre bar carrying a significantly higher current than those to each side of it. As such, the person carrying out the inspection could suggest their client looks into improving the load balancing of this part of the installation.

In a further example, Figure 4.4 shows a contactor and the thermal image has highlighted a potential loose termination. After this was tightened Figure 4.5 shows the result, with all three terminations now operating at a much more uniform temperature.

Whilst the remedial work was being carried out it would be sensible to inspect the insulation of the conductors in the terminations to confirm that the insulation remained effective and had not suffered significant damage.

The requirements of the *Electricity at Work Regulations 1989* must be taken into account when considering the use of thermographic surveying equipment as its use may necessitate the temporary removal or bypassing of measures that provide basic protection (as defined in BS 7671), such as opening doors to electrical panels and/or the removal of barriers and covers. The requirements of Regulation 14 (Work on or near live conductors), which is reproduced as follows, are particularly pertinent:

No person shall be engaged in any work activity on or so near any live conductor (other than one suitably covered with insulating material so as to prevent danger) that danger may arise unless –

(a) it is unreasonable in all the circumstances for it to be dead; and
(b) it is reasonable in all the circumstances for him to be at work on or near it while it is live; and
(c) suitable precautions (including where necessary the provision of suitable protective equipment) are taken to prevent injury.

The HSE's guidance on the *Electricity at Work Regulations 1989*(HSR25) recognises that it may be necessary, in some circumstances, for conductors to remain live during testing or diagnostic work. However, such work in close proximity to live conductors may only be carried out if it can be done safely and if all precautions required to allow it to be done so are put in place. Additionally, the work may only be performed by persons who are suitably competent with regard to the type and nature of the work activity being performed, as required by Regulation 16 (Persons to be competent to prevent danger or injury). HSR25 also makes clear that although live testing may be justifiable it does not follow that there will necessarily be justification for subsequent repair work to be carried out live.

Persons carrying out thermographic surveying should:

(a) have sufficient competence to prevent danger and injury;
(b) understand the system being worked on, the hazards that may arise as a result of the work and the precautions that are required to prevent danger;
(c) be able to identify those parts of equipment being inspected which are, or are capable of being, live when the supply to the equipment is switched on;
(d) implement all precautions required to prevent injury that have been identified as part of the risk assessment for the work;
(e) maintain the maximum possible distance from the live or potentially live parts described above at all times;
(f) maintain effective control of the area in which the equipment being inspected is situated; and
(g) ensure that all protective measures which may have been affected by their actions when carrying out the inspection work are fully reinstated. All guards and barriers must be replaced and panel doors, lids and covers must be closed and secured properly after the inspection is completed.

As previously mentioned, thermographic inspection can be an effective method of identifying potential defects that may not be identified by a more conventional visual inspection. However, such thermal surveying should not be seen as a substitute for periodic inspection and testing, but rather as an additional tool that can be used by the inspector. Thermographic surveys can be a highly effective means of targeting preventive maintenance to where it is most required. Defects identified may be factored into the planned maintenance programme for the installation, or where necessary may justify the remedial work being performed without delay.

Forms 5

This chapter provides guidance on completing the necessary schedules, certificates and reports associated with inspection and testing. Sample certificates and report, completed with typical entries, are provided together with sample test result schedules and sample inspection schedules, again completed with typical results.

The chapter also contains some notes on completion of the forms, although helpful information on this will also be gained by reading earlier chapters of this Guidance Note.

5.1 Initial verification (inspection and testing) forms

Following the initial verification of a new installation or of an addition or alteration to an existing installation, an Electrical Installation Certificate is required to be completed and issued together with inspection schedule(s) and test result schedule(s).

- Form 1 – Electrical Installation Certificate, EIC (three signatory version from Appendix 6 of BS 7671)

When an Electrical Installation Certificate is used, appropriate numbers of the following forms are required to accompany the Certificate:

- Form 2 – Schedule of Inspections for domestic and similar premises with up to 100 A supply or a more extensive schedule where necessary - (see below), and
- Form 3 – Generic Schedule of Test Results.

642.3 Form 2 is not suitable for inspection of installations rated at more than 100 A or that are more complex. For such installations the inspector will probably need to formulate their own inspection schedules. These should be based on the requirements of Regulation 642.3 and the list of examples of items requiring inspection during initial verification, given in Appendix 6 of BS 7671.

For completeness, two samples of typical completed Form 3s (schedule of test results) are included, one being for a single-phase installation and the other for a three-phase installation.

5.2 Minor works

The complete set of forms for initial verification (inspection and testing) may not be appropriate for minor works. When an addition to an electrical installation does not extend to the installation of a new circuit, the Minor Electrical Installation Works Certificate may be used. This one page certificate is intended for such work as the addition of a socket-outlet or lighting point to an existing circuit, or for a repair or modification to each circuit worked on Consequently, where three circuits are worked on, for example, three Minor Electrical Installation Work Certificates would have to be issued; or all of the work could be detailed on an Electrical Installation Certificate.

A Minor Electrical Installation Works Certificate must not be used for the replacement of a consumer unit.

The Minor Electrical Installation Works Certificate (Form 4) is included and is taken from Appendix 6 of BS 7671. Notes on completion and guidance for recipients are provided with the form.

5.3 Periodic inspection and testing

The inspection and testing of an existing electrical installation is reported on using an Electrical Installation Condition Report (EICR), see Form 5. And, just like with an EIC, this document is issued with the appropriate number of Generic Schedule(s) of Test Results (Form 3).

For periodic inspections the Schedule of Inspections for initial verification, i.e. Form 2, should not be used but the dedicated model suggested in BS 7671 as shown in Form 6, may be used for inspections of domestic installations and installations up to 100 A. For larger and more complex installations the inspector will need to formulate his/her own inspection schedules. These should be based on the requirements of Regulation 642.3 and the list of examples of items requiring inspection for an Electrical Installation Condition Reports, given in Appendix 6 of BS 7671.

5.4 Model forms for certification and reporting

ELECTRICAL INSTALLATION CERTIFICATE
(REQUIREMENTS FOR ELECTRICAL INSTALLATIONS - BS 7671 [IET WIRING REGULATIONS])

Form 1 No. 555513 /2,

DETAILS OF THE CLIENT
Mr D Roberts
23 Acacia Avenue, SOMETOWN Postcode: SL0 0LT

INSTALLATION ADDRESS
Unit 3, The Quadrant
Sometown Business Park
SOMETOWN Postcode: SL1 0ZZ

DESCRIPTION AND EXTENT OF THE INSTALLATION
Description of installation: Complete electrical installation to new 2 floor office building

New installation ☑

Extent of installation covered by this Certificate:
Complete electrical installation, comprising main switchboard, sub-main and distribution boards. To include all power and lighting circuits but excluding car-park lighting - which is supplied from adjacent building.

Addition to an existing installation ☐

Alteration to an existing installation ☐

(Use continuation sheet if necessary) see continuation sheet No: ....

FOR DESIGN
I/We being the person(s) responsible for the design of the electrical installation (as indicated by my/our signatures below), particulars of which are described above, having exercised reasonable skill and care when carrying out the design and additionally where this certificate applies to an addition or alteration, the safety of the existing installation is not impaired, hereby CERTIFY that the design work for which I/we have been responsible is to the best of my/our knowledge and belief in accordance with BS 7671:2018, amended to 2018 (date) except for the departures, if any, detailed as follows:

Details of departures from BS 7671 (Regulations 120.3, 133.1.3 and 133.5): None

Details of permitted exceptions (Regulation 411.3.3). Where applicable, a suitable risk assessment(s) must be attached to this Certificate.
None

Risk assessment attached ☐

The extent of liability of the signatory or signatories is limited to the work described above as the subject of this Certificate.

For the DESIGN of the installation: **(Where there is mutual responsibility for the design)

Signature: D Jones Date: 20-Jul-2018 Name (IN BLOCK LETTERS): D. JONES Designer No 1

Signature: N/A Date: .... Name (IN BLOCK LETTERS): .... Designer No 2**

FOR CONSTRUCTION
I being the person responsible for the construction of the electrical installation (as indicated by my signature below), particulars of which are described above, having exercised reasonable skill and care when carrying out the construction hereby CERTIFY that the construction work for which I have been responsible is to the best of my knowledge and belief in accordance with BS 7671:2018, amended to 2018 (date) except for the departures, if any, detailed as follows:

Details of departures from BS 7671 (Regulations 120.3 and 133.5): None

The extent of liability of the signatory is limited to the work described above as the subject of this Certificate.

For CONSTRUCTION of the installation:

Signature: T Smith Date: 20/07/2018 Name (IN BLOCK LETTERS): T. SMITH Constructor

FOR INSPECTION & TESTING
I being the person responsible for the inspection & testing of the electrical installation (as indicated by my signature below), particulars of which are described above, having exercised reasonable skill and care when carrying out the inspection & testing hereby CERTIFY that the work for which I have been responsible is to the best of my knowledge and belief in accordance with BS 7671:2018, amended to 2018 (date) except for the departures, if any, detailed as follows:

Details of departures from BS 7671 (Regulations 120.3 and 133.5): None

The extent of liability of the signatory is limited to the work described above as the subject of this Certificate.

For INSPECTION AND TESTING of the installation:

Signature: G Wilson Date: 20/07/2018 Name (IN BLOCK LETTERS): G. WILSON Inspector

NEXT INSPECTION
I/We the designer(s), recommend that this installation is further inspected and tested after an interval of not more than 5 years/~~months.~~

Page 1 of 5

Form 1 No. 555513 /2

PARTICULARS OF SIGNATORIES TO THE ELECTRICAL INSTALLATION CERTIFICATE

Designer (No 1)
Name: D Jones Company: The Electrical Design Partnership
Address: 23 High Street
SOMETOWN Postcode: SL10 OYY Tel No: 01000 999999

Designer (No 2) (if applicable)
Name: .... Company: ....
Address: ....
.... Postcode: .... Tel No: ....

Constructor
Name: T Smith Company: County Electrics
Address: Unit 8a, Sometown Industrial Estate
SOMETOWN Postcode: SL3 OXX Tel No: 01000 888888

Inspector
Name: G Wilson Company: County Electrics
Address: 11, Crabtree Row
SOMETOWN Postcode: SL2 OWW Tel No: 01000 777777

SUPPLY CHARACTERISTICS AND EARTHING ARRANGEMENTS

Earthing arrangements	Number and Type of Live Conductors		Nature of Supply Parameters	Supply Protective Device
TN-C ☐	AC ☑	DC ☐	Nominal voltage, U / U_0 (1) 400/230 V	BS (EN) 1361
TN-S ☐	1-phase, 2-wire ☐	2-wire ☐	Nominal frequency, f (1) 50 Hz	Type type II
TN-C-S ☑	2 phase, 3-wire ☐	3-wire ☐	Prospective fault current, I_{pf} (2) 1.5 kA	Rated current 100 A
TT ☐	3 phase, 3-wire ☐	Other ☐	External loop impedance, Z_e (2) 0.30 Ω	
IT ☐	3 phase, 4-wire ☑		*(Note: (1) by enquiry (2) by enquiry or by measurement)*	
	Confirmation of supply polarity ☐			

Other sources of supply (as detailed on attached schedule) ☐

PARTICULARS OF INSTALLATION REFERRED TO IN THE CERTIFICATE

Means of Earthing
Distributor's facility ☑
Installation earth electrode ☐

Maximum Demand
Maximum demand (load) 50 ~~kVA~~ / Amps (Delete as appropriate)

Details of Installation Earth Electrode *(where applicable)*
Type (e.g. rod(s), tape etc) N/A
Location N/A
Electrode resistance to Earth N/A Ω

Main Protective Conductors

Earthing conductor	Material Copper	csa 16 mm²	Connection / continuity verified ☑
Main protective bonding conductors (to extraneous-conductive-parts)	Material Copper	csa 16 mm²	Connection / continuity verified ☑
To water installation pipes ☑	To gas installation pipes ☑	To oil installation pipes ☐	To structural steel ☐
To lightning protection ☐	To other ☐ Specify		

Main Switch / Switch-Fuse / Circuit-Breaker / RCD

Location Main switchroom adjacent reception area	Current rating 100 A	**If RCD main switch**
BS(EN) 60947-3	Fuse / device rating or setting N/A A	Rated residual operating current ($I_{\Delta n}$) N/A mA
No of poles 4	Voltage rating 400 V	Rated time delay N/A ms
		Measured operating time N/A ms

COMMENTS ON EXISTING INSTALLATION (in the case of an addition or alteration see Regulation 644.1.2):
Not applicable

SCHEDULES
The attached Schedules are part of this document and this Certificate is valid only when they are attached to it.
1 Schedules of Inspections and 1 Schedules of Test Results are attached.
(Enter quantities of schedules attached).

Page 2 of 5

ELECTRICAL INSTALLATION CERTIFICATE

NOTES FOR FORM 1 (from BS 7671)

1 The Electrical Installation Certificate is to be used only for the initial certification of a new installation or for an addition or alteration to an existing installation where new circuits have been introduced or a consumer unit changed. It is not to be used for a Periodic Inspection and Test, for which an Electrical Installation Condition Report form should be used. For an addition or alteration which does not extend to the introduction of new circuits, a Minor Electrical Installation Works Certificate may be used.

The 'original' Certificate is to be given to the person ordering the work (Regulation 644.1). A duplicate should be retained by the contractor.

2 This Certificate is only valid if accompanied by the Schedule of Inspections and the Schedule(s) of Test Results.
3 The signatures appended are those of the persons authorized by the companies executing the work of design, construction, inspection and testing respectively. A signatory authorized to certify more than one category of work should sign in each of the appropriate places.
4 The time interval recommended before the first periodic inspection must be inserted.
The proposed date for the next inspection should take into consideration the frequency and quality of maintenance that the installation can reasonably be expected to receive during its intended life, and the period should be agreed between the designer, installer and other relevant parties.
5 The page numbers for each of the Schedules of Test Results should be indicated, together with the total number of sheets involved.
6 The maximum prospective value of fault current (I_{pf}) recorded should be the greater of either the prospective value of short-circuit current or the prospective value of earth fault current.

GUIDANCE FOR RECIPIENTS (to be appended to the Certificate)

This safety Certificate has been issued to confirm that the electrical installation work to which it relates has been designed, constructed, inspected and tested in accordance with British Standard 7671 (the IET Wiring Regulations).

You should have received an 'original' Certificate and the contractor should have retained a duplicate. If you were the person ordering the work, but not the owner of the installation, you should pass this Certificate, or a full copy of it including the schedules, immediately to the owner.

The 'original' Certificate should be retained in a safe place and be shown to any person inspecting or undertaking further work on the electrical installation in the future. If you later vacate the property, this Certificate will demonstrate to the new owner that the electrical installation complied with the requirements of British Standard 7671 at the time the Certificate was issued. The Construction (Design and Management) Regulations require that, for a project covered by those Regulations, a copy of this Certificate, together with schedules, is included in the project health and safety file.

For safety reasons, the electrical installation will need to be inspected at appropriate intervals by a skilled person or persons, competent in such work. The maximum time interval recommended before the next inspection is stated on Page 1 under 'NEXT INSPECTION'.

This Certificate is intended to be issued only for a new electrical installation or for new work associated with an addition or alteration to an existing installation. It should not have been issued for the inspection of an existing electrical installation. An "Electrical Installation Condition Report" should be issued for such an inspection.

This Certificate is only valid if accompanied by the Schedule of Inspections and the Schedule(s) of Test Results.

SCHEDULE OF INSPECTIONS (for new installation work only) for DOMESTIC AND SIMILAR PREMISES WITH UP TO 100 A SUPPLY

Form 2 No. 555513 /3

NOTE 1: This form is suitable for many types of smaller installation, not exclusively domestic.

All items inspected in order to confirm, as appropriate, compliance with the relevant clauses in BS 7671. The list of items and associated examples where given are not exhaustive.

NOTE 2: Insert ✓ to indicate an inspection has been carried out and the result is satisfactory, or N/A to indicate that the inspection is not applicable to a particular item.

ITEM NO	DESCRIPTION	Outcome See Note 2
1.0	**DISTRIBUTOR'S / SUPPLY INTAKE EQUIPMENT (visual inspection only)**	
1.1	Service cable	✓
1.2	Service head	✓
1.3	Earthing arrangement	✓
1.4	Meter tails	✓
1.5	Metering equipment	✓
1.6	Isolator (where present)	✓
2.0	**PARALLEL OR SWITCHED ALTERNATIVE SOURCES OF SUPPLY**	
2.1	Adequate arrangements where a generating set operates as a switched alternative to the public supply (551.6)	N/A
2.2	Adequate arrangements where a generating set operates in parallel with the public supply (551.7)	N/A
3.0	**AUTOMATIC DISCONNECTION OF SUPPLY**	
3.1	**Presence and adequacy of earthing and protective bonding arrangements:**	
	• Distributor's earthing arrangement (542.1.2.1; 542.1.2.2)	✓
	• Installation earth electrode (where applicable) (542.1.2.3)	✓
	• Earthing conductor and connections, including accessibility (542.3; 543.3.2)	✓
	• Main protective bonding conductors and connections, including accessibility (411.3.1.2; 543.3.2; 544.1)	✓
	• Provision of safety electrical earthing / bonding labels at all appropriate locations (514.13)	✓
	• RCD(s) provided for fault protection (411.4.9; 411.5.3)	N/A
4.0	**BASIC PROTECTION**	
4.1	**Presence and adequacy of measures to provide basic protection (prevention of contact with live parts) within the installation:**	
	• Insulation of live parts e.g. conductors completely covered with durable insulating material (416.1)	✓
	• Barriers or enclosures e.g. correct IP rating (416.2)	✓
5.0	**ADDITIONAL PROTECTION**	
5.1	**Presence and effectiveness of additional protection methods:**	
	•RCD(s) not exceeding 30 mA operating current (415.1; Part 7), see Item 8.14 of this schedule	✓
	•Supplementary bonding (415.2; Part 7)	✓
6.0	**OTHER METHODS OF PROTECTION**	
6.1	**Presence and effectiveness of methods which give both basic and fault protection:**	
	• SELV system, including the source and associated circuits (Section 414)	N/A
	• PELV system, including the source and associated circuits (Section 414)	N/A
	• Double or reinforced insulation i.e. Class II or equivalent equipment and associated circuits (Section 412)	N/A
	• Electrical separation for one item of equipment e.g. shaver supply unit (Section 413)	N/A
7.0	**CONSUMER UNIT(S) / DISTRIBUTION BOARD(S):**	
7.1	Adequacy of access and working space for items of electrical equipment including switchgear (132.12)	✓
7.2	Components are suitable according to assembly manufacturers instructions or literature (536.4.203)	X
7.3	Presence of linked main switch(s) (462.1.201)	X
7.4	Isolators, for every circuit or group of circuits and all items of equipment (462.2)	✓
7.5	Suitability of enclosure(s) for IP and fire ratings (416.2; 421.1.6; 421.1.201; 526.5)	✓

Page 3 of 5

Form 2 No. 555513 /3

ITEM NO	DESCRIPTION	Outcome See Note 2
	CONSUMER UNIT(S) / DISTRIBUTION BOARD(S) continued	
7.6	Protection against mechanical damage where cables enter equipment (522.8.1; 522.8.5; 522.8.11)	✓
7.7	Confirmation that ALL conductor connections are correctly located in terminals and are tight and secure (526.1)	✓
7.8	Avoidance of heating effects where cables enter ferromagnetic enclosures e.g. steel (521.5)	✓
7.9	Selection of correct type and ratings of circuit protective devices for overcurrent and fault protection (411.3.2; 411.4; 411.5; 411.6; Sections 432, 433; 537.3.1.1)	✓
7.10	**Presence of appropriate circuit charts, warning and other notices:**	
	• Provision of circuit charts/schedules or equivalent forms of information (514.9)	✓
	• Warning notice of method of isolation where live parts not capable of being isolated by a single device (514.11)	✓
	• Periodic inspection and testing notice (514.12.1)	✓
	• RCD six-monthly test notice; where required (514.12.2)	✓
	• AFDD six-monthly test notice; where required	✓
	• Warning notice of non-standard (mixed) colours of conductors present (514.14)	N/A
7.11	Presence of labels to indicate the purpose of switchgear and protective devices (514.1.1; 514.8)	✓

ITEM NO	DESCRIPTION	Outcome
8.0	**CIRCUITS**	
8.1	Adequacy of conductors for current-carrying capacity with regard to type and nature of the installation (Section 523)	✓
8.2	Cable installation methods suitable for the location(s) and external influences (Section 522)	✓
8.3	Segregation/separation of Band I (ELV) and Band II (LV) circuits, and electrical and non-electrical services (528)	N/A
8.4	Cables correctly erected and supported throughout including escape routes, with protection against abrasion (Sections 521, 522)	✓
8.5	Provision of fire barriers, sealing arrangements where necessary (527.2)	✓
8.6	Non-sheathed cables enclosed throughout in conduit, ducting or trunking (521.10.1; 526.8)	N/A
8.7	Cables concealed under floors, above ceilings or in walls/partitions, adequately protected against damage (522.6.201; 522.6.202; 522.6.204)	✓
8.8	Conductors correctly identified by colour, lettering or numbering (Section 514)	✓
8.9	Presence, adequacy and correct termination of protective conductors (411.3.1.1; 543.1)	✓
8.10	Cables and conductors correctly connected, enclosed and with no undue mechanical strain (Section 526)	✓
8.11	No basic insulation of a conductor visible outside enclosure (526.8)	✓
8.12	Single-pole devices for switching or protection in line conductors only (132.14.1; 530.3.3; 643.6)	✓
8.13	Accessories not damaged, securely fixed, correctly connected, suitable for external influences (134.1.1; 512.2; Section 526)	✓
8.14	**Provision of additional protection by RCD not exceeding 30mA:**	
	• Socket-outlets rated at 32 A or less, unless exempt (411.3.3)	✓
	• Mobile equipment with a current rating not exceeding 32 A for use outdoors (411.3.3)	✓
	• Cables concealed in walls at a depth of less than 50 mm (522.6.202; 522.6.203)	✓
	• Cables concealed in walls / partitions containing metal parts regardless of depth (522.6.202; 522.6.203)	✓
	• Final circuits supplying luminaires within domestic (household) premises (411.3.4)	N/A
8.15	**Presence of appropriate devices for isolation and switching correctly located including:**	
	• Means of switching off for mechanical maintenance (464; 537.3.2)	✓
	• Emergency switches (565.1; 537.3.3)	N/A
	• Functional switches, for control of parts of the installation and current-using equipment (463.1; 537.3.1)	✓
	• Firefighter's switches (537.4)	N/A

ITEM NO	DESCRIPTION	Outcome
9.0	**CURRENT-USING EQUIPMENT (PERMANENTLY CONNECTED)**	
9.1	Equipment not damaged, securely fixed and suitable for external influences (134.1.1; 416.2; 512.2)	✓
9.2	Provision of overload and/or undervoltage protection e.g. for rotating machines, if required (Sections 445, 552)	✓
9.3	Installed to minimize the build-up of heat and restrict the spread of fire (421.1.4; 559.4.1)	✓
9.4	Adequacy of working space. Accessibility to equipment (132.12; 513.1)	✓

ITEM NO	DESCRIPTION	Outcome
10.0	**LOCATION(S) CONTAINING A BATH OR SHOWER (SECTION 701)**	
10.1	30 mA RCD protection for all LV circuits, equipment suitable for the zones, supplementary bonding (where required) etc.	✓

ITEM NO	DESCRIPTION	Outcome
11.0	**OTHER PART 7 SPECIAL INSTALLATIONS OR LOCATIONS**	
11.1	List all other special installations or locations present, if any. (Record separately the results of particular inspections applied)	N/A

Inspected by:
Name (Capitals) G. WILSON **Signature** G Wilson **Date** 20/7/2018

Page 4 of 5

Form 3

Generic Schedule of Test Results for a single-phase installation

GENERIC SCHEDULE OF TEST RESULTS

Form 3 No. ......1235...... /4

DB reference no ...Consumer unit...
Location ...Understairs cupboard...
Z_s at DB (Ω) ...0.29 Ω...
I_{pf} at DB (kA) ...0.8 kA...
Correct supply polarity confirmed ☑
Phase sequence confirmed (where appropriate) N/A

Details of circuits and/or installed equipment vulnerable to damage when testing ...SELV lights in bathroom...

Details of test instruments used (state serial and/or asset numbers)
Continuity ...1012F multi-function...
Insulation resistance ...“...
Earth fault loop impedance ...“...
RCD ...“...
Earth electrode resistance ...N/A...

Tested by:
Name (Capitals) ...G. THOMPSON...
Signature ...G. Thompson... Date ...17-Jan-2019...

Circuit number (1)	Circuit Description (2)	Circuit details – Protective device: BS (EN) (3)	type (4)	rating (A) (5)	breaking capacity (kA) (6)	RCD $I_{\Delta n}$ (mA) (7)	Maximum permitted Z_s (Ω*) (8)	Conductor details: Reference Method (9)	Live (mm²) (10)	cpc (mm²) (11)	Test results – Ring final circuit continuity (Ω): r_1 (line) (12)	r_n (neutral) (13)	r_2 (cpc) (14)	Continuity (Ω) ($R_1 + R_2$) or R_2: ($R_1 + R_2$) (15)	R_2 (16)	Insulation Resistance Test Voltage V (17)	Insulation Resistance (MΩ): Live - Live (18)	Live - Earth (19)	Polarity (20)	Z_s (Ω) Maximum measured (21)	RCD: Disconnection time (ms) (22)	RCD test button operation (23)	AFDD: Manual AFDD test button operation (24)	Remarks (continue on a separate sheet if necessary) (25)
1	Ring-sockets downstairs	61009	B	32	6	30	1.37	100	2.5	1.5	0.62	0.62	1.02	0.41	N/A	500	+299	+299	✓	0.71	28	✓	✓	NOTE: The high earth fault
2	Ring-sockets upstairs	61009	B	32	6	30	1.37	100	2.5	1.5	0.62	0.62	1.02	0.41	N/A	500	+299	+299	✓	0.71	36	✓	✓	loop impedance on the
3	Ring-kitchen	61009	B	32	6	30	1.37	100	2.5	1.5	0.22	0.22	0.37	0.15	N/A	500	+299	+299	✓	0.44	25	✓	✓	upstairs lighting circuit was
4	Cooker-kitchen	61009	B	32	6	30	1.37	100	6.0	2.5	N/A	N/A	N/A	0.16	N/A	500	+299	+299	✓	0.46	34	✓	✓	found to be due to loose
5	Lights-downstairs	61009	B	6	6	30	7.28	100	1.5	1.0	N/A	N/A	N/A	2.56	N/A	500	+299	+299	✓	2.85	29	✓	✓	terminals at the point of
6	Lights-upstairs	61009	B	6	6	30	7.28	100	1.5	1.0	N/A	N/A	N/A	8.2	N/A	500	+299	+299	✓	2.86	33	✓	✓	connection of the additional
7	Lights-garage	61009	B	6	6	30	7.28	100	1.5	1.0	N/A	N/A	N/A	1.57	N/A	500	+299	+299	✓	1.9	31	✓	✓	lighting circuitry. With this
8	Spare	–	–	–	–	–	–	–	–	–														additional circuitry
																								disconnected, a satisfactory
																								measurement of 2.86 ohms
																								was obtained. However the
																								circuit conductors remain
																								damaged and affected
																								cabling must be replaced.

* Where the maximum permitted earth fault loop impedance value stated in column 8 is taken from a source other than the tabulated values given in Chapter 41 of this standard, state the source of the data in the appropriate cell for the circuit in the Remarks column (column 25) of the schedule.

Page 5 of 5

Form 3

Generic Schedule of Test Results for part of a three-phase installation

GENERIC SCHEDULE OF TEST RESULTS

Form 3 No. 533373 /4

DB reference no DB1
Location Main Switch Room
Z_s at DB (Ω) 0.30 Ω
I_{pf} at DB (kA) 0.8 kA
Correct supply polarity confirmed ☑
Phase sequence confirmed (where appropriate) ☑

Details of circuits and/or installed equipment vulnerable to damage when testing None

Details of test instruments used (state serial and/or asset numbers)
Continuity 110586E
Insulation resistance "
Earth fault loop impedance "
RCD "
Earth electrode resistance N/A

Tested by:
Name (Capitals) G. WILSON
Signature G. Wilson Date 20-Jan-2019

Circuit details		Protective device						Conductor details			Test results: Ring final circuit continuity (Ω)			Continuity (Ω) $(R_1 + R_2)$ or R_2		Insulation Resistance Test Voltage	Insulation Resistance (MΩ)		Polarity	Z_s (Ω)	RCD		AFDD	Remarks (continue on a separate sheet if necessary)
Circuit number 1	Circuit Description 2	BS (EN) 3	type 4	rating (A) 5	breaking capacity (kA) 6	RCD $I_{\Delta n}$ (mA) 7	Maximum permitted Z_s (Ω*) 8	Reference Method 9	Live (mm²) 10	cpc (mm²) 11	r_1 (line) 12	r_n (neutral) 13	r_2 (cpc) 14	$(R_1 + R_2)$ 15	R_2 16	V 17	Live - Live 18	Live - Earth 19	20	Maximum measured 21	Disconnection time (ms) 22	RCD test button operation 23	Manual AFDD test button operation 24	25
1	L1 Ring-Ground floor	60898	B	32	10	30	1.37	B	4.0	1.5	0.65	0.65	1.81	0.61	N/A	500	+299	+299	✓	0.91	52	✓	✓	RCD1
2	L1 Radial-Kitchen	60898	B	32	10	30	1.37	B	4.0	1.5	N/A	N/A	N/A	0.51	N/A	500	+299	+299	✓	0.81	52	✓	✓	RCD1
3	L1 Radial-Fire alarm	60898	B	10	10	–	4.37	B	2.5	1.5	N/A	N/A	N/A	0.58	N/A	500	+299	+299	✓	0.88	–	✓	✓	
4	L1 Lighting-Ground floor	60898	B	16	10	–	4.37	A	2.5	1.5	N/A	N/A	N/A	1.08	N/A	500	+299	+299	✓	1.38	–	✓	✓	Cable tray + architrave switch drops
5	L2 Ring-Ground floor	60898	B	32	10	30	1.37	B	4.0	1.5	0.65	0.65	1.81	0.61	N/A	500	+299	+299	✓	0.91	51	✓	✓	RCD2
6	L2 Lighting-Ground floor	60898	B	10	10	–	4.37	A	2.5	1.5	N/A	N/A	N/A	1.08	N/A	500	+299	+299	✓	1.38	–	✓	✓	Cable tray + architrave switch drops
7	L2 External lighting	60898	B	10	10	30		C	2.5	1.5	N/A	N/A	N/A	1.35	N/A	500	+299	+299	✓	1.65	51	✓	✓	RCD2
8	Spare	–	–	–	–	–		–								–								
9	L3 Ring-Ground floor	60898	B	32	10	30	1.37	B	4.0	1.5	0.65	0.65	1.81	0.61	N/A	500	+299	+299	✓	0.91	50	✓	✓	RCD3
10	L3 Radial-a/c plant room	60898	C	20	10	30	1.09	B	4.0	1.5	N/A	N/A	N/A	1.15	N/A	500	+299	+299	✓	1.36	50	✓	✓	RCD3
11	L3 Lighting-Ground floor	60898	B	10	16	–	4.37	A	2.5	1.5	N/A	N/A	N/A	1.07	N/A	500	+299	+299	✓	1.37	–	–	✓	Cable tray + architrave switch drops
12	Spare	–	–	–	–	–	–	–								–								

* Where the maximum permitted earth fault loop impedance value stated in column 8 is taken from a source other than the tabulated values given in Chapter 41 of this standard, state the source of the data in the appropriate cell for the circuit in the Remarks column (column 25) of the schedule.

Page 5 of 5

GENERIC SCHEDULE OF TEST RESULTS

NOTES

The following notes relate to the column number in the form (Form 3).

1 Circuit number, for three-phase installations it is preferred to use the designation L1, L2, L3. For example, for the 5th circuit, the designation would be 5L1, 5L2 and 5L3.
2 Circuit description – can be brief (such as fluorescent lighting).
3 BS (EN), enter the Standard of manufacturer of the circuit protective device (such as (BS EN) 60898).
4 Type – where relevant for circuit-breakers enter the characteristic type (e.g. C).
5 Rating – enter the protective device's current rating.
6 Breaking capacity – enter the protective device's breaking capacity, often 'printed' on circuit-breakers (e.g. 6000).
7 RCD $I_{\Delta n}$ rating in mA – 30 mA for additional protection.
8 Maximum permitted loop impedance for the circuit protective device from Table 41 of BS 7671.
9 Reference Method – enter the cable's installed reference method, by using Table 4A2 of BS 7671
10 Conductor details – enter live conductor csa in mm^2.
11 Conductor details – enter circuit protective conductor csa in mm^2.
12 Ring line-line open resistance continuity in ohms, see 2.6.6.
13 Ring neutral-neutral open resistance continuity in ohms, see 2.6.6.
14 Ring cpc-cpc open resistance continuity in ohms, see 2.6.6.
15 Ring ($R_1 + R_2$) – enter the value recorded whilst carrying out Step 3 of the ring continuity test, see 2.6.6. Note that where meaningless results are recorded, due to parallel return paths, and it has been established and the inspector has verified continuity, a value is not necessary in this cell, and the cell may be ticked.
16 Continuity R_2 – add the value of the cpc continuity reading. If using Test method 2, the 'wandering lead' method, then enter the maximum value of the various readings that were measured on the circuit. Note that where meaningless results are recorded, due to parallel return paths and it has been established and the inspector has verified continuity, a value is not necessary in this cell, and the cell may be ticked.
17 Insulation resistance test voltage usually 500 V unless circuit may be damaged.
18 Insulation resistance, L-L – enter the minimum value recorded during testing the circuit for each of the various configurations, see 2.6.7.
19 Insulation resistance, L-E – enter the minimum value recorded during testing the circuit for each of the various configurations, see 2.6.7.
20 Polarity – tick this cell when the polarity for the circuit has been confirmed, see 2.6.13. A cross, 'X', may be used to indicate incorrect polarity only where the form accompanies an EICR.
21 Z_S – enter the circuit earth fault loop impedance by whatever method you have selected to determine it by, see 2.6.16.
22, 23 Enter the results from the tests carried out on any RCDs fitted to the circuit, 2.6.19.
24 Confirm AFDD test button test, where AFDD's have test buttons.
25 Remarks – this cell is provided to note anything relevant to the circuit and testing, see the completed examples of Form 3.

MINOR ELECTRICAL INSTALLATION WORKS CERTIFICATE

Form 4 No. 1234 /

(REQUIREMENTS FOR ELECTRICAL INSTALLATIONS - BS 7671 [IET WIRING REGULATIONS])

To be used only for minor electrical work which does not include the provision of a new circuit

PART 1: Description of the minor works

1. Details of the Client: Mr & Mrs Bloggs   Date minor works completed: 27 July 2018
2. Installation location/address: 41 Larkspur Drive, Newtown, NT1 1ES
3. Description of the minor works: 2 new lighting points to office/bedroom 3 of dwelling
4. Details of departures, if any, from BS 7671:2018 for the circuit altered or extended (Regulation 120.3, 133.1.3 and 133.5):
   Where applicable, a suitable risk assessment(s) must be attached to the Certificate
   None, electricity suppliers terminal equipment in need of attention cut-out fuse corner cracked. Customer advised to contact supplier   Risk assessment attached ☐
5. Comments on (including any defects observed in) the existing installation (Regulation 644.1.2):
   None

PART 2: Presence and adequacy of installation earthing and bonding arrangements (Regulation 132.16)

1. System earthing arrangement: TN-S ☐ TN-C-S ☑ TT ☐
2. Earth fault loop impedance at distribution board (Z_{db}) supplying the final circuit 1.2 Ω
3. Presence of adequate main protective conductors:
   Earthing conductor ☑
   Main protective bonding conductor(s) to: Water ☑ Gas ☑ Oil ☐ Structural steel ☐ Other.......... ☐

PART 3: Circuit details

DB Reference No.: 1   DB Location and type: Top of stairs - 8WSPN

Circuit No.: 5   Circuit description: Lighting to upstairs

Circuit overcurrent protective device: BS(EN) 61009   Type B   Rating 6 A

Conductor sizes: Live 1.5 mm²   cpc 1.0 mm²

PART 4: Test results for the circuit altered or extended (where relevant and practicable)

Protective conductor continuity: $R_1 + R_2$ .... Ω or R_2 0.1 Ω

Continuity of ring final circuit conductors: L/L N/A Ω   N/N N/A Ω   cpc/cpc N/A Ω

Insulation resistance: Live - Live +299 MΩ   Live - Earth +299 MΩ

Polarity satisfactory: ☑   Maximum measured earth fault loop impedance: Z_s .... Ω

RCD operation: Rated residual operating current ($I_{\Delta n}$) 30 mA

Disconnection time at 28 ms

Satisfactory test button operation ☑

PART 5: Declaration

I certify that the work covered by this certificate does not impair the safety of the existing installation and the work has been designed, constructed, inspected and tested in accordance with BS 7671:2018 (IET Wiring Regulations) amended to 2018 (date) and that to the best of my knowledge and belief, at the time of my inspection, complied with BS 7671 except as detailed in Part 1 above.

Name: GEOFF THOMPSON

For and on behalf of: T&G Electrical

Address: 25 Whiteleaf Close
Newtown
EA4 5XX

Signature: G Thompson

Position: Proprietor

Date: 27 July 2018

MINOR ELECTRICAL INSTALLATION WORKS CERTIFICATE

Notes for the person producing the certificate

Scope

The Minor Electrical Installation Works Certificate is intended to be used for alterations or additions to an installation that do not extend to the provision of a new circuit. Examples include the addition of socket-outlets or lighting points to an existing circuit, the relocation of a light switch etc. This 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. Appropriate inspection and testing, however, should always be carried out irrespective of the extent of the work undertaken.

Part 1 Description of minor works

1,2,3 The minor works must be so described that the work that is the subject of the certification can be readily identified.

4 See Regulations 120.3 and 133.5. No departures are to be expected except in the most unusual circumstances. See also Regulation 644.1.

5 Note any defects observed in the existing installation that are not related to the work being carried out.

Under the 'Comments on existing installation ...' heading, only deficiencies that do not impair the safety of any alteration or addition covered by the certificate may be referred to. An example is existing main bonding conductors identified by the colour green only (rather than green-and-yellow) or which have a cross-sectional area less than that required by Chapter 54 but nevertheless considered adequate by the designer of the alteration or addition.

Any deficiency liable to impair the safety of the alteration or addition must be corrected before the alteration or addition is carried out. See Regulation 132.16. It would be unacceptable simply to refer to the deficiency on the certificate.

Part 2 Installation earthing and bonding - existing installation

The existing earthing and bonding must be inspected and tested to confirm that it is adequate for the new works. Any extension to earthing and bonding must be installed for the works if required.

Part 3 Circuit details

Generally for domestic installations this be simple. Record details of the circuit protective device and circuit conductors. COMPLETE THE CIRCUIT CHART DETAILS ON THE DB OR CONSUMER UNIT.

Part 4 Essential tests

The relevant provisions of Part 6 'Inspection and testing' of BS 7671 must be applied in full to all minor works. For example, where a socket-outlet is added to an existing circuit it is necessary to:

(a) establish that the earthing contact of the socket-outlet is connected to a suitable means of earthing via the main earthing terminal

(b) measure the insulation resistance of the circuit that has been added to, and establish that it complies with Table 64 of BS 7671
(c) measure the earth fault loop impedance to establish that the maximum permitted disconnection time is not exceeded
(d) check that the polarity of the socket-outlet is correct
(e) (if the work is protected by an RCD) verify the effectiveness of the RCD.

Part 5 Declaration

When filling out and signing a form on behalf of a company or other business entity, individuals must state for whom they are acting.

GUIDANCE FOR RECIPIENTS (to be appended to the Certificate)

This Certificate has been issued to confirm that the electrical installation work to which it relates has been designed, constructed, inspected and tested in accordance with British Standard 7671 (*IET Wiring Regulations*).

You should have received an 'original' Certificate and the contractor should have retained a duplicate. If you were the person ordering the work, but not the owner of the installation, you should pass this Certificate, or a copy of it, to the owner. A separate Certificate should have been received for each existing circuit on which minor works have been carried out. This Certificate is not appropriate if you requested the contractor to undertake more extensive installation work, for which you should have received an Electrical Installation Certificate.

The Certificate should be retained in a safe place and be shown to any person inspecting or undertaking further work on the electrical installation in the future. If you later vacate the property, this Certificate will demonstrate to the new owner that the minor electrical installation work carried out complied with the requirements of British Standard 7671 at the time the Certificate was issued.

ELECTRICAL INSTALLATION CONDITION REPORT

Form 5 No. ....1235 /6

SECTION A. DETAILS OF THE PERSON ORDERING THE REPORT

Name ......M Parker

Address ...The Beeches

............QUAINTLIFE .... Postcode: EA11 2ZZ

SECTION B. REASON FOR PRODUCING THIS REPORT ....Client reported flickering lights

Date(s) on which inspection and testing was carried out ....

SECTION C. DETAILS OF THE INSTALLATION WHICH IS THE SUBJECT OF THIS REPORT

Occupier As above

Address ..As Above

.... Postcode: EA11 2ZZ

Description of premises

Domestic ☑ Commercial ☐ Industrial ☐ Other (include brief description) ☐ ....

Estimated age of wiring system ....9......years

Evidence of additions/alterations Yes ☑ No ☐ Not apparent ☐ If yes, estimate age ....4......years

Installation records available? (Regulation 651.1) Yes ☐ No ☑ Date of last inspection .... (date)

SECTION D. EXTENT AND LIMITATIONS OF INSPECTION AND TESTING

Extent of the electrical installation covered by this report

Visual inspection only of suppliers terminal equipment, inspection and test of consumer unit, main protective and supplementary bonding conductors and final circuits.

Agreed limitations including the reasons (see Regulation 653.2) No disturbance of building fabric.

Agreed with: Client

Operational limitations including the reasons (see page no.............) None

The inspection and testing detailed in this report and accompanying schedules have been carried out in accordance with BS 7671: 2018 (IET Wiring Regulations) as amended to .2018........................

It should be noted that cables concealed within trunking and conduits, under floors, in roof spaces, and generally within the fabric of the building or underground, have **not** been inspected unless specifically agreed between the client and inspector prior to the inspection. An inspection should be made within an accessible roof space housing other electrical equipment.

SECTION E. SUMMARY OF THE CONDITION OF THE INSTALLATION

General condition of the installation (in terms of electrical safety) This installation was constructed when the requirements of BS 7671:2001 were in place. The installation does not comply with BS 7671:2018, but is in generally good condition, apart from the connection arrangement of additional lighting points which were installed in 2008. This has given rise to the flickering lights and presents a potential risk of fire and electric shock.

Overall assessment of the installation in terms of its suitability for continued use

~~SATISFACTORY~~ / UNSATISFACTORY* (Delete as appropriate)

*An unsatisfactory assessment indicates that dangerous (code C1) and/or potentially dangerous (code C2) conditions have been identified.

SECTION F. RECOMMENDATIONS

Where the overall assessment of the suitability of the installation for continued use above is stated as UNSATISFACTORY, I / we recommend that any observations classified as *'Danger present'* (code C1) or *'Potentially dangerous'* (code C2) are acted upon as a matter of urgency.

Investigation without delay is recommended for observations identified as *'Further investigation required' (code FI)*.

Observations classified as *'Improvement recommended'* (code C3) should be given due consideration.

Subject to the necessary remedial action being taken, I/we recommend that the installation is further inspected and tested by July 2018 (date)

SECTION G. DECLARATION

I/We, being the person(s) responsible for the inspection and testing of the electrical installation (as indicated by my/our signatures below), particulars of which are described above, having exercised reasonable skill and care when carrying out the inspection and testing, hereby declare that the information in this report, including the observations and the attached schedules, provides an accurate assessment of the condition of the electrical installation taking into account the stated extent and limitations in section D of this report.

Inspected and tested by:	Report authorised for issue by:
Name (Capitals) GEOF THOMPSON	Name (Capitals) GEOF THOMPSON
Signature G Thompson	Signature G Thompson
For/on behalf of T and C Electrical	For/on behalf of T and C Electrical
Position Proprietor	Position Proprietor
Address 25 Whiteleasf Close, NEWTOWN	Address 25 Whiteleasf Close, NEWTOWN
Date 17-July-2018 Postcode: EA4 5XX	Date 17-July-2018 Postcode: EA4 5XX

SECTION H. SCHEDULE(S)

......1....schedule(s) of inspection and ...1....schedule(s) of test results are attached.

The attached schedule(s) are part of this document and this report is valid only when they are attached to it.

Page 1 of .5.

SECTION I. SUPPLY CHARACTERISTICS AND EARTHING ARRANGEMENTS

Earthing arrangements	Number and Type of Live Conductors		Nature of Supply Parameters	Supply Protective Device
TN-C ☐	AC ☑	DC ☐	Nominal voltage, U / U0(1) ......230.... V	BS (EN) ......1361......
TN-S ☐	1-phase, 2-wire ☑	2-wire ☐	Nominal frequency, f(1) ......50.... Hz	Type ....type II....
TN-C-S ☑	2 phase, 3-wire ☐	3-wire ☐	Prospective fault current, I_{pf}(2) ......0.8.... kA	
TT ☐	3 phase, 3-wire ☐	Other ☐	External loop impedance, Ze(2) ......0.29.... Ω	Rated current ......100.... A
IT ☐	3 phase, 4-wire ☐		*(Note: (1) by enquiry (2) by enquiry or by measurement)*	
	Confirmation of supply polarity ☑			

Other sources of supply (as detailed on attached schedule) ☐

SECTION J. PARTICULARS OF INSTALLATION REFERRED TO IN THE REPORT

Means of Earthing	Details of Installation Earth Electrode *(where applicable)*
Distributor's facility ☑	Type ....N/A..........
Installation earth electrode ☐	Location ....N/A..........
	Resistance to Earth N/A.... Ω

Main Protective Conductors

Earthing conductor	Material ...Copper..... csa ....16......mm²	Connection / continuity verified ☑
Main protective bonding conductors (to extraneous-conductive-parts)	Material ...Copper..... csa ....10......mm²	Connection / continuity verified ☑

To water installation pipes ☑ | To gas installation pipes ☑ | To oil installation pipes ☐ | To structural steel ☐

To lightning protection ☐ | To other ☐ Specify ....

Main Switch / Switch-Fuse / Circuit-Breaker / RCD

		If RCD main switch
Location ...Under-stairs... ...cupboard...	Current rating ....100 A	Rated residual operating current ($I_{\Delta n}$) ...N/A....mA
BS(EN) .....60947-3.....	Fuse / device rating or setting N/A A	Rated time delay ....N/A....ms
No of poles .....2.....	Voltage rating ....230 V	Measured operating time ....N/A....ms

SECTION K. OBSERVATIONS

Referring to the attached schedules of inspection and test results, and subject to the limitations specified at the *Extent and limitations of inspection and testing* section

No remedial action is required ☐ The following observations are made ☑ (see below):

OBSERVATION(S) Include schedule reference, as appropriate	CLASSIFICATION CODE
1. Damage to lighting circuit at junction box. Arcing and burnt insulation evident.	C1
2. Loose connection as above, causing unreliable earthing of circuit and risk of fire.	C2
3. No additional protection by RCD for low voltage circuits in bathroom.	C3
4. No earthed, mechanical or addition protection by RCD for cables concealed in walls.	C3
NOTE: Faulty section of lighting circuit disconnected with client's approval	

One of the following codes, as appropriate, has been allocated to each of the observations made above to indicate to the person(s) responsible for the installation the degree of urgency for remedial action.

C1 – Danger present. Risk of injury. Immediate remedial action required

C2 – Potentially dangerous - urgent remedial action required

C3 – Improvement recommended

FI – Further investigation required without delay

Page 2 of 5

CONDITION REPORT INSPECTION SCHEDULE FOR DOMESTIC AND SIMILAR PREMISES WITH UP TO 100 A SUPPLY

Form 6 No. ....1235.... /6

Note: This form is suitable for many types of smaller installation, not exclusively domestic.

OUTCOMES	Acceptable condition	✓	Unacceptable condition	State C1 or C2	Improvement recommended	State C3	Further investigation	FI	Not verified	N/V	Limitation	LIM	Not applicable	N/A

ITEM NO	DESCRIPTION	OUTCOME (Use codes above. Provide additional comment where appropriate. C1, C2, C3 and FI coded items to be recorded in Section K of the Condition Report)
1.0	**DISTRIBUTOR'S / SUPPLY INTAKE EQUIPMENT (visual inspection only)**	
1.1	Service cable	N/A
1.2	Service head	✓
1.3	Earthing arrangement	✓
1.4	Meter tails	✓
1.5	Metering equipment	✓
1.6	Isolator (where present)	N/A
2.0	**PRESENCE OF ADEQUATE ARRANGEMENTS FOR OTHER SOURCES SUCH AS MICROGENERATORS (551.6; 551.7)**	N/A
3.0	**EARTHING / BONDING ARRANGEMENTS (411.3; Chap 54)**	
3.1	Presence and condition of distributor's earthing arrangement (542.1.2.1; 542.1.2.2)	✓
3.2	Presence and condition of earth electrode connection where applicable (542.1.2.3)	N/A
3.3	Provision of earthing/bonding labels at all appropriate locations (514.13.1)	✓
3.4	Confirmation of earthing conductor size (542.3; 543.1.1)	✓
3.5	Accessibility and condition of earthing conductor at MET (543.3.2)	✓
3.6	Confirmation of main protective bonding conductor sizes (544.1)	✓
3.7	Condition and accessibility of main protective bonding conductor connections (543.3.2; 544.1.2)	✓
3.8	Accessibility and condition of other protective bonding connections (543.3.1)	✓
4.0	**CONSUMER UNIT(S) / DISTRIBUTION BOARD(S)**	
4.1	Adequacy of working space/accessibility to consumer unit/distribution board (132.12; 513.1)	✓
4.2	Security of fixing (134.1.1)	✓
4.3	Condition of enclosure(s) in terms of IP rating etc (416.2)	✓
4.4	Condition of enclosure(s) in terms of fire rating etc (421.1.201, 526.5)	✓
4.5	Enclosure not damaged/deteriorated so as to impair safety (651.2)	✓
4.6	Presence of main linked switch (as required by 462.1.201)	✓
4.7	Operation of main switch (functional check) (643.10)	✓
4.8	Manual operation of circuit-breakers and RCDs to prove disconnection (643.10)	✓
4.9	Correct identification of circuit details and protective devices (514.8.1; 514.9.1)	✓
4.10	Presence of RCD six-monthly test notice at or near consumer unit/distribution board (514.12.2)	✓
4.11	Presence of non-standard (mixed) cable colour warning notice at or near consumer unit/distribution board (514.14)	✓
4.12	Presence of alternative supply warning notice at or near consumer unit/distribution board (514.15)	N/A
4.13	Presence of other required labelling (please specify) (Section 514)	N/A
4.14	Compatibility of protective devices, bases and other components; correct type and rating (No signs of unacceptable thermal damage, arcing or overheating) (411.3.2; 411.4; 411.5; 411.6; Sections 432, 433)	✓
4.15	Single-pole switching or protective devices in line conductors only (132.14.1; 530.3.3)	✓
4.16	Protection against mechanical damage where cables enter consumer unit/distribution board (132.14.1; 522.8.1; 522.8.5; 522.8.11)	✓
4.17	Protection against electromagnetic effects where cables enter consumer unit/distribution board/enclosures (521.5.1)	✓
4.18	RCD(s) provided for fault protection – includes RCBOs (411.4.9; 411.5.2; 531.2)	N/A
4.19	RCD(s) provided for additional protection - includes RCBOs (411.3.3; 415.1)	C3
4.20	Confirmation of indication that SPD is functional (651.4)	N/A
4.21	Confirmation that ALL conductor connections, including connections to busbars, are correctly located in terminals and are tight and secure (526.1)	✓
4.22	Adequate arrangements where a generating set operates as a switched alternative to the public supply (551.6)	N/A
4.23	Adequate arrangements where a generating set operates in parallel with the public supply (551.7)	N/A

Page ..3.. of ..5..

Form 6 No. 1235 /6

OUTCOMES	Acceptable condition	✓	Unacceptable condition	State C1 or C2	Improvement recommended	State C3	Further investigation	FI	Not verified	N/V	Limitation	LIM	Not applicable	N/A

ITEM NO	DESCRIPTION	OUTCOME (Use codes above. Provide additional comment where appropriate. C1, C2, C3 and FI coded items to be recorded in Section K of the Condition Report)
5.0	**FINAL CIRCUITS**	
5.1	Identification of conductors (514.3.1)	✓
5.2	Cables correctly supported throughout their run (521.10.202; 522.8.5)	✓
5.3	Condition of insulation of live parts (416.1)	C1
5.4	Non-sheathed cables protected by enclosure in conduit, ducting or trunking (521.10.1)	✓
	▪ To include the integrity of conduit and trunking systems (metallic and plastic)	✓
5.5	Adequacy of cables for current-carrying capacity with regard for the type and nature of installation (Section 523)	✓
5.6	Coordination between conductors and overload protective devices (433.1; 533.2.1)	✓
5.7	Adequacy of protective devices: type and rated current for fault protection (411.3)	✓
5.8	Presence and adequacy of circuit protective conductors (433.1; Section 543)	✓
5.9	Wiring system(s) appropriate for the type and nature of the installation and external influences (Section 522)	✓
5.10	Concealed cables installed in prescribed zones (see Section D. *Extent and limitations*) (522.6.202)	✓
5.11	Cables concealed under floors, above ceilings or in walls/partitions, adequately protected against damage (see Section D. *Extent and limitations*) (522.6.204)	✓
5.12	Provision of additional protection by RCD not exceeding 30 mA:	
	▪ for all socket-outlets of rating 20 A or less, unless an exception is permitted (411.3.3)	✓
	▪ for supply to mobile equipment not exceeding 32 A rating for use outdoors (411.3.3)	✓
	▪ for cables concealed in walls at a depth of less than 50 mm (522.6.202; 522.6.203)	C3
	▪ for cables concealed in walls/partitions containing metal parts regardless of depth (522.6.203)	N/A
	▪ Final circuits supplying luminaires within domestic (household) premises (411.3.4)	✓
5.13	Provision of fire barriers, sealing arrangements and protection against thermal effects (Section 527)	✓
5.14	Band II cables segregated/separated from Band I cables (528.1)	✓
5.15	Cables segregated/separated from communications cabling (528.2)	✓
5.16	Cables segregated/separated from non-electrical services (528.3)	✓
5.17	Termination of cables at enclosures – indicate extent of sampling in Section D of the report (Section 526)	
	▪ Connections soundly made and under no undue strain (526.6)	C1
	▪ No basic insulation of a conductor visible outside enclosure (526.8)	✓
	▪ Connections of live conductors adequately enclosed (526.5)	✓
	▪ Adequately connected at point of entry to enclosure (glands, bushes etc.) (522.8.5)	✓
5.18	Condition of accessories including socket-outlets, switches and joint boxes (651.2(v))	C1
5.19	Suitability of accessories for external influences (512.2)	✓
5.20	Adequacy of working space/accessibility to equipment (132.12; 513.1)	✓
5.21	Single-pole switching or protective devices in line conductors only (132.14.1, 530.3.3)	✓

6.0	**LOCATION(S) CONTAINING A BATH OR SHOWER**	
6.1	Additional protection for all low voltage (LV) circuits by RCD not exceeding 30 mA (701.411.3.3)	C3
6.2	Where used as a protective measure, requirements for SELV or PELV met (701.414.4.5)	N/A
6.3	Shaver sockets comply with BS EN 61558-2-5 formerly BS 3535 (701.512.3)	✓
6.4	Presence of supplementary bonding conductors, unless not required by BS 7671:2018 (701.415.2)	✓
6.5	Low voltage (e.g. 230 volt) socket-outlets sited at least 2.5 m from zone 1 (701.512.3)	✓
6.6	Suitability of equipment for external influences for installed location in terms of IP rating (701.512.2)	✓
6.7	Suitability of accessories and controlgear etc. for a particular zone (701.512.3)	✓
6.8	Suitability of current-using equipment for particular position within the location (701.55)	✓

7.0	**OTHER PART 7 SPECIAL INSTALLATIONS OR LOCATIONS**	
7.1	List all other special installations or locations present, if any. (Record separately the results of particular inspections applied.)	N/A

Inspected by:
Name (Capitals) GEOFF THOMPSON **Signature** G Thompson **Date** 17/7/2018

Test results schedules (Page 5 of 5 etc) are also to be included with the EICR as requested

Page 4 of 5

ELECTRICAL INSTALLATION CONDITION REPORT

NOTES FOR THE PERSON PRODUCING THE REPORT

1 This Report should only be used for reporting on the condition of an existing electrical installation and not for the installation of a consumer unit/distribution board distribution board. An installation which was designed to an earlier edition of the Regulations and which does not fully comply with the current edition is not necessarily unsafe for continued use, or requires upgrading. Only damage, deterioration, defects, dangerous conditions and non-compliance with the requirements of the Regulations, which may give rise to danger, should be recorded.

2 The Report, normally comprising at least five pages, should include schedules of both the inspection and the test results. Additional pages may be necessary for other than a simple installation and for the "Guidance for recipients". The number of each page should be indicated, together with the total number of pages involved.

3 The reason for producing this Report, such as change of occupancy or landlord's periodic maintenance, should be identified in Section B.

4 Those elements of the installation that are covered by the Report and those that are not should be identified in Section D (Extent and limitations). These aspects should have been agreed with the person ordering the report and other interested parties before the inspection and testing commenced. Any operational limitations, such as inability to gain access to parts of the installation or an item of equipment, should also be recorded in Section D.

5 The maximum prospective value of fault current (I_{pf}) recorded should be the greater of either the prospective value of short-circuit current or the prospective value of earth fault current.

6 Where an installation has an alternative source of supply a further schedule of supply characteristics and earthing arrangements based upon Section I of this Report should be provided.

7 A summary of the condition of the installation in terms of safety should be clearly stated in Section E. Observations, if any, should be categorised in Section K using the coding C1 to C3 as appropriate. Any observation given a code C1 or C2 classification should result in the overall condition of the installation being reported as unsatisfactory.

8 Wherever practicable, **items classified as 'Danger present' (C1) should be made safe on discovery**. Where this is not possible the owner or user should be given written notification as a matter of urgency.

9 Where an observation requires further investigation (FI) because the inspection has revealed an apparent deficiency which could not, owing to the extent or limitations of the inspection, be fully identified and further investigation may reveal a code C1 or C2 item, this should be recorded within Section K, given the code FI and marked as unsatisfactory in Section E.

10 If the space available for observations in Section K is insufficient, additional pages should be provided as necessary.

11 The date by which the next Electrical Installation Condition Report is recommended should be given in Section F. The interval between inspections should take into account the type and usage of the installation and its overall condition.

12 Any deficiencies with intake equipment should be reported to the person ordering the work.

ELECTRICAL INSTALLATION CONDITION REPORT

GUIDANCE FOR RECIPIENTS (to be appended to the Report)

This Report is an important and valuable document which should be retained for future reference.

1 The purpose of this Condition Report is to confirm, so far as reasonably practicable, whether or not the electrical installation is in a satisfactory condition for continued service (see Section E). The Report should identify any damage, deterioration, defects and/or conditions which may give rise to danger (see Section K).

2 The person ordering the Report should have received the "original" Report and the inspector should have retained a duplicate.

3 The "original" Report should be retained in a safe place and be made available to any person inspecting or undertaking work on the electrical installation in the future. If the property is vacated, this Report will provide the new owner/ occupier with details of the condition of the electrical installation at the time the Report was issued.
4 Where the installation incorporates a residual current device (RCD) there should be a notice at or near the device stating that it should be tested quarterly. **For safety reasons it is important that this instruction is followed.**
5 Section D (Extent and Limitations) should identify fully the extent of the installation covered by this Report and any limitations on the inspection and testing. The inspector should have agreed these aspects with the person ordering the Report and with other interested parties (licensing authority, insurance company, mortgage provider and the like) before the inspection was carried out.
6 Some operational limitations such as inability to gain access to parts of the installation or an item of equipment may have been encountered during the inspection. The inspector should have noted these in Section D.
7 For items classified in Section K as C1 ("Danger present"), **the safety of those using the installation is at risk**, and it is recommended that a skilled person or persons competent in electrical installation work undertakes the necessary remedial work immediately.
8 For items classified in Section K as C2 ("Potentially dangerous"), **the safety of those using the installation may be at risk** and it is recommended that a skilled person or persons competent in electrical installation work undertakes the necessary remedial work as a matter of urgency.
9 Where it has been stated in Section K that an observation requires further investigation (code FI) the inspection has revealed an apparent deficiency which may result in a code C1 or C2, and could not, due to the extent or limitations of the inspection, be fully identified. Such observations should be investigated without delay. A further examination of the installation will be necessary, to determine the nature and extent of the apparent deficiency (see Section F).
10 For safety reasons, the electrical installation should be re-inspected at appropriate intervals by a skilled person or persons, competent in such work. The recommended date by which the next inspection is due is stated in Section F of the Report under 'Recommendations' and on a label at or near to the consumer unit/distribution board.

CONDITION REPORT INSPECTION SCHEDULE

GUIDANCE FOR INSPECTORS

1 Section 1.0. Where inadequacies in the intake equipment are encountered the inspector should advise the person ordering the work to inform the appropriate authority.
2 Older installations designed prior to BS 7671:2008 may not have been provided with RCDs for additional protection. The absence of such protection should as a minimum be given a code C3 classification (item 5.12).
3 The schedule is not exhaustive.
4 Numbers in brackets are Regulation references to specified requirements.

Appendix A

Maximum permissible measured earth fault loop impedance

A1 Tables

643.7.3 411.4.201 411.4.202 411.4.203 The tables in this appendix provide maximum permissible measured earth fault loop impedances (Z_S) for compliance with BS 7671, which must not be exceeded when the tests are carried out at an ambient temperature of 10 °C. Table A6 provides correction factors for other ambient temperatures.

Where the cables to be used are to Table 3, 4 or 5 of BS 6004, Table 3, 4 or 5 of BS 7211, Table B.1 or B.2 of BS EN 50525-3-41 or are other thermoplastic (PVC) or thermosetting (low smoke halogen-free – LSHF) cables to these British Standards, and the cable loading is such that the maximum operating temperature is 70 °C, then Tables A1 to A3 give the maximum earth fault loop impedances for circuits with:

(a) protective conductors of copper and having from 1 mm^2 to 16 mm^2 cross-sectional area; and
(b) an overcurrent protective device (i.e. a fuse) to BS 3036, BS 88-2 or BS 88-3.

For each type of fuse, two tables are given:

411.3.2.2 **(a)** where the circuit concerned is a final circuit not exceeding 32 A and the maximum disconnection time for compliance with Regulation 411.3.2.2 is 0.4 s for TN systems, and
411.3.2.3 **(b)** where the circuit concerned is a final circuit exceeding 32 A or a distribution circuit and the disconnection time for compliance with Regulation 411.3.2.3 is 5 s for TN systems.

543.1.3 In each table the earth fault loop impedances given correspond to the appropriate disconnection time from a comparison of the time/current characteristics of the device concerned and the adiabatic equation given in Regulation 543.1.3.

The tabulated values apply only where the nominal voltage to Earth (U_0) is 230 V.

Table A4 gives the maximum measured Z_S for circuits protected by circuit-breakers to BS 3871-1 and BS EN 60898, and RCBOs to BS EN 61009.

Tables 41.2 to 41.4 543.1.3 **Note:** The impedances tabulated in this appendix are lower than those in Tables 41.2 to 41.4 of BS 7671. This is because the impedances in this appendix are measured values at an assumed conductor temperature of 10 °C, whilst those in BS 7671 are design figures at the line conductor maximum permitted operating temperature given in Table 52.1 of BS 7671 and the protective conductor assumed initial temperature given in Tables 54.2 to 54.5 of BS 7671. The correction factor (divisor) used is 1.25. This corresponds to the line conductor maximum operating temperature and protective conductor assumed initial temperature both being 70 °C. For smaller cross-sectional area cables the impedance may also be limited by the adiabatic equation of Regulation 543.1.3. A value of k of 115 from Table 54.3 of BS 7671 is used. This is suitable for PVC insulated and sheathed cables to Table 3, 4 or 5 of BS 6004 and for thermosetting (LSHF) insulated and sheathed cables to Table 3, 4 or 5 of BS 7211 or Table B.1 or B.2 of BS EN 50525-3-41. The k value is based on both the thermoplastic (PVC) and thermosetting (LSHF) cables operating at a maximum temperature of 70 °C. The IET Commentary on the 17th Edition of the IET Wiring Regulations provides a full explanation.

▼ **Table A1** Semi-enclosed fuses. Maximum measured earth fault loop impedance (in ohms) at ambient temperature where the overcurrent protective device is a semi-enclosed fuse to BS 3036

i) 0.4 second disconnection (final circuits not exceeding 32 A in TN systems)

Protective conductor (mm^2)	Fuse rating			
	5 A	15 A	20 A	30 A
1.0	7.28	1.94	1.34	NP
≥ 1.5	7.28	1.94	1.34	0.83

(ii) 5 seconds disconnection (final circuits exceeding 32 A and distribution circuits in TN systems)

Protective conductor (mm^2)	Fuse rating			
	20 A	30 A	45 A	60 A
1.0	2.3	NP	NP	NP
1.5	2.91	1.6	NP	NP
2.5	2.91	2.0	1.0	NP
4.0	2.91	2.0	1.2	0.85
≥ 6.0	2.91	2.0	1.2	0.85

Note: NP means that the combination of the protective conductor and the fuse is Not Permitted.

▼ **Table A2** BS 88-2 fuses. Maximum measured earth fault loop impedance (in ohms) at ambient temperature where the overcurrent protective device is a fuse to BS 88-2 or BS 88-6

(i) 0.4 second disconnection (final circuits not exceeding 32 A in TN systems)

Protective conductor (mm^2)	Fuse rating							
	2 A	4 A	6 A	10 A	16 A	20 A	25 A	32 A
1.0	26.5	12.5	6.2	3.7	1.9	1.3	1.0	0.6
1.5	26.5	12.5	6.2	3.7	1.9	1.3	1.0	0.8
≥ 2.5	26.5	12.5	6.2	3.7	1.9	1.3	1.0	0.8

(ii) 5 seconds disconnection (final circuits exceeding 32 A and distribution circuits in TN systems)

Protective conductor (mm^2)	Fuse rating							
	20 A	25 A	32 A	40 A	50 A	63 A	80 A	100 A
1.0	1.46	1.03	0.63	0.55	NP	NP	NP	NP
1.5	2.13	1.2	0.87	0.83	NP	NP	NP	NP
2.5	2.24	1.76	1.336	1.04	0.5	0.3	NP	NP
4.0	2.24	1.76	1.364	1.04	0.76	0.49	0.22	0.12
6.0	2.24	1.76	1.36	1.04	0.79	0.62	0.3	0.19
10.0	2.24	1.76	1.36	1.04	0.79	0.62	0.44	0.32
16.0	2.24	1.7	1.36	1.04	0.79	0.62	0.44	0.34

Note: NP means that the combination of the protective conductor and the fuse is Not Permitted.

▼ **Table A3** BS 88-3 fuses. Maximum measured earth fault loop impedance (in ohms) at ambient temperature where the overcurrent protective device is a fuse to BS 88-3

(i) 0.4 second disconnection (final circuits not exceeding 32 A in TN systems)

Protective conductor (mm^2)	Fuse rating			
	5 A	16 A	20 A	32 A
1.0	7.94	1.84	1.54	0.6
1.5	7.94	1.84	1.54	0.73
2.5 to 16	7.94	1.84	1.54	0.73

(ii) 5 seconds disconnection (final circuits exceeding 32 A and distribution circuits in TN systems)

Protective conductor (mm^2)	Fuse rating					
	20 A	32 A	45 A	63 A	80 A	100 A
1.0	2.13	0.59	NP	NP	NP	NP
1.5	2.57	0.76	NP	NP	NP	NP
2.5	2.57	1.13	0.55	0.24	NP	NP
4.0	2.57	1.25	0.76	0.32	0.19	NP
6.0	2.57	1.25	0.76	0.51	0.29	0.16
10.0	2.57	1.25	0.76	0.55	0.4	0.26
16.0	2.57	1.25	0.76	0.55	0.4	0.3

Note: NP means that the combination of the protective conductor and the fuse is Not Permitted.

Table A4 Circuit-breakers. Maximum measured earth fault loop impedance (in ohms) at ambient temperature where the overcurrent device is a circuit-breaker to BS 3871 or BS EN 60898 or RCBO to BS EN 61009

For 0.1 to 5 second disconnection times (includes 0.4 second disconnection time)															
Circuit-breaker type	Circuit-breaker rating (amperes)														
	3	5	6	10	15	16	20	25	30	32	40	45	50	63	100
1	14.56	8.74	7.28	4.4	2.93	2.76	2.2	1.76	1.47	1.38	1.1	0.98	0.88	0.7	0.44
2	8.4	5.0	4.2	2.5	1.67	1.58	1.25	1.0	0.83	0.79	0.63	0.56	0.5	0.4	0.25
B	11.65	7.0	5.82	3.5	2.33	2.15	1.75	1.4	1.17	1.1	0.87	0.78	0.7	0.55	0.35
3&C	5.82	3.49	2.91	1.75	1.16	1.10	0.87	0.7	0.58	0.54	0.44	0.38	0.35	0.28	0.18

Circuit-breakers. Maximum measured earth fault loop impedance (in ohms) at ambient temperature where the overcurrent device is a circuit-breaker to BS EN 60898 type D or RCBO to BS EN 61009 type D										
Circuit-breaker type	Circuit-breaker rating (amperes)									
	6	10	16	20	25	32	40	50	63	100
D 0.4 sec	1.46	0.87	0.55	0.44	0.35	0.28	-	-	-	-
D 5 sec	2.91	1.75	1.09	0.87	0.7	0.55	0.44	0.35	0.28	0.17

Regulation 434.5.2 of BS 7671:2018 requires that the protective conductor csa meets the requirements of BS EN 60898-1-2 or BS EN 61009-1, or the minimum quoted by the manufacturer. The sizes given in Table A5 are for energy-limiting class 3, Types B and C devices only.

Table A5 Minimum protective conductor size for class 3 Types B and C devices

Energy-limiting class 3 device rating (A)	Fault level (kA)	Protective conductor csa (mm²)*	
		Type B	Type C
Up to and including 16 A	≤ 3	1.0	1.5
Up to and including 16 A	≤ 6	2.5	2.5
Over 16 up to and including 32 A	≤ 3	1.5	1.5
Over 16 up to and including 32 A	≤ 6	2.5	2.5
40 A	≤ 3	1.5	1.5
40 A	≤ 6	2.5	2.5

* For other device types and ratings or higher fault levels consult manufacturer's data. See Regulation 434.5.2 and The IET Commentary on the 17th Edition of the Wiring Regulations.

▼ **Table A6** Ambient temperature correction factors

Ambient temperature (°C)	Correction factor (from 10 °C) (notes 1 and 2)
0	0.96
5	0.98
10	1.00
20	1.04
25	1.06
30	1.08

Notes: **1** The correction factor is given by: {1 + 0.004 (ambient temp – 20)}/{1 + 0.004 (10 - 20)} where 0.004 is the simplified resistance coefficient per °C at 20 °C given by BS EN 60228 for both copper and aluminium conductors. (Alternatively the correction factor is given by (ambient temp + 230)/(10 + 230)).

2 The factors are different from those of Table B.2 because Table A6 corrects from 10 °C and Table B.2 from 20 °C.

The ambient correction factor of Table A6 is applied to the earth fault loop impedances of Tables A1 to A4 if the ambient temperature is other than 10 °C.

For example, if the ambient temperature is 25 °C the measured earth fault loop impedance of a circuit protected by a 32 A type B circuit-breaker to BS EN 60898 should not exceed 1.1 × 1.06 = 1.17 Ω.

A2 Appendix 3 of BS 7671

Appx 3 Appendix 3 of BS 7671 takes into account the increase of the conductor resistance with increase of temperature due to load current, which may be used to verify compliance with the requirements of Regulation 411.4 for TN systems.

The requirements of Regulation 411.4.4 are considered met when the measured value of fault loop impedance satisfies the following equation:

$$Z_s(m) = 0.8 \times \frac{U_0 \times C_{min}}{I_a}$$

where:

$Z_s(m)$	is the measured impedance of the earth fault current loop up to the most distant point of the relevant circuit from the origin of the installation (Ω)
U_0	is the nominal AC rms line voltage to Earth (V)
I_a	is the current in amps (A) causing operation of the protective device within the time stated in Table 41.1 of BS 7671 or within 5 s according to the conditions stated in Regulation 411.3.2.3 (A).
C_{min}	is the minimum voltage factor to take account of voltage variations depending on time and place, change of transformer taps and other considerations.
0.8	is a temperature adjustment factor for ambient temperature (see A6 above).

Note: For a low voltage supply given in accordance with the ESQCR, C_{min} is given the value 0.95.

A3 Methods of adjusting tabulated values of Z_s

(See also 2.6.16 'Earth fault loop impedance verification'.)

A circuit is wired in flat twin and cpc 70 °C thermoplastic (PVC) cable and protected by a 6 A type B circuit-breaker to BS EN 60898. When tested at an ambient temperature below 20 °C, determine the maximum acceptable measured value of Z_S for the circuit.

Solution:

$$Z_{test\ (max)} = \frac{1}{F} Z_S$$

From Table 41.3(a) of BS 7671, the maximum permitted value of $Z_S = 7.28\ \Omega$

From Table B3 in Appendix B of this Guidance Note, $F = 1.20$

$$Z_{test\ (max)} = \frac{1}{1.20} \times 7.28$$

$$Z_{test\ (max)} = 6.07\ \Omega$$

A more accurate value can be obtained if the external earth fault loop impedance, Z_e, is known. In this case, the following formula may be used:

$$Z_{test} \leq Z_e + \frac{1}{F}\left(Z_s - Z_e\right)$$

In the example above, assume Z_e is 0.35. Thus, the more accurate value is:

$$Z_{test\ (max)} = 0.35 + \frac{1}{1.2}\left(7.28 - 0.35\right)$$

$$Z_{test\ (max)} = 6.13\ \Omega$$

Where the test ambient temperature is likely to be other than 20 °C, a further correction can be made to convert the value to correspond with the expected ambient temperature, using the following formula:

$$Z_{test\ (max)} = Z_e + \frac{\alpha}{F}\left(Z_S - Z_e\right)$$

where α is given by Table B2 of Appendix B.

In the example above, assume the test ambient temperature is 5 °C.

From Table B2, $\alpha = 0.94$

Thus, the accurate reading including temperature compensation is:

$$Z_{test\ (max)} = 0.35 + \frac{0.94}{1.20}\left(7.28 - 0.35\right)$$

$$Z_{test\ (max)} = 5.78\ \Omega$$

Note: Where reduced cross-sectional area protective conductors are used, maximum earth fault loop impedances may need to be further reduced to ensure disconnection times are sufficiently short to prevent overheating of protective conductors during earth faults. The requirement of the equation in Regulation 543.1.3 needs to be met:

$$S \geq \frac{\sqrt{I^2 t}}{k}$$

where:

S	is the nominal cross-sectional area of the conductor in mm^2
≥	means greater than or equal to
k	is a factor taking account of the resistivity, temperature coefficient and heat capacity of the conductor material, and the appropriate initial and final temperatures; see Tables 54.2–54.4
I	is the value in amperes (rms for AC) of fault current for a fault of negligible impedance, which can flow through the associated protective device, due account being taken of the current limiting effect of the circuit impedances and the limiting capability (I^2t) of that protective device
Z_S	is the loop impedance at conductor normal operating temperature
t	is the operating time of the overcurrent device in seconds corresponding to the fault current I amperes - obtained from the graphs in Appendix 3 of BS 7671, as the prospective earth fault current I (= $U_0 \times C_{min}/Z_S$) is known.

Note: C_{min} is the minimum voltage factor, the meaning of which is explained in Section A2 of this appendix.

The following example illustrates how measurements taken at 20 °C may be adjusted to 70 °C values, taking the ($R_1 + R_2$) reading for the circuit into account.

In the previous example, taking the ($R_1 + R_2$) reading for the circuit as 0.2 ohm:

Z_S for the circuit at 70 °C

$$= Z_e + F(R_1 + R_2)_{test}$$
$$= 0.35 + 1.20 \times 0.2$$
$$= 0.59\ \Omega$$

The temperature-corrected Z_S figure of 0.59 Ω is acceptable, since it is less than the maximum value of 7.28 Ω given in Table 41.3 of BS 7671.

The formula above involves taking measurements at 20 °C and converting them to 70 °C values. Alternatively, the 70 °C values can be converted to the values at the expected ambient temperature, for example, 20 °C, when the measurement is carried out.

Taking the same circuit,

$$\begin{aligned} Z_{test} &= Z_e + (R_1 + R_2)_{test} \\ &= 0.32 + 0.2 \\ &= 0.55\,\Omega \end{aligned}$$

From the formula $Z_{test(max)} = \frac{1}{F} Z_s$

$Z_{s\,(max)}$ from BS 7671 = 7.28 Ω

$Z_{test(max)} = \frac{1}{1.20} \times 7.28 = 6.07\,\Omega$

Therefore, as 0.55 Ω is less than 6.07 Ω, the circuit is acceptable.

Appendix B

Resistance of copper and aluminium conductors

434.5.2 543.1.3 To check compliance with Regulation 434.5.2 and/or Regulation 543.1.3, i.e. to evaluate the equation

$$S^2 = \frac{I^2t}{k^2}$$

it is necessary to establish the impedances of the circuit conductors to determine the fault current, I, and hence the protective device disconnection time, t.

Fault current, $I = \frac{U_0 \times C_{min}}{Z_s}$

where:

U_0 is the nominal voltage to Earth,

C_{min} is the minimum voltage factor to take account of voltage variations depending on time and place, changing of transformer taps and other considerations.

Note: For low voltage supplies given in accordance with the ESQCR, C_{min} is given the value 0.95.

Z_s is the earth fault loop impedance, and

$Z_s = Z_e + R_1 + R_2$

where:

Z_e is that part of the earth fault loop impedance external to the installation

Note: If the distribution board is not at the origin of the installation, Z_e is replaced in the above equation by Z_{db}, that part of the earth fault loop impedance on the supply side of the distribution board.

R_1 is the resistance of the line conductor from the origin of the circuit to the point of utilization

R_2 is the resistance of the protective conductor from the origin of the circuit to the point of utilization.

Similarly, in order to design circuits for compliance with the limiting values of earth fault loop impedance given in Tables 41.2 to 41.4 of BS 7671, it is necessary to establish the relevant impedances of the circuit conductors when the line conductor is at the appropriate maximum permitted operating temperature, as given in Table 52.1 of BS 7671, and the circuit protective conductor is at the appropriate 'assumed initial temperature', as given in Tables 54.2 to 54.5.

Table B1 gives values of (R_1 + R_2) per metre for various combinations of conductors up to and including 50 mm² cross-sectional area. It also gives values of resistance (milliohms) per metre for each size of conductor. These values are at 20 °C.

▼ **Table B1** Values of resistance/metre for copper and aluminium conductors and of (R_1 + R_2) per metre at 20 °C in milliohms/meter

Cross-sectional area (mm²)		Resistance/metre or (R_1 + R_2)/metre (mΩ/m)	
Line conductor	**Protective conductor**	**Copper**	**Aluminium**
1	–	18.10	
1	1	36.20	
1.5	–	12.10	
1.5	1	30.20	
1.5	1.5	24.20	
2.5	–	7.41	
2.5	1	25.51	
2.5	1.5	19.51	
2.5	2.5	14.82	
4	–	4.61	
4	1.5	16.71	
4	2.5	12.02	
4	4	9.22	
6	–	3.08	
6	2.5	10.49	
6	4	7.69	
6	6	6.16	
10	–	1.83	
10	4	6.44	
10	6	4.91	
10	10	3.66	
16	–	1.15	1.91
16	6	4.23	–
16	10	2.98	–
16	16	2.30	3.82
25	–	0.727	1.20
25	10	2.557	–
25	16	1.877	–
25	25	1.454	2.40
35	–	0.524	0.87
35	16	1.674	2.78

Cross-sectional area (mm^2)		Resistance/metre or $(R_1 + R_2)$/metre (mΩ/m)	
Line conductor	Protective conductor	Copper	Aluminium
35	25	1.251	2.07
35	35	1.048	1.74
50	–	0.387	0.64
50	25	1.114	1.84
50	35	0.911	1.51
50	50	0.774	1.28

▼ **Table B2** Ambient temperature multipliers (α) to Table B1

Expected ambient temperature (°C)	Correction factor*
0	0.92
5	0.94
10	0.96
15	0.98
20	1.00
30	1.04
40	1.08

* The correction factor is given by: {1 + 0.004 (ambient temp − 20 °C)} where 0.004 is the simplified resistance coefficient per °C at 20 °C given by BS EN 60228 for copper and aluminium conductors.

To assist anyone using Table B1, the following two formulas may be helpful:

$$R = \frac{m\Omega/m \times L}{1000}$$

$$L = \frac{R \times 1000}{m\Omega/m}$$

For verification purposes the designer will need to give the values of the line and circuit protective conductor resistances at the ambient temperature expected during the tests. This may be different from the reference temperature of 20 °C used for Table B1. The correction factors in Table B2 may be applied to the Table B1 values to take account of the ambient temperature (for test purposes only).

B1 Standard overcurrent devices

Table 41.2
Table 41.3
Table 41.4

Table B3 gives the multipliers to be applied to the values given in Table B1 for the purpose of calculating the resistance at maximum operating temperature of the line conductors and/or circuit protective conductors in order to determine compliance with the earth fault loop impedance of Table 41.2, 41.3 or 41.4 of BS 7671.

▼ **Table B3** Conductor temperature factor F for standard devices

Multipliers to be applied to Table B1 for devices in Tables 41.2, 41.3, 41.4

Conductor installation	Conductor insulation		
	70 °C thermoplastic (PVC)	85 °C thermosetting (note 4)	90 °C thermosetting (note 4)
Not incorporated in a cable and not bunched (notes 1, 3)	1.04	1.04	1.04
Incorporated in a cable or bunched (notes 2, 3)	1.20	1.26	1.28

Table 54.2 **Notes:**

1 See Table 54.2 of BS 7671. These factors apply when protective conductor is not incorporated or bunched with cables, or for separate bare protective conductors in contact with cable covering but not bunched with cables.

Table 54.3 **2** See Table 54.3 of BS 7671. These factors apply when the protective conductor is a core in a cable or is bunched with cables.

3 The factors are given by F = 1 + 0.004 {conductor operating temperature – 20 °C} where 0.004 is the simplified resistance coefficient per °C at 20 °C given in BS EN 60228 for copper and aluminium conductors.

4 If cable loading is such that the maximum operating temperature is 70 °C, thermoplastic (70 °C) factors are appropriate.

GN6

B2 Steel-wire armour, steel conduit and steel trunking

Formulae for the calculation of the resistance and inductive reactance values of the steel-wire armour of cables and of steel conduit, ducting and trunking are published in Guidance Note 6.

Generally, it is accepted that there is approximately a 10 °C difference between the conductor temperature and the outer sheath temperature for a steel-wire armoured cable at full load.

GN1 See also the guidance in the appendices of Guidance Note 1 for mineral insulated copper sheathed cable temperature data.

Index

Q, R