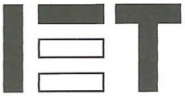
The Institution of Engineering and Technology

On-Site Guide

BS 7671:2018+A2:2022

Updated to BS 7671:2018+A2:2022
IET Wiring Regulations

On-Site Guide



The Institution of Engineering and Technology

On-Site Guide

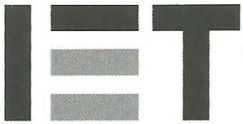
BS 7671:2018+A2:2022

Updated to BS 7671:2018+A2:2022

IET Wiring Regulations

Published by the Institution of Engineering and Technology, London, United Kingdom

The Institution of Engineering and Technology is registered as a Charity in England & Wales (no. 211014) and Scotland (no. SC038698).



The Institution of Engineering and Technology is the institution formed by the joining together of the IEE (The Institution of Electrical Engineers) and the HE (The Institution of Incorporated Engineers).

© 1992, 1995, 1998, 2002, 2004 The Institution of Electrical Engineers
© 2008, 2011, 2015, 2018, 2022 The Institution of Engineering and Technology
First published 1992 (0 85296 537 0)
Reprinted (with amendments) May 1993
Reprinted (with amendments to Appendix 9) July 1993
Reprinted (with amendments) 1994
Revised edition (incorporating Amendment No. 1 to BS 7671:1992) 1995
Reprinted (with new cover) 1996
Revised edition (incorporating Amendment No. 2 to BS 7671:1992) 1998
Second edition (incorporating Amendment No. I to BS 7671:2001) 2002 (0 85296 987 2)
Reprinted (with new cover) 2003
Third edition (incorporating Amendment No. 2 to BS 7671:2001) 2004 (0 86341 374 9)
Fourth edition (incorporating BS 7671:2008) 2008 (978-0-86341-854-9)
Reprinted (with amendments) October 2008
Fifth edition (incorporating Amendment No. I to BS 7671:2008) 2011 (978-1-84919-287-3)
Reprinted 2012
Reprinted (with minor corrections) 2013
Reprinted 2014
Sixth edition (incorporating Amendment No. 3 to BS 7671:2008) 2015 (978-1-84919-887-5)
Reprinted (with minor corrections) 2015
Seventh edition (incorporating 18th Edition to BS 7671:2018) 2018 (978-1-78561-442-2)
Reprinted (with minor corrections) 2018
Eighth edition (incorporating Amendment No. 2 to BS 7671:2018) 2022 (978-1-83953-227-6)

This publication is copyright under the Berne Convention and the Universal Copyright Convention. All rights reserved. Apart from any fair dealing for the purposes of research or private study, or criticism or review, as permitted under the Copyright, Designs and Patents Act, 1988, this publication may be reproduced, stored or transmitted, in any form or by any means, only with the prior permission in writing of the publishers, or in the case of reprographic reproduction in accordance with the terms of licences issued by the Copyright Licensing Agency. Enquiries concerning reproduction outside those terms should be sent to the publishers at The Institution of Engineering and Technology, Michael Faraday House, Six Hills Way, Stevenage, SGI 2AY, United Kingdom.

Copies of this publication may be obtained from:
PO Box 96, Stevenage, SGI 2SD, UK
Tel: +44 (0)1438 767328
Email: sales@theiet.org
https://electrical.theiet.org

While the author, publisher and contributors believe that the information and guidance given in this work are correct, all parties must rely upon their own skill and judgement when making use of them. The author, publisher and contributors do not assume any liability to anyone for any loss or damage caused by any error or omission in the work, whether such an error or omission is the result of negligence or any other cause. Where reference is made to legislation it is not to be considered as legal advice. Any and all such liability is disclaimed.

Permission to reproduce extracts from British Standards is granted by BSI. No other use of this material is permitted. British Standards can be obtained in PDF or hard copy formats from the BSI online shop: https://shop.bsigroup.com/.

ISBN 978-1-83953-227-6 (wiro bound)
ISBN 978-1-83953-229-0 (vitalsource)

Typeset in the UK by the Institution of Engineering and Technology, Stevenage
Printed in the UK by A McLay and Company Ltd, Longwood Drive, Forest Farm, Cardiff, CF14 7ZB

Contents

© The Institution of Engineering and Technology

© The Institution of Engineering and Technology

© The Institution of Engineering and Technology

Cooperating organizations

The Institution of Engineering and Technology acknowledges the invaluable contribution made by the following individuals in the preparation of this Guide:

Institution of Engineering and Technology

J. Bradley BScCEng FIET FCIBSE

M. Coles BEng(Hons) MIET

G.D. Cronshaw CEng FIET

R. Giddings IEng MIET ACIBSE

G. Gundry MIET

M. Peace CEng MIET MCIBSE

Eur Ing L. Markwell MSc BSc(Hons) CEng MIET MCIBSE LCGI

S. Devine IEng MIET

We would like to thank the following organizations for their continued support:

British Cables Association (BCA)

BEAMA

British Gas

British Standards Institution (BSI)

Certsure trading as NICEIC

Department for Levelling Up, Housing and Communities (DLUHC)

ECA

Electrical Contractors' Association of Scotland (SELECT)

NEC Ltd

RINA Tech UK Ltd

Electrical Safety First

Health and Safety Executive (HSE)

NAPIT

The Safety Assessment Federation (SAFed)

Revised, compiled and edited

M. Doughton IEng MIET LCGI

© The Institution of Engineering and Technology

Acknowledgements

References to British Standards, CENELEC Harmonization Documents and International Electrotechnical Commission (IEC) Standards are made with the kind permission of the British Standards Institution (BSI).

Complete copies can be obtained by post from:

BSI Customer Services
389 Chiswick High Road
London, W4 4AL
Tel: +44 0345 080 9000
Email: cservices@bsigroup.com

BSI also maintains stocks of international and foreign standards, with many English translations. Up-to-date information on BSI Standards can be obtained from the BSI website: www.bsigroup.com.

Illustrations of test instruments were provided by G Kenyon Technology Ltd.

Other illustrations, from different sources, are acknowledged within the text.

Cover design and illustration were created by Ken Dobson at Studio Stunt Double: http://studiostuntdouble.com/.

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

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

HSE Books
Customer Services
PO Box 29
Norwich, NR3 1GN
Tel: +44 (0)333 202 5070
Email: hseorders@tso.co.uk
Web: http://books.hse.gov.uk

© The Institution of Engineering and Technology

NOTE

© The Institution of Engineering and Technology

Preface

This Guide is one of a number of publications prepared by the Institution of Engineering and Technology (IET) to explain and enlarge upon the requirements in BS 7671 :2018+A2:2022 *Requirements for Electrical Installations, IET Wiring Regulations.* BS 7671 is a joint publication of the British Standards Institution and the Institution of Engineering and Technology. All references to BS 7671 in the text of this Guidance Note are references to BS 7671:2018+A2:2022, unless otherwise noted.

From herein, BS 7671:2018+A2:2022 is referred to as BS 7671. The year reference will only be included where there is a need to reference a requirement made in an earlier edition, such as BS 7671:2008.

110.1 The scope generally follows that of BS 7671, but also includes material not included in BS 7671, providing background to the intentions of BS 7671 and giving other sources of information. However, it does not ensure compliance with BS 7671. It is a simple guide to the requirements of BS 7671; electrical installers should always consult BS 7671 itself to satisfy themselves of compliance.

It is expected that persons carrying out work in accordance with this Guide will be competent to do so.

HSR25, EAWR Regulation 16 Electrical installations in the United Kingdom that comply with BS 7671, must also comply with all relevant statutory regulations, such as the Electricity at Work Regulations 1989 (EAWR), the Building Regulations and, where relevant, the Electricity Safety, Quality and Continuity Regulations 2002 (ESQCR), as amended.

114.1 It cannot be guaranteed that BS 7671 complies with all relevant statutory regulations,
115.1 It is, therefore, essential to establish which statutory and other appropriate regulations apply and to install accordingly. For example, an installation in licensed premises may have requirements that differ from or are additional to those of BS 7671, and these will take precedence.

Users of this Guide should assure themselves that they have complied with any relevant legislation, including legislation that post-dates the publication.

Part 1 This Guide is concerned with limited application of BS 7671 in accordance with Section 1.1: Scope.

BS 7671 and the *On-Site Guide* are not design guides.

It is essential to prepare a design and/or schedule of the work to be done prior to commencement or alteration of an electrical installation and to provide all necessary information and operating instructions of any equipment supplied to the user on completion.

Any specification should set out the detailed design and provide sufficient information to enable competent persons to carry out the installation and commissioning.

The specification must provide for all the commissioning procedures that will be required and for the production of any operation and maintenance manual and building logbook.

The persons or organizations who may be concerned in the preparation of the specification include the:

- **(a)** designers) (seethe Construction (Design and Management) Regulations 2015 (CDM) for information on designers' duties);
- **(b)** installer(s) (contractor or, if there is more than one, principal contractor and contractors);
- **(c)** electricity distributor
- **(d)** installation owner and/or user
- **(e)** architect
- **(f)** local building control authority/standards division or approved inspector
- **(g)** fire prevention officer
- **(h)** construction (design and management) (CDM) co-ordinator
- **(i)** building information modelling (BIM) co-ordinator
- **(j)** regulatory authorities
- **(k)** licensing authority (where necessary);
- **(l)** Health and Safety Executive (HSE); and
- **(m)** client.

In producing the specification, advice should be sought from the installation owner and/or user as to the intended use. Often, such as in a speculative building, the detailed intended use is unknown. In those circumstances the specification and/or the operation and maintenance manual and building logbook must set out the basis of use for which the installation is suitable.

Precise details of each item of equipment should be obtained from the manufacturer and/or equipment supplier and compliance with appropriate standards confirmed.

The operation and maintenance manual must include a description of how the installed system is to operate and must include all 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 Institution of Engineering and Technology

Building Regulations 2010, Part L 2013 (Amended 2021) of England, for example, requires that building owners or operators are provided with summary information relating to a new or refurbished building which includes building services information and the maintenance requirements in a building logbook. Information on howto develop and assemble a building logbook can be obtained from CIBSE:

Tel: 020 8675 5211

Website: www.cibse.org

Address: CIBSE
222 Balham High Road
London
SW12 9BS

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. Guidance on the preparation of technical manuals is given in BS EN IEC/IEEE 82079-1:2020 *Preparation of instructions for use. Structuring, content and presentation Ceneral principles and detailed requirements* and BS 4940 series (1994) *Technical information on construction products and services.* The size and complexity of the installation will dictate the nature and extent of the manual.

© The Institution of Engineering and Technology

NOTE

© The Institution of Engineering and Technology

Introduction 1

1.1 Scope

This Guide is for installers (for simplicity, the term **installer** is used for electricians and electrical installers). It covers the following installations:

(a) domestic and similar installations, including off-peak supplies, supplies to associated garages, outbuildings and the like; and

(b) small industrial and commercial single- and three-phase installations.

Part 7 NOTE 1: Special Installations or Locations (Part 7 of BS 7671) are generally excluded from this Guide. Advice, however, is given on installations in locations containing a bath or shower and underfloor heating installations.

Chapter 82 **NOTE 2:** Some information is given regarding Prosumers Installations from Chapter 82 but this is an informative overview and does not cover the requirements of Chapter 82 in any depth.

This Guide is restricted to installations:

313.1 **(a)** at a supply frequency of 50 Hz;

(b) at a nominal voltage of 230 V AC single-phase or 400/230 V AC three-phase;

(c) supplied through a distributor's cut-out having a fuse or fuses rated at 100 A or less to one of the following Standards:

- BS 88-2
- BS 88-3
- BS 88-6
- BS 1361 Type II

NOTE: BS 1361 was withdrawn in March 2010 and replaced by BS 88-3; BS 88-2.2 and BS 88-6 were both withdrawn in March 2010 and replaced by BS 88-2 (BS EN 60269-2). However, fuses complying with these withdrawn Standards will be found in existing installations for many years to come.

(d) typical maximum values of earth fault loop impedance, Z_e, for TN earthing arrangements outside the consumer's installation commonly quoted by distributors are as follows:

- ► TN-C-S arrangement - 0.35 Ω, (see Figure 2.1(i)); and
- ► TN-S arrangement - 0.8 Ω, (see Figure 2.1(ii))

NOTE: The values of 0.35 Ω and 0.8 Ω are typical maximum values as quoted by distributors of electricity upon enquiry which will aid, for example, designs for new-build installations.

© The Institution of Engineering and Technology

Table 41.5
542.2.4

For a TT arrangement, 21 Ω is the usual stated maximum resistance of the distributor's earth electrode at the supply transformer. The resistance of the consumer's installation earth electrode should be as low as practicable and an earth electrode resistance or Z_e measurement exceeding 200 Ω may not be stable due to environmental changes, such as drying out in summer and freezing in winter.

Appx E This Guide also contains information that may be required in general installation work, for example, conduit and trunking capacities and the bending radii of cables, etc.

The Guide introduces the use of standard circuits, which are discussed in Section 7. However, due to simplification, this Guide may not give the most economical result.

This Guide is not a replacement for BS 7671, which should always be consulted.

Defined terms according to Part 2 of BS 7671 are used.

In compliance with the definitions in BS 7671, throughout this Guide the term **line conductor** is used instead of **phase conductor** and **live part** is used to refer to a conductor or conductive part intended to be energized in normal use, including a neutral conductor.

The terminals of electrical equipment are identified by the letters L, N and E (or PE).

Further information is available in the series of Guidance Notes published by the IET:

- GN 1 *Selection & Erection*
- GN 2 *Isolation & Switching*
- GN 3 *Inspection & Testing*
- GN 4 *Protection Against Fire*
- GN 5 *Protection Against Electric Shock*
- GN 6 *Protection Against Overcurrent*
- GN 7 *Special Locations*
- GN 8 *Earthing & Bonding*

NOTES:

For clarification:

- the *distributor* of electricity is deemed to be: "A party that distributes electricity to consumers using electrical lines and equipment they own or operate" and
- the *supplier* of electricity is the organisation from whom electricity is purchased.

1.2 Building Regulations

Refer to the IET publication *Electrician's Guide to the Building Regulations* for more in-depth guidance on electrical installations in dwellings.

1.2.1 England: the Building Regulations 2010

Persons carrying out electrical work in dwellings must comply with the Building Regulations of England, in particular Part P (Electrical safety - dwellings).

© The Institution of Engineering and Technology

Persons responsible for work within the scope of Part P of the Building Regulations may also be responsible for ensuring compliance with other Parts of the Building Regulations, where relevant, particularly if there are no other parties involved with the work. Building Regulations requirements relevant to installers carrying out electrical work include the following:

Part	Title	Examples of relevance to electrical installers
A	Structure	Depth of chases in walls, sizes of holes and notches in floor and roof joists
B	Fire safety	Fire safety of certain electrical installations; provision of fire alarm and fire detection systems; fire resistance of penetrations through floors and walls
C	Site preparation and resistance to contaminants and moisture	Moisture resistance of cable penetrations through external walls
D	Toxic substances	Cable jointing compounds, galvafroid paint, use of solvents
E	Resistance to the passage of sound	Penetrations through floors, ceilings and walls
F	Ventilation	Ventilation rates for dwellings
G	Sanitation, hot water safety and water efficiency	Electric water heating
K	Protection from falling collision and impact	Electrical means of opening windows
L	Conservation of fuel and power	Energy efficient lighting
M	Access to and use of buildings	Mounting heights of switches, socket-outlets etc. and consumer units
P	Electrical safety - dwellings	All electrical work within dwellings, of which some is notifiable
R	Physical infrastructure for high speed electronic communications networks	Installation of data networks and equipment
Regulation 7	Materials and workmanship	Implementation of European Regulation 305/201 1/EU-CPR covering construction products, referred to as the Construction Products Regulation (CPR).

NOTE: Guidance is available for each part of the Building Regulations in the form of approved documents which can be freely downloaded from the Department for Levelling Up, Housing and Communities (DLUHC) website: http://www.gov.uk/planning-permission-england-wales

© The Institution of Engineering and Technology

1.2.2 The Building (Scotland) Regulations 2004 (as amended)

The detailed requirements are given in the Technical Standards for compliance with the Building (Scotland) Regulations.

Guidance on how to achieve compliance with these Standards is given in two Scottish Building Standards Technical Handbooks - Domestic and Non-domestic.

These handbooks contain recommendations for electrical installations, covering the following:

(a) compliance with BS 7671;
(b) the minimum number of socket-outlets in dwellings;
(c) the minimum number of lighting points in dwellings;
(d) the minimum illumination levels in common areas of domestic buildings, for example, blocks of flats;
(e) the range of mounting heights of switches and socket-outlets, etc.;
(f) separate switching for concealed socket-outlets, for example, behind white goods in kitchens; and
(g) conservation of fuel and power in buildings.

With regard to electrical installations in Scotland, the requirements of the above are deemed to be satisfied by compliance with BS 7671.

NOTE: The handbooks are available in electronic format only from the Building Standards Division of the Scottish Government from website: www.scotland.gov.uk/bsd

1.2.3 The Building Regulations of Northern Ireland

The Building Regulations (Northern Ireland) 2000 (as amended) apply.

NOTE: Information can be obtained from the website: www.buildingconlrol-ni.com

1.2.4 The Building Regulations of Wales

On 31st December 2011 the power to make building regulations for Wales was transferred to Welsh ministers. This means Welsh ministers make any new building regulations or publish any new building regulations guidance applicable in Wales from that date.

The Building Regulations 2010 and related guidance for England and Wales, including approved documents as at that date, will continue to apply in Wales until Welsh ministers make changes to them. The latest update was published July 2018 and information can be obtained from their website: https://gov.wales/building-regulations

© The Institution of Engineering and Technology

313.1

1.3 Basic information required

Before starting work on an installation that requires a new electrical supply, the installer should establish the following information with the local electricity distributor:

(a) the number of live conductors required by the design
(b) the distributor's requirement for cross-sectional area (csa) and maximum length of the consumer's tails (see NOTE below)
(c) the maximum prospective fault current ($I_p f$) at the supply terminals
(d) the typical maximum earth fault loop impedance (Z_e of the earth fault path outside the consumer's installation
(e) the type and rating of the distributor's fusible cut-out or protective device

544.1 **(f)** the distributor's requirements regarding the size of main protective bonding conductors

312 **(g)** the conductor arrangement and system earthing; and
(h) the arrangements for the incoming cable and metering.

NOTE: Some distributors will specify a maximum permitted length for consumer's tails. The distributor may also apply particular requirements for isolation or protection.

132.16 For additions and alterations to existing installations, installers should satisfy themselves as to the suitability of the supply, the distributor's equipment and the earthing and bonding arrangements.

120.3

1.4 Intended departures from BS 7671

Where the designer decides to depart from the requirements of BS 7671, the resulting degree of safety must not be less than that obtained by compliance with the Regulations. The designer is responsible for the safety of the design. Any intended departure from the requirements of BS 7671, although the designer is confident regarding safety, must be recorded on the Electrical Installation Certificate (EIC). There is a difference between an intended departure and a non-compliance. Note the following distinction:

(a) an intended departure must be recorded on the EIC
(b) an intended departure not recorded on the EIC is unacceptable, as it is simply a non-compliance and the certificate would, therefore, be worthless.

© The Institution of Engineering and Technology

NOTE

© The Institution of Engineering and Technology

The electrical supply 2

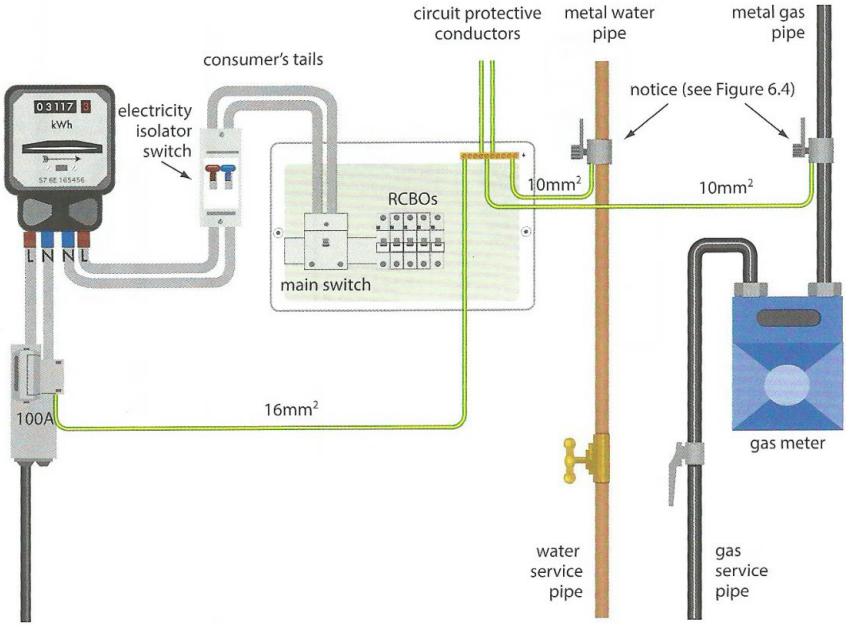
2.1 General layout of equipment

The general layout of the equipment at the service position is shown in Figures 2.1(i) to 2.1(iii), including typical protective conductor cross-sectional areas.

The following scenarios are considered:

(a) Figure 2.1(i) TN-C-S (protective multiple earthing - PME) earthing arrangement;
(b) Figure 2.1(ii) TN-S earthing arrangement (cable sheath earth); and
(c) Figure 2.1(iii) TT earthing arrangement (no distributor's earth provided/used).

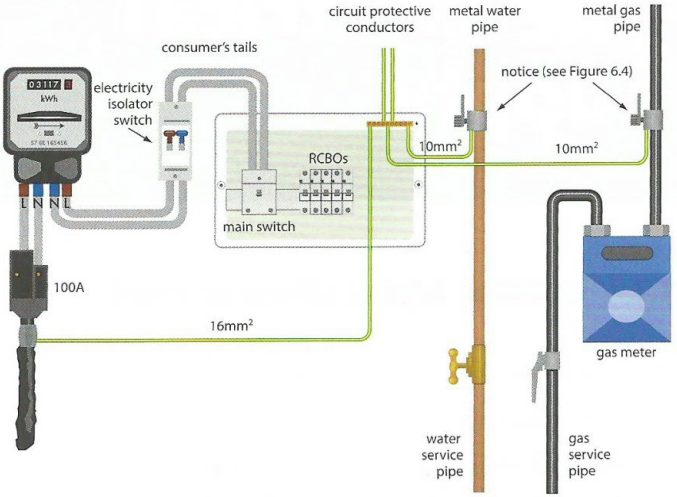
▼ **Figure 2.1 (i)** TN-C-S (PME) earthing arrangement



NOTE: An electricity isolator switch may not always be installed by the distributor.

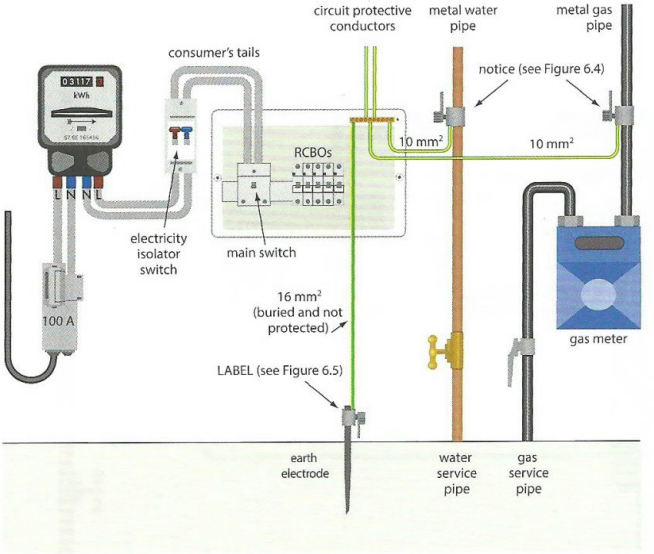
© The Institution of Engineering and Technology

▼ **Figure 2.1 (ii)** TN-S earthing arrangement (cable sheath earth)



NOTE: An electricity isolator switch may not always be installed by the distributor.

▼ **Figure 2.1 (iii)** TT earthing arrangement (no distributor's earth provided/used)



NOTES:

1 An electricity isolator switch may not always be installed by the distributor.

542.3.1 2 See Table 4.4(iii) for further information regarding the sizing of the earthing conductor for a TT earthing arrangement.

3 See 2.2.6 for requirements for consumer unit enclosures.

© The Institution of Engineering and Technology

2.2 Function of components

2.2.1 Distributor's cut-out

This will be sealed to prevent the fuse being withdrawn by unauthorized persons. When the consumer's tails and consumer unit are installed in accordance with the requirements of the distributor, the cut-out may be assumed to provide protection against fault current up to the consumer's main switch.

As the cut-out is the property of the distributor, installers must not cut seals and withdraw cut-out fuses without permission. Where removal of the cut-out for isolation is required, the supplier of electricity should be contacted to arrange disconnection and subsequent reconnection. Should an installer encounter a distributors seal which has already been broken or removed it is recommended that this is notified to the person ordering the work before work commences.

NOTE: The supplier of electricity may not be the same organization as the distributor; (see 1.1).

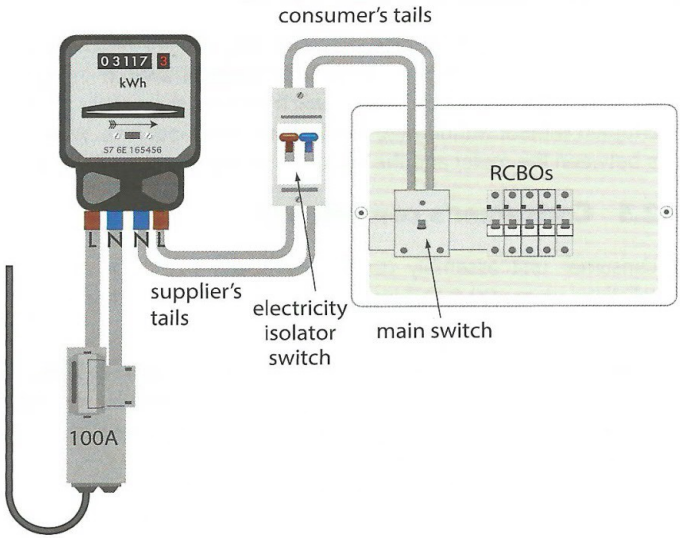
2.2.2 Electricity meter

The terminals will be sealed by the meter owner to prevent interference by unauthorized persons.

2.2.3 Meter tails

521.10.1 Meter tails fall into two categories, consumer's tails and supplier's tails. There is a need to differentiate between the two.

▼ **Figure 2.2.3** Meter tails



© The Institution of Engineering and Technology

2.2. 3.1 Consumer's tails

The cables between the electricity meter and the consumer unit, known as the consumer's tails, are part of the consumer's installation and should be insulated and non-metallic sheathed or insulated and enclosed within containment, for example, conduit or trunking. Consumer's tails are provided by the installer and are the responsibility of the owner of the electrical installation.

514.3.1 Polarity should be indicated by the colour of the insulation and the minimum cable size should be 25 mm ^{2}. The distributor may specify the maximum length of tails between the meter and the consumer unit in addition to the minimum cross-sectional area (see 1.3). In some cases, the distributor may require an electricity isolator switch (see 2.2.4).

434.3(iv) Where the consumer's tails are protected against fault current by the distributor's cut-out, the method of installation, maximum length and minimum cross-sectional area of the tails must comply with the requirements of the distributor.

2.2.3.2 Supplier's tails

The cables between the distributor's cut-out and the electricity meter, known as the supplier's tails, are part of the supplier's equipment.

522.6.202 522.6.203 Where tails are buried in walls or enclosed within the fabric of the building, further protection is required (see 7.3.2).

It is important that both supplier's and consumer's tails are sufficiently protected from mechanical damage and disturbance by the use of trunking and/or cable clips; see 2.2.6 of this Guide.

2.2.4 Electricity isolator switch

Distributors may provide and install an electricity isolator switch between the meter and the consumer unit, labelled as **'electricity isolator switch'** in Figures 2.1(i) to 2.1(iii) and Figure 2.2.3. This double-pole switch permits the supply to the installation to be interrupted without withdrawing the distributor's cut-out fuse. Where this is the case the tails between the meter and the electricity isolator are part of the supplier's equipment.

2.2.5 Consumer's controlgear

536.4.201 A consumer unit assembly (to BS EN 61439-3:2012) is for use on single-phase installations up to 100 A and may include the following components:

- **(a)** a double-pole isolator;
- **(b)** fuses, circuit-breakers or residual current circuit-breakers (with overcurrent protection) (RCBOs) for protection against overload and fault currents;
- **(c)** residual current devices (RCDs) for additional protection against electric shock
- **(d)** RCDs for fault protection;
- **(e)** arc fault detection devices (AFDDs) for additional protection against fire; and
- **(f)** surge protection device(s) (SPDs) where required.

© The Institution of Engineering and Technology

Alternatively, a separate main switch and distribution board may be provided.

All devices and components shall only be those declared suitable according to the assembly manufacturer's instructions or literature. The scope of BS EN 61439-3 includes distribution boards with an incoming rated current not exceeding 250 A and outgoing circuits not exceeding 125 A. They are intended to be operated by ordinary persons. They can be used in domestic and commercial single and three-phase installations up to 100 A within the scope of this Guide.

See IET Guidance Note 1 and the BEAMA guide: Overload protection of an RCCB or switch in an LV assembly to BS EN 61439-3.

2.2.6 Consumer unit assemblies

421.1.201 Where a consumer unit assembly is installed in domestic (household) premises one of the following applies:

- the enclosure is to be manufactured from non-combustible material; or
- the consumer unit is to be enclosed in a cabinet constructed from non-combustible material.

Ferrous metal, i.e. steel, is deemed to be an example of a non-combustible material.

Plastic enclosures manufactured from 960 °C degree glow-wire rated material would **not** be classified as 'non-combustible' in the context of this Regulation.

Where a steel consumer unit is installed in an installation forming part of a TT system, the earth fault loop impedance, Z_e, is likely to be much higher than the maximum permitted for use of the overcurrent protective device (OCPD), i.e. cut-out, in order to provide fault protection. Should the consumer's tails become loose or damaged and make contact with the metal enclosure, it is likely that the overcurrent device will not operate within the maximum permitted time of 1 s.

421.1.201 The IET's Wiring Regulations Policy Committee, therefore, advises the following:

(a) a Class I metal consumer unit is installed and each outgoing circuit is protected by an RCBO; and

31.3.5.3.2.201 **(b)** a split, Class I metal consumer unit is installed, where the double-pole main switch of the consumer unit should incorporate an S-type (time-delayed) residual current circuit-breaker (RCCB), for example 100 mA S-type RCCB.

NOTE: In cases where RCBOs protect each outgoing circuit, the risk of the solid busbar (connecting the supply side of each RCBO) making contact with the ferrous enclosure is minimal. In split consumer units, where two or three RCCBs protect multiple circuits through individual circuit-breakers, the risk of the single-insulated conductors (connecting the load side of the double-pole main switch to the supply side of the RCCBs) making contact with the ferrous enclosure due to vibration and/or abrasion or being damaged is far higher. In essence, where the construction and layout of the consumer unit is such that the risk of live conductors making contact with the ferrous enclosure is minimal, then the double-pole main switch need not incorporate an S-type RCCB.

© The Institution of Engineering and Technology

In all cases:

412.2.4.1
531.3.5.3.2.201

(a) the consumer's tails need to meet the requirements for the protective measure of double or reinforced insulation throughout their length. This can be achieved by the use of single-core insulated and non-metallic sheathed cable with the sheath being kept on the right up to the terminals of the incoming device (main switch or RCD) of the consumer unit.

522.8.1

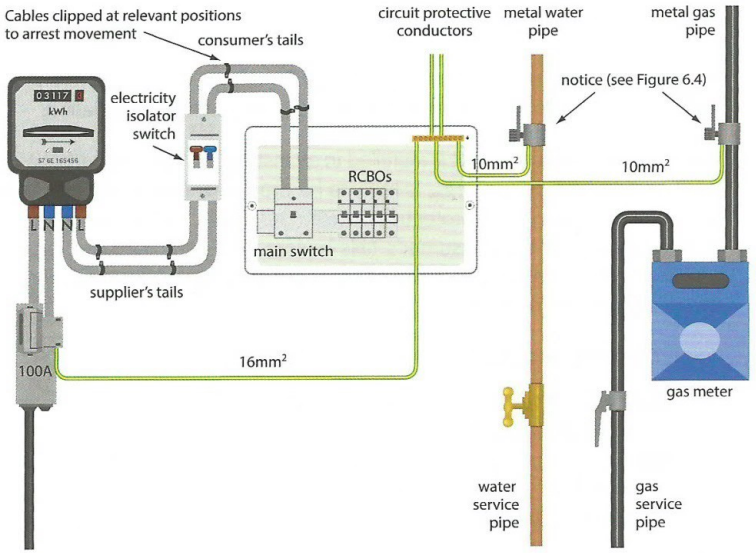
(b) the consumer's tails need to be protected to avoid mechanical damage and disturbance at the incoming terminals in the consumer unit in order to avoid:

(i) the line conductor becoming disconnected and making contact with the metal enclosure; and

(ii) the incoming terminals becoming loose, which may give rise to arcing and/or fire.

This can be achieved by, for example, clipping or clamping the consumer's tails, or by installing them in trunking and the use of a suitable cable entry gland. In all cable entry arrangements, the enclosure shall not have sharp edges that could damage cables.

▼ **Figure 2.2.6** Example of clipping tails to arrest movement



412.2.2.1
416.2.2

(c) the cable installation entry method shall, so far as is reasonably practicable, maintain the fire containment of the enclosure. It is essential that account is taken of the manufacturer's instructions, if any.

This can generally be achieved by the installer ensuring that cable access holes made in the enclosure do not leave gaps greater than:

(i) 1.0 mm for the horizontal top surface; and

(ii) 2.5 mm for all other surfaces of the enclosure that are accessible after installation.

© The Institution of Engineering and Technology

The installer could for example, select (as they deem appropriate) trunking, conduit, cable gland or cable entry accessories to minimize the opening around the cables.

522.8.1
521.5.1

(d) the consumer's tails also need to be protected to avoid any foreseeable damage and, where entering a ferrous enclosure, need to do so through the same entry point.

A non-combustible enclosure includes the base, cover, door and any components, such as the hinges, covers, screws and catches necessary to maintain fire containment. Devices and blanks are contained within the non-combustible enclosure and, therefore do not have to be manufactured from a non-combustible material, such as steel. However, the use of non-combustible blanks is not precluded. Any unused ways in the consumer unit must be closed off using blanks to provide at least IP XXB protection.

NOTE: This information on consumer units has been kindly provided by BEAMA. Further information can be found at: http://www.beama.org.uk/en/publications/technical-bulletins.cfm

Where the consumer unit is to be located in an external, non-habitable building, such as a garage or shed, which is not in close proximity to a dwelling, consideration could still be given to installing a consumer unit of non-ferrous construction. The term 'not in close proximity' is always a moot point and the decision to install a non-ferrous enclosure must be supported by a documented risk assessment by a skilled person (electrically), which must be appended to the Electrical Installation Certificate (EIC).

2.3 Separation of gas installation pipework from the electrical installation

Where gas installation pipework is not separated from electrical equipment or cables by an insulating enclosure, dividing barrier, trunking, or conduit, the following separation distances shall be observed:

(a) at least 150 mm away from electricity supply equipment, such as metering equipment and main service cut-outs or supplier (main) isolation switches and distribution boards or consumer units; and

(b) at least 25 mm away from electrical switches, sockets and electricity supply and distribution cables.

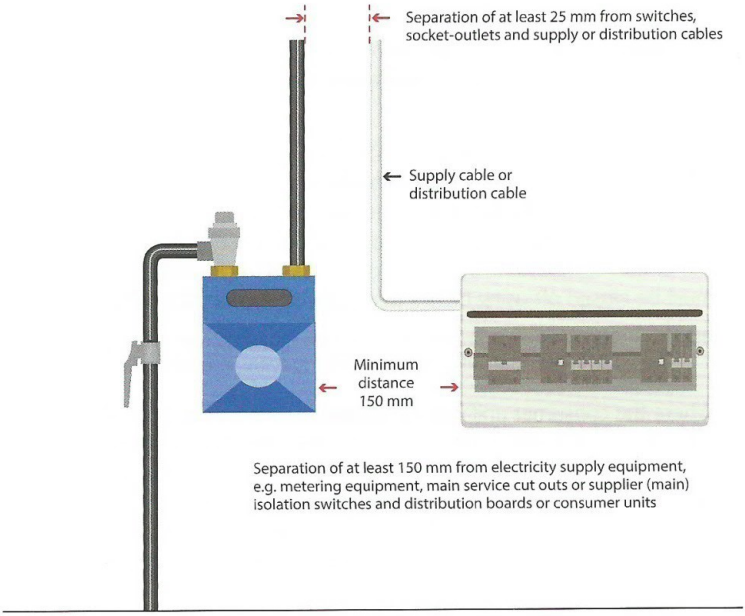
The installation pipework shall not be positioned in a manner that prevents the operation of any electrical accessory, i.e. a switch or socket-outlet.

NOTE: Where these spacing requirements are impracticable the pipework should either be sheathed with an electric insulating material rated at 230 V or more, or a panel of electrical insulating material should be interposed.

The cited distances are quoted within Clause 8.4.2 of BS 6891 :2O15+A1 :2019 *Specification for the installation and maintenance of low pressure gas installation pipework of up to 35 mm* ("RI'/*) *on premises.*

© The Institution of Engineering and Technology

528.3.4 ▼ Figure 2.3 Separation from the gas installation



551.4.4

2.4 Portable generators

It is recognized that generators will be used occasionally as a temporary or short-term means of supplying electricity for use, for example:

(a) on a construction site;
(b) on stalls at a street market; or
(c) at an external gathering or function attended by the general public, such as a country show.

This Guide considers three scenarios relating to the use of portable generators: see 2.4.1 to 2.4.3.

For information relating to the permanent use of generators see IET Guidance Notes 5 and 7 and Section 551 of BS 7671. Further information on the use of temporary generators is available in the IET *Practitioner's Guide to Temporary Power.*

Where generators are used to supply mobile or transportable units such as catering vans or temporary buildings, see also Section 717 Mobile and Transportable Units of BS 7671 and IET Guidance Note 7.

© The Institution of Engineering and Technology

551.4.4

2.4.1 Electrically separated generator systems

The windings of smaller portable generators are often isolated from the mass of Earth and the protective conductor, i.e. there is no connection between the chassis and/or earth connection of the socket-outlet(s) of the unit and either of the live conductors of the generator winding. The ends of the generator winding are brought out to one or more three-pin socket-outlets which should preferably conform to BS EN 60309-2. The protective conductor of the socket-outlet(s) is usually connected internally to the frame of the generator only (see Figure 2.4.1).

413
418.3

The electrical system connected to this type of earthing arrangement is a form of **electrical separation**, where basic protection is provided by basic insulation of live parts or by barriers and enclosures, and fault protection is provided by simple separation of the separated circuit from other circuits and from Earth. The requirements for electrical separation can be found in Section 413 of BS 7671 where one item of equipment is supplied and Regulation 418.3 where more than one item of equipment is supplied by the separated circuit. However, the requirements of Regulation 418.3 could prove difficult or impracticable to meet in a typical application of a portable generator.

It is extremely important to note that a portable generator isolated from earth should only be used to supply equipment in the following permutations:

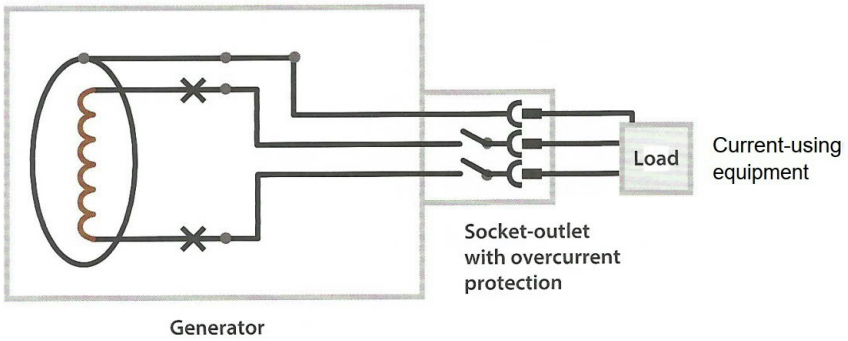
(a) one or more items of Class II equipment;
(b) one item of Class I equipment; or
(c) one or more items of Class II and one item of Class I equipment.

The supply of only Class II equipment, however, is preferable.

No more than one item of Class I equipment should be supplied at any time unless further measures are put in place. This is because first faults will go undetected, putting users at risk of shock in the event of a second fault (as the users can provide a path for current flowing between exposed-conductive-parts of faulty electrical equipment).

© The Institution of Engineering and Technology

▼ **Figure 2.4.1** Portable generator using electrical separation as the protective measure



551.4.4

2.4.2 Portable generator used without an Earth electrode

Where a generator is used for a short duration, or is powering a simple system (e.g. a mobile unit), and providing the connecting cables are adequately protected from mechanical damage, it may not be necessary to connect the system to the mass of Earth. It is important to ensure that the protective conductor connections of the socket-outlets at the generator are connected to the neutral of the generator winding in addition to the chassis or frame of the generator (see Figure 2.4.2). This arrangement is described as a 'floating earth' as the source of supply is not connected to the mass of Earth.

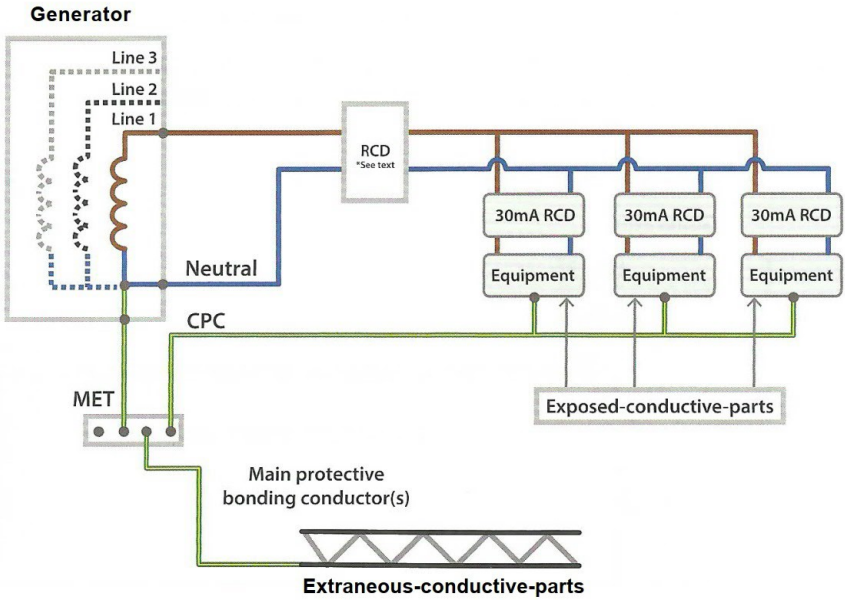
Such a configuration will provide a return path for any fault current caused by contact between live parts and exposed-conductive-parts of the connected equipment, enabling automatic disconnection of supply (ADS) to be used as the protective measure, as is common with most installations. If this arrangement is used and the system is not connected to the mass of Earth, it constitutes a departure from BS 7671 Regulation 411.4.1 as Earth does not form part of the fault path.

With this configuration, neither of the live conductors of the generator are connected to the conductive mass of the Earth. If this method of supply is used, care should be taken to ensure that there is no intended or casual interconnection with any other electrical system, such as extraneous conductive-parts or exposed-conductive-parts from other electrical systems.

As an additional protective measure, distribution circuits supplied from the generator output should be protected by an RCD operating at no more than 100 mA with a time delay not more than 200 ms. This is to provide detection of faults caused by unintentional earthing of the system, such as may occur with Class I equipment in contact with the mass of Earth (e.g. a metal-framed distribution unit on the ground). The settings will allow selectivity with other 30 mA RCDs providing Additional Protection on final circuits.

© The Institution of Engineering and Technology

▼ **Figure 2.4.2** Generator with floating earth arrangement



2.4.3 Portable generator with Earth Electrode

For longer term use, or if there are several circuits supplied by the generator a reliable connection with Earth is required. Connecting the system to Earth allows for detection of insulation faults in the distribution - see Figure 2.4.3.

Note that this does not create a TT system; the system will be TN-S from the generator, with the neutral or star point being connected to the conductive mass of the Earth. Where an earth electrode is supplied it will need to be tested by the standard method using a proprietary earth electrode resistance tester; (see 10.3.5.2). Note that an earth fault loop impedance tester cannot be used for this test as the earth electrode does not form part of the earth fault loop path.

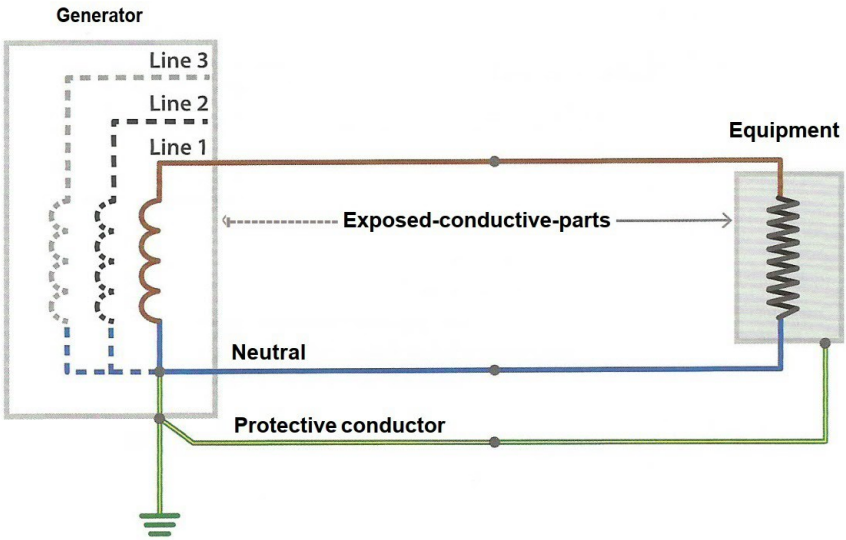
The required value of electrode resistance is determined by the protective devices on the output of the generator. For example, if a single-phase 8 kVA generator has a Type C 32 A circuit breaker on the output, in order to disconnect following a distribution cable insulation fault of negligible impedance to the mass of Earth, a current of 320 A must flow to meet the required disconnection time. At a supply voltage of 230 V (note $C_m i_n$ does not apply) this requires an electrode value of 0.72 Ohms or less. In practice such a value will be very hard to achieve for a temporary system and so it is common to use RCDs or Residual Current Monitors to provide ADS.

© The Institution of Engineering and Technology

In practice the installation of an earth electrode for a temporary system is unlikely to produce a sufficiently low resistance to enable overcurrent protective devices to operate. Because of this it is most common to use RCDs or Residual Current Monitors to provide ADS.

Chapter 54 The requirements of BS 7671 Chapter 54 apply. For generator fault currents, manufacturers advice should be complied with as the ability of a generator to sustain high fault currents varies.

▼ **Figure 2.4.3** Generator using earth electrode



Where restrictions, such as concreted/paved areas or where the portable generator is being used some distance above ground level, make it impossible to install an earth electrode and it is not suitable to operate the system un-earthed as described in 2.4.1, other earthed metalwork may be used, such as metal fencing or structural steelwork. Connections to street furniture with an electrical installation such as street lighting or other electrical systems of buildings should be avoided.

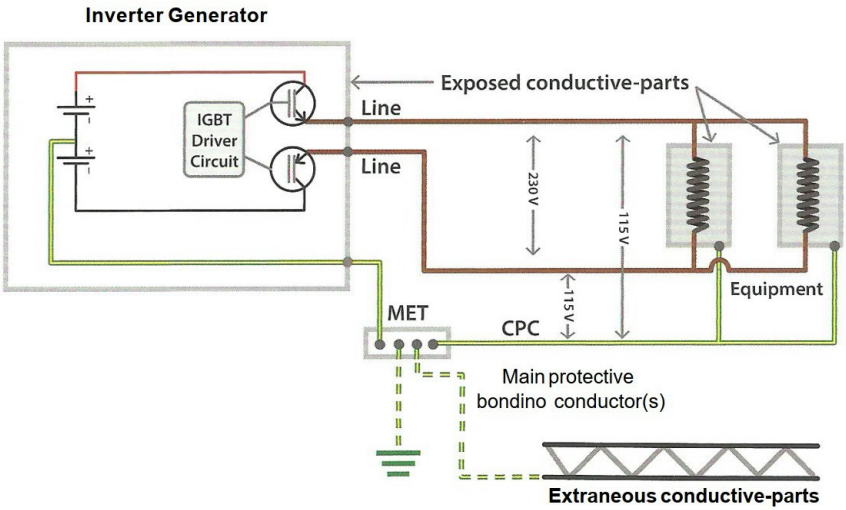
419

2.4.4 Inverter generators

Because traditional engine/alternator generators can suffer stability issues when powering low-energy loads such as LED lighting, the use of electronic inverter generators are increasingly common. These have the appearance of being centre-tapped to earth (see Figure 2.4.4) and test equipment may not function correctly.

© The Institution of Engineering and Technology

▼ **Figure 2.4.4** Inverter generator configuration



Such arrangements should be treated in the same way as those in 2.4.2 or 2.4.3, though they may not sustain high fault currents and the requirements of BS 7671 regulation group 419 may apply.

© The Institution of Engineering and Technology

NOTE

© The Institution of Engineering and Technology

Protection 3

3.1 Types of protective device

The consumer unit (or distribution board) may contain devices providing:

433 **(a)** protection against overload current;

434 **(b)** protection against short-circuit current and earth fault current;

411.3.2 **(c)** automatic disconnection in case of a fault (fault protection);

415.1 **(d)** additional protection (electric shock protection) by means of 30 mA residual current devices (RCD(s));

421.1.7 **(e)** additional protection against fire may also be included (arc fault detection devices (AFDDs)); and

443 **(f)** protection against transient overvoltage may be included (surge protection devices (SPDs)).

Functions (a) and (b) are usually carried out by one device, i.e. a fuse or circuit-breaker.

434 Function (c) is usually carried out by the device performing function (b), except where a high value of earth fault loop impedance makes the use of a fuse or circuit-breaker for function (c) impracticable (such as a TT system), in which case an RCD has to be used.

434 411 A residual current circuit-breaker with integral overcurrent protection (RCBO), being a unit with a combined circuit-breaker and RCD, will carry out functions (a) to (d).

Appendix 3 533.1

3 2 Protection against overload current

Protection against overload current will be provided by the use of any of the following devices:

(a) fuses to BS 88-2 (BS EN 60269-2), BS 88-3, BS 88-6, BS 1361 or BS 3036;
(b) circuit-breakers to BS 3871-1 types 1, 2 and 3;
(c) circuit-breakers to BS EN 60898 types B, C and D; and
(d) RCBOs to the BS EN 61009 series and to BS EN 62423.

NOTE: BS 3871-1 has been withdrawn and is replaced by BS EN 60898-1:2019; however, these devices are likely to be present in older installations.

© The Institution of Engineering and Technology

3.3 Protection against short-circuit current and earth fault current

When a consumer unit to BS EN 61439-3:2012 or BS 5486: Part 13 or a fuseboard having fuse links to BS 88-2 (BS EN 60269-2) or BS 88-6 or BS 1361 is used, protection against short-circuit current and earth fault current will be provided by that particular overcurrent protective device (OCPD).

NOTE: BS 5486: Part 13 has been withdrawn; however, consumer units to this standard may still be found in older installations.

For other protective devices the breaking capacity must be adequate for the prospective fault current at their point of installation.

3.4 Protection against electric shock

3.4.1 Automatic disconnection of supply (ADS)

411 ADS is the most the common method of protection against electric shock. There are two
411.1 elements to ADS: **basic protection** and **fault protection.**

411.2 3.4.1.1 Basic protection

411.1 Basic protection is the physical barrier between persons/livestock and a live part.
416 Examples of basic protection are:

416.1 **(a)** electrical insulation; and
416.2 **(b)** enclosures and barriers.

521.10.1 It follows that single-core non-sheathed insulated conductors must be protected by conduit or trunking and be terminated within a suitable enclosure.

415.1.1 A 30 mA RCD may be provided to give additional protection against contact with live
415.1.2 parts but must not be used as primary protection.

411.3 3.4.1.2 Fault protection

411.1 Fault protection comprises:

411.3.1.1 **(a)** protective earthing;
411.3.1.2 **(b)** protective equipotential bonding; and
411.3.2 **(c)** automatic disconnection in case of a fault.

Fault protection works by limiting the magnitude and duration of voltages that may appear under earth fault conditions between simultaneously accessible exposed-conductive-parts of equipment and between them and extraneous-conductive-parts or Earth.

© The Institution of Engineering and Technology

3.4.2 Other methods of protection against electric shock

410.3.3 In addition to ADS, BS 7671 recognizes other methods of protection against electric shock.

414 3.4.3 SELV and PELV

SELV

Separated extra-low voltage .(SELV) systems:

414.3 **(a)** are supplied from isolated safety sources such as a safety isolating transformer to BS EN 61558-2-6 or BS EN 61558-2-8;

(b) have no live part connected to earth or the protective conductor of another system;

414.4.1 **(c)** have basic insulation from other SELV and protective extra-low voltage (PELV) circuits;

(d) have double or reinforced insulation or basic insulation plus earthed metallic screening from LV circuits; and

414.4.4 **(e)** have no exposed-conductive-parts connected to earth or to exposed-conductive-parts or protective conductors of another circuit.

PELV

414.4.1 Protective extra-low voltage (PELV) systems must meet all the requirements for SELV, except that the circuits are not electrically separated from earth.

414.4.5 For SELV and PELV systems, basic protection need not be provided if voltages do not exceed those given in Table 3.4.3.

▼ **Table 3.4.3** SELV and PELV basic protection voltage limits

Location	SELV and PELV
Dry areas	25 V AC or 60 V DC
Immersed equipment	Further protection required at all voltages
Locations containing a bath or shower, swimming pools, saunas	Further protection required at all voltages
Other areas	12 V AC or 30 V DC

411 3.5 Automatic disconnection

3.5.1 Standard circuits

For the standard final circuits given in Section 7 of this Guide, the correct disconnection time is obtained for the protective devices by limiting the maximum circuit lengths.

© The Institution of Engineering and Technology

Table 41.1

3.5.2 Disconnection times: TN systems

411.3.2.2 A disconnection time of not more than 0.4 s is required for final circuits not exceeding:

- 63 A with one or more socket-outlets; and
- 32 A when supplying only fixed equipment.

411.3.2.3 A disconnection time of not more than 5 s is permitted for:

- final circuits exceeding 32 A, (excluding circuits with socket-outlets); and
- distribution circuits.

Table 41.1

3.5.3 Disconnection times -TT systems

411.3.2.2 The required disconnection times for installations forming part of a TT system can, except in the most exceptional circumstances outside the scope of this Guide, only be achieved by protecting every circuit with an ROD,hence, a time of not more than 0.2 s is required for final circuits not exceeding:

- 63 A with one or more socket-outlets; and
- 32 A when supplying only fixed equipment.

411.3.2.4 A disconnection time of not more than 1 s is permitted for:

- final circuits exceeding 32 A, (excluding circuits with socket-outlets); and
- distribution circuits.

3.6 Residual current devices (RCDs)

RCD is the generic term for a device that operates when the residual current in the circuit reaches a predetermined value. The RCD is, therefore, the main component in an RCCB (residual current operated circuit-breaker without integral overcurrent protection) or one of the functions of an RCBO (residual current operated circuit-breaker with integral overcurrent protection).

3.6.1 Types of RCD

531.3.3 Different types of RCD are manufactured and they vary depending on their behaviour in the presence of DC components and frequencies. The appropriate type of RCD shall be selected from the following:

(a) RCD Type AC: RCD tripping on alternating sinusoidal residual current, suddenly applied or smoothly increasing. Type AC RCDs shall only be used to serve fixed equipment, where it is known that the load contains no DC components. Examples of fixed equipment containing no DC components include electric heating appliances and simple filament lighting which does not include electronic transformers or dimmer controls.

(b) RCD Type A: RCD tripping on alternating sinusoidal residual current and on residual pulsating direct current, suddenly applied or smoothly increasing.

© The Institution of Engineering and Technology

(c) RCD Type F: RCD for which tripping is achieved as for Type A, and in addition:

(i) for composite residual currents, whether suddenly applied or slowly rising, intended for a circuit supplied between line and neutral or line and earthed middle conductor; and

(ii) for residual pulsating direct currents superimposed on a smooth direct current.

(d) RCD Type B: RCD for which tripping is achieved as for Type F, and in addition:

(i) for residual sinusoidal alternating currents up to 1 kHz;

(ii) for residual alternating currents superimposed on a smooth direct current;

(iii) for residual pulsating direct currents superimposed on a smooth direct current;

(iv) for residual pulsating rectified direct current which results from two or more phases; and

(v) for residual smooth direct currents, whether suddenly applied or slowly increased, independent of polarity.

For general purposes, only Type A RCDs may be used.

For further guidance on the correct use of RCDs for household and similar use, see PD IEC/TR 62350 *Guidance for the correct use of residual current operated protective devices (RCDs) for household and similar use.*

3.6.2 Protection by RCDs

RCDs are required for:

411.4
411.5
(a) fault protection where the earth fault loop impedance is too high to meet the required disconnection time, for example, where the distributor does not provide a connection to a means of earthing, i.e. TT earthing arrangement;

411.3.3
(b) In AC systems, additional protection by means of an RCD with a rated residual operating current not exceeding 30 mA shall be provided for:

Appendix 5
(i) socket-outlets with a rated current not exceeding 32 A in locations where they are liable to be used by persons of capability BAI, BA3 or children (BA2, BA3);

411.3.3(ii)
(ii) additional protection for socket-outlets not exceeding 32 A in other locations; and

(iii) mobile equipment with a rated current not exceeding 32 A for use outdoors.

Note 2 to Regulation 411.3.3: RCD protection of all socket-outlets is recommended.

411.3.4
(c) additional protection for lighting circuits in domestic (household) premises;

701.411.3.3
(d) additional protection for all low voltage circuits serving locations containing a bath or shower;

701.411.3.3
(e) additional protection for all low voltage circuits passing through zones 1 and 2 of locations containing a bath or shower but not serving equipment within the location;

© The Institution of Engineering and Technology

522.6.202 **(f)** additional protection for cables without earthed metallic covering installed in walls or partitions at a depth of less than 50 mm and not protected by earthed steel conduit, earthed trunking or earthed ducting; and

522.6.203 **(g)** additional protection for cables without earthed metallic covering installed in walls or partitions with metal parts (not including screws or nails) and not protected by earthed steel conduit or the like.

Note 4 to Regulation 411.3.3 clarifies those means of connection which are not considered to be a socket outlet as: "A lighting distribution unit complying with BS 5733, shaver supply unit complying with BS EN 61558-2-5, luminaire track system, installation coupler, LSC or DCL is not regarded as a socket-outlet for the purposes of this regulation".

3.6.3 Omission of RCD protection

411.3.3 **3.6.3.1** Specific cases

RCDs for additional protection for socket-outlets not exceeding 32 A in locations other than:

- socket-outlets with a rated current not exceeding 32 A in locations where they are liable to be used by persons of capability BA1, BA3 or children (BA2, BA3); and/or
- mobile equipment with a rated current not exceeding 32 A for use outdoors

can be omitted, where a documented risk assessment determines that RCD protection is not necessary. The risk assessment must be appended to the certificate issued for the work. See 3.6.3.2.

411.4 411.5 Cables installed on the surface do not specifically require RCD protection; however, RCD protection may be required for other reasons, for example, for fault protection where the earth fault loop impedance is such that the disconnection time for an overcurrent device cannot be met.

411.3.3 **3.6.3.2** Risk assessment and the omission of additional requirements by RCDs for socket-outlets

As identified above, BS 7671 permits RCDs, where usually provided for additional protection to socket-outlets, to be omitted where a documented risk assessment determines that the risk to users and those in the vicinity is sufficiently low and, hence, that RCD protection is not necessary.

411.3.3 Note 3 Appendix 2 Item 11 The Management of Health and Safety at Work Regulations 1999 puts the responsibility for carrying out risk assessments onto (as applicable) the persons responsible for the operations or work activity.

For this situation, the risk assessment needs to be carried out by a skilled person (electrically) together with the responsible person and must be appended to the appropriate Electrical Installation Certificate (EIC).

© The Institution of Engineering and Technology

The risk assessment should consider the frequency of use, the environment, the equipment to be connected, the skill level of the person using the equipment and the socket-outlet and the persons who will have access to the area when the equipment is in operation, amongst many other factors.

The intention is that the omission of RCDs for additional protection to socket-outlets should be only as a last resort and certainly not for implementation in domestic premises.

Note that the risk assessment, like all risk assessments, will need to be revisited at pertinent intervals to assess any change in circumstances, such as change of use, change of ownership or when a periodic inspection is undertaken and must be appended to the Electrical Installation Condition Report (EICR).

3.6.4 Applications of RCDs

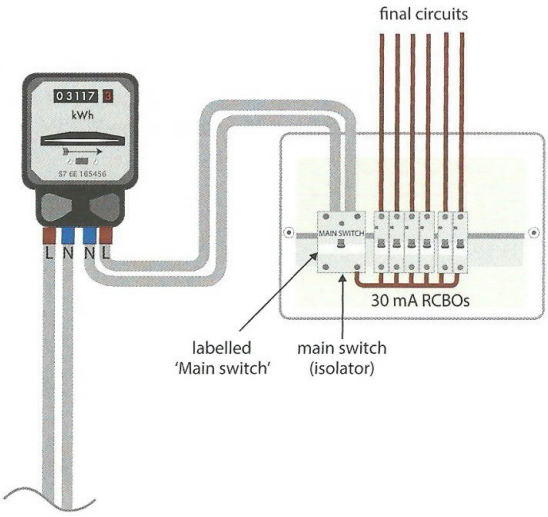
314 Installations are required to be divided into circuits to avoid hazards and minimize inconvenience in the event of a fault and to take account of danger that might arise from the failure of a single circuit, such as a lighting circuit.

The following scenarios show different methods of providing RCD protection within installations. Note that, for clarity, earthing and bonding connections are not shown.

3.6.4.1 Examples of RCDs within installations

In each case, refer to 2.2.6 of this Guide.

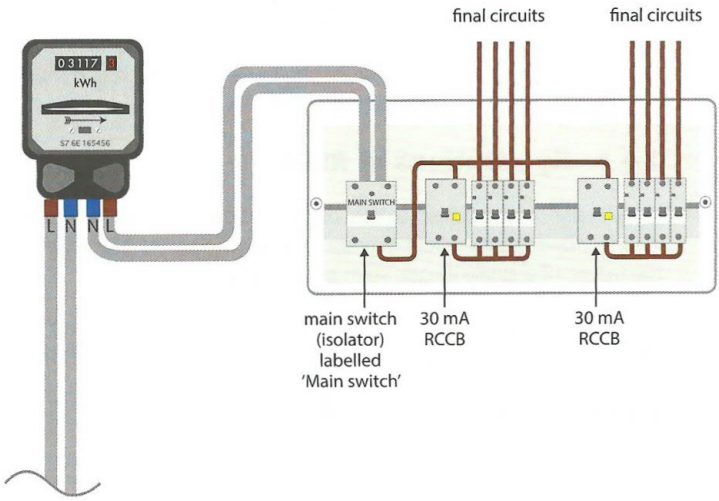
▼ **Figure 3.6.4(i)** Consumer unit with RCBOs, suitable for all installations (TN and TT)



© The Institution of Engineering and Technology

Single RCBOs protect each outgoing circuit and the risk of the busbar (connecting the supply side of each RCBO) becoming loose and making contact with the ferrous enclosure is minimal. The use of RCBOs will minimize inconvenience in the event of a fault and is applicable to all systems.

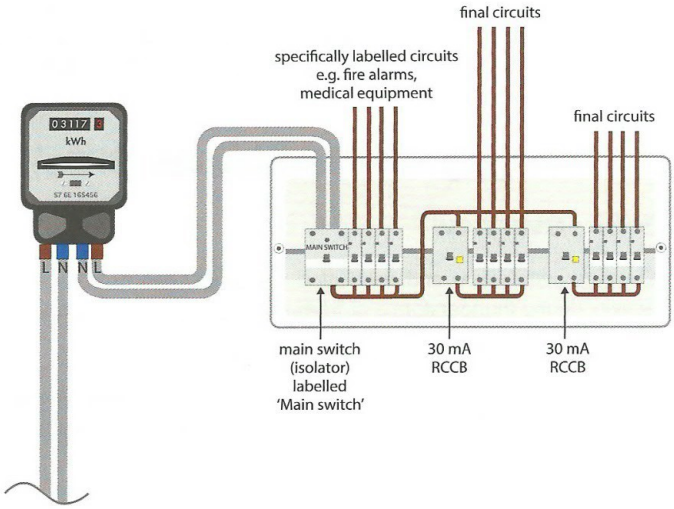
▼ **Figure 3.6.4(ii)** Split consumer unit with separate main switch and two 30 mA RCCBs



The division of an installation into two parts with separate 30 mA RCCBs will ensure that part of the installation will remain on supply in the event of a fault. Generally, this is not suitable for an installation forming part of a TT system as there is insufficient fault protection of the single-insulated conductors that connect the load side of the double-pole main switch to the supply side of the RCCBs.

© The Institution of Engineering and Technology

▼ **Figure 3.6.4(iii)** Three-way split consumer unit with separate main switch, two 30 mA RCCBs and circuits without RCD protection



The three-way division of an installation can provide ways unprotected by RCDs for, say, fire systems and for two separate 30 mA RCCBs to ensure that part of the installation will remain on supply in the event of a fault. Unprotected circuits will usually need to be installed in earthed metal conduit or wired with earthed metal-sheathed cables. This is not suitable for an installation forming part of a TT system as there is insufficient fault protection of the single-insulated conductors connecting the load side of the double-pole main switch to the supply side of the RCCBs.

3.6.4.2 RCBOs

The use of RCBOs will minimize inconvenience in the event of a fault and is applicable to all systems (see Figure 3.6.4(i)).

Such a consumer unit arrangement also easily allows individual circuits, such as fire alarms, to be protected by a circuit-breaker without RCD protection. Such circuits will usually need to be installed in earthed metal conduit or wired with earthed metal-sheathed cables.

3.6.4.3 Split board with two 30 mA RCDs

The division of an installation into two parts with separate 30 mA RCCBs will ensure that part of the installation will remain on supply in the event of a fault (see Figure 3.6.4(ii)).

© The Institution of Engineering and Technology

3.6.4.4 Three-way split board with two 30 mA RCDs

The three-way division of an installation can provide ways unprotected by RCDs for, say, fire systems and for two separate 30 mA RCCBs to ensure that part of the installation will remain on supply in the event of a fault. Unprotected circuits will usually need to be installed in earthed metal conduit or wired with earthed metal-sheathed cables (see Figure 3.6.4(iii)).

534

3.7 Surge protection devices (SPDs)

3.7.1 Overview

131.6.2 Electrical installations and connected equipment can be severely affected by lightning activity during thunderstorms or from electrical switching events.

GN 1 For more information, see IET Guidance Note 1.

443.6.2 Damage can occur when the surge or transient overvoltage, as the result of lightning or
Table 443.2 electrical switching, exceeds the impulse withstand voltage rating of electrical equipment - the levels of which are defined in Table 443.2 of BS 7671.

Surges from electrical switching events are created when large inductive loads, such as motors or air conditioning units, switch off and release stored energy which dissipates as a transient overvoltage. Switching surges are, in general, not as severe as lightning surges but are more repetitive and can reduce equipment lifespan.

Overvoltages of atmospheric origin, i.e. created by lightning events, can present a risk of fire and electric shock owing to a dangerous flashover. Note the following:

443 (a) Section 443 of BS 7671 has requirements for the protection of persons, livestock and property from injury and damage as a consequence of overvoltage; and

534 (b) Section 534 has requirements for the selection and installation of SPDs.

NOTES:

1 Section 534 applies to AC power circuits only. When the need for power SPDs is identified, additional SPDs on other services such as telecommunications lines and equipment is also recommended. See BS EN 62305 and BS EN 61643.

2 Some electronic equipment may have protection levels lower than Category I of Table 443.2.

3 BS 7671 does not specify requirements for protection against transient overvoltages due to direct or nearby lightning strokes on the structure. For risk management for protection against such transient overvoltages, see BS EN 62305-2.

3.7.2 Arrangements for protection against overvoltages

443 Protection according to Section 443 can only be achieved if transient overvoltages are
534 limited to values lower than those given in Table 443.2, requiring the correct selection and installation of suitable SPDs.

© The Institution of Engineering and Technology

443.4 3.7.2.1 Surge protection requirements

Regulation 443.4.1 of BS 7671 states that:

- "Protection against transient overvoltages shall be provided where the consequence caused by the overvoltage could result in:
  - **(i)** serious injury to, or loss of, human life (for example. Hospitals and, care homes, or in the provision of home dialysis equipment)
  - **(ii)** failure of a safety service, as defined in Part 2
  - **(iii)** significant financial or data loss.
- For all other cases, protection against transient overvoltages shall be provided unless the owner of the installation declares it is not required due to any loss or damage being tolerable and they accept the risk of damage to equipment and any consequential loss."

Therefore, protection against transient overvoltages shall be provided where the consequence caused by overvoltage:

- **(a)** results in serious injury to, or loss of, human life, (for example hospitals and care homes or in the provision of home dialysis equipment);
- **(b)** results in the interruption of public services and/or damage to cultural heritage, (for example in data centres or heritage status buildings, such as museums and castles);
- **(c)** results in the interruption of commercial or industrial activity (for example, in banks, hotels, supermarkets, industrial plants or farms); or
- **(d)** affects a large number of collocated individuals (for example, in offices, universities, schools or residential tower blocks).

For all cases other than those listed above, a risk assessment to determine if protection against transient overvoltages is required (see BS 7671 Appendix 16 and IET Guidance Note 1 for further information).

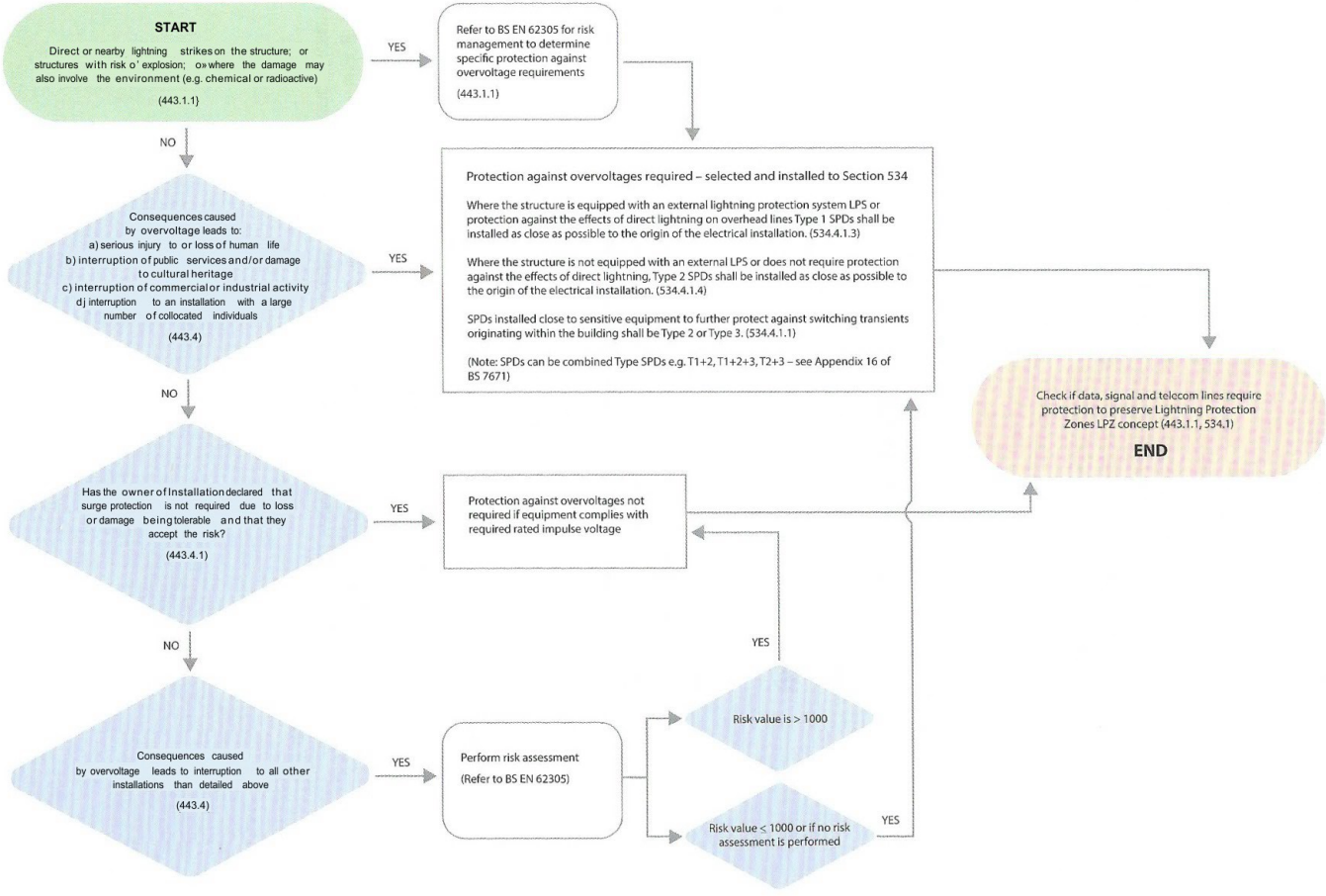
NOTE: The protection against lightning risk assessment method of BS EN 62305-2 must be used for high-risk installations such as nuclear or chemical sites where the consequences of transient overvoltages could lead to explosions or harmful chemical or radioactive emissions thus affecting the environment.

The flow chart in Figure 3.7.2.1 is designed to aid the decision-making process for electrical installations within the scope of this Guide. See IET Guidance Note 1 for more information.

© The Institution of Engineering and Technology

© The Institution of Engineering and Technology

▼ **Figure 3.7.2.1** SPD decision flow chart for installations within the scope of this Guide



3.7.3 Types of SPD protection

534.1 For the protection of AC power circuits, SPDs are allocated a type number:

534.4
(a) Type 1 SPDs are only used where there is a risk of direct lightning current and, typically, are installed at the origin of the installation;
(b) Type 2 SPDs are used at distribution boards; and
(c) Type 3 SPDs are used near terminal equipment.

See also Table 3.7.3.

Appendix 16 Combined Type SPDs are classified with more than one type, for example Type 1 & 2, Type 2 & 3, and can provide both lightning current with overvoltage protection in addition to protection between all conductor combinations (or modes of protection) within a single unit. Combined Type SPDs provide high surge current handling combined with better overvoltage protection levels (Up) (the latter being a performance parameter of an SPD).

534.4.10 ▼ Table 3.7.3(i) CSA of conductors and types of SPD protection

Type	Name	Location	Conductor csa	Hazard
1	Equipotential bonding or lightning protection/current SPD	Origin of the installation	16 mm^2 minimum - length of tails - ideally <0.5 m but no longer than 1 m	Protect against flashover from direct lightning strikes to structure or to LV overhead supply
2	Overvoltage SPD	Origin of the installation	6 mm^2 or equal to CSA of circuit conductors	Protect against overvoltages that can overstress the electrical installation

▼ Table 3.7.3(H) CSA of conductors connecting SPDs and the OCPDs to live conductors

Type	Location	Conductor csa
1	Origin of the installation	16 mm^2 minimum - length of tails - ideally <0.5 m but no longer than 1 m
2	Origin of the installation	6 mm^2 or equal to CSA of circuit conductors

© The Institution of Engineering and Technology

3.7.4 Coordination and selection of surge protection

534.4.10 Where a number of SPDs are required to operate in conjunction with each other they must be coordinated to ensure the correct type of protection is installed where required; see Figure 3.7.4.

SPD protection should be coordinated as follows:

(a) choose the correct type of SPD for the installation and site in the correct location;

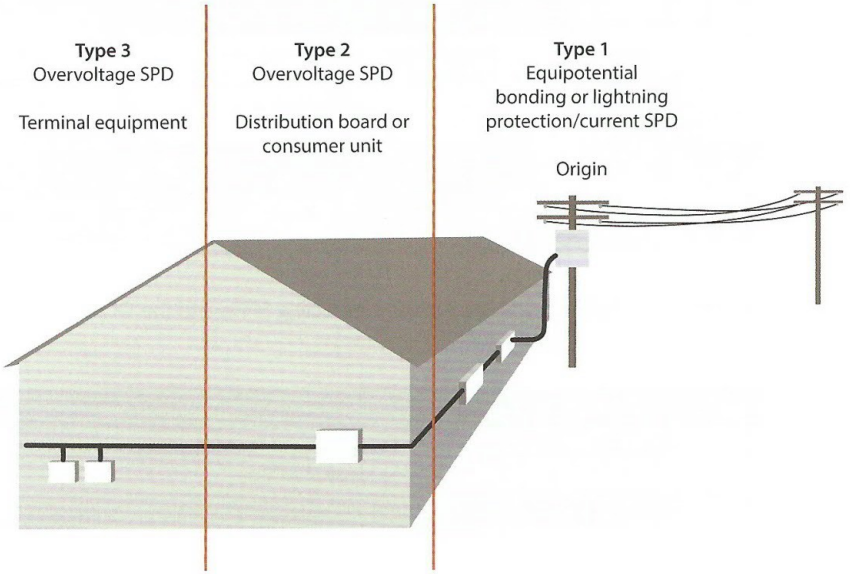
(b) refer to Regulation 443.6.2 and Table 443.2 of BS 7671 (impulse withstand voltage);

534.4.4.2 **(c)** choose SPDs with a protection level (Up) sufficiently lower than the impulse withstand voltage or lower than the impulse immunity of the equipment to be protected; and

(d) choose SPDs of the same make or manufacture.

NOTE: Coordinated SPDs must be of the same make or manufacture unless the designer is satisfied that devices of different makes will coordinate as required.

▼ **Figure 3.7.4** Typical location of a coordinated set of SPDs



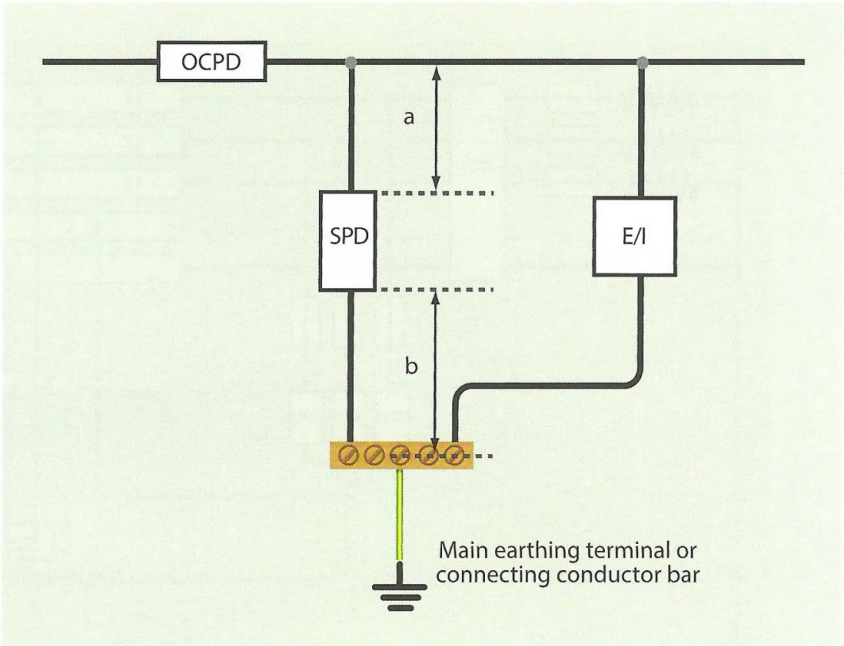
© The Institution of Engineering and Technology

3.7.5 Critical length of connecting conductors for SPDs

534.4.8 To gain maximum protection the connecting conductors to SPDs must be kept as short as possible, to minimize additive inductive voltage drops across the conductors. The total lead length (a + *b)* should preferably not exceed 0.5 m but in no case exceed 1.0 m; see Figure 3.7.5.

Refer to the SPD manufacturer's instructions for optimal installation.

▼ **Figure 3.7.5** Critical length of connecting conductors for SPDs



OCPD = overcurrent protective device

SPD = surge protection device

E/I = equipment or installation to be protected against overvoltages

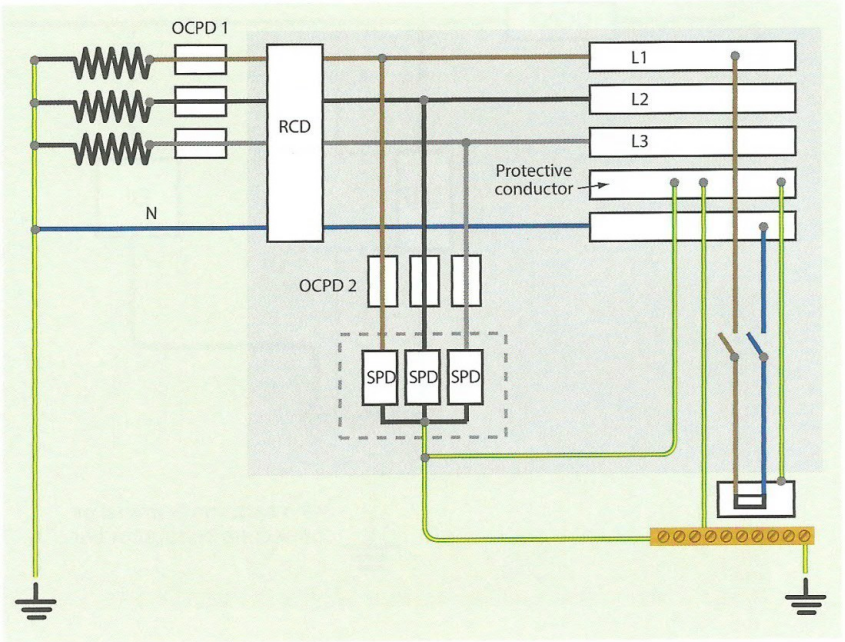
© The Institution of Engineering and Technology

3.7.6 Methods of connection

534.4.3 Primarily, the installation of SPDs must follow the manufacturer's instructions. However, minimum SPD connections at the origin of the electrical supply are usually made as those shown in Figure 3.7.6(i) (TN-C-S, TN-S, TT) and Figure 3.7.6(ii) (TT - SPDs upstream of an RCD):

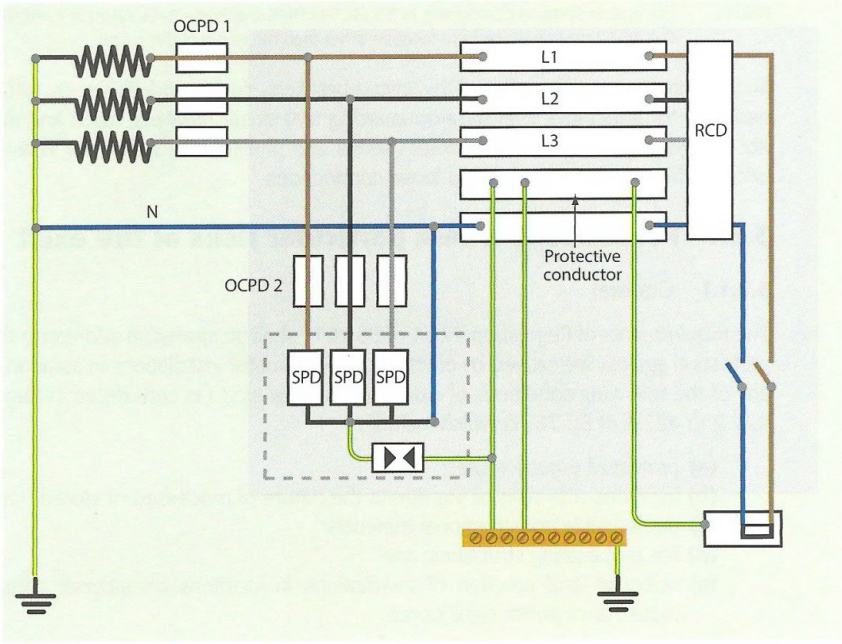
Type 1 SPDs should be installed upstream from any RCD to avoid unwanted tripping. Where this cannot be avoided, the RCD should be of the time-delayed or S-type.

534.4.7 ▼ **Figure 3.7.6(i)** SPDs on the load side of an RCD



© The Institution of Engineering and Technology

534.4.7 ▼ **Figure 3.7.6(ii)** SPDs on the supply side of an RCD



NOTE: See Appendix 16 of BS 767 1 for further information on the connection of SPDs.

421.1.7
532.6

3.8 Arc fault detection devices (AFDDs)

Arc fault detection devices (AFDDs) conforming to BS EN 62606 shall be provided for single-phase AC final circuits supplying socket-outlets with a rated current not exceeding 32 A in:

- Higher Risk Residential Buildings (HRRB)
- Houses in Multiple Occupation (HMO)
- Purpose built student accommodation
- Care homes.

NOTE: A higher risk residential building is generally categorized as having: the floor of the top storey of the building 18 metres or more above ground level, or containing 6 storeys or two or more dwellings, or two or more rooms used for residential purposes, or student accommodation

For all other premises, the use of AFDDs conforming to BS EN 62606 is recommended for single-phase AC final circuits supplying socket-outlets not exceeding 32 A.

Where used, AFDDs shall be placed at the origin of the circuit to be protected.

© The Institution of Engineering and Technology

The use of AFDDs does not obviate the need to apply one or more measures provided in other clauses in BS 7671.

NOTE: For busbar systems conforming to BS EN 61439-6 and Powertrack systems to BS EN 61534, the AFDD may be placed at a location other than the origin of the circuit.

Such protection is not offered by circuit-breakers, fuses and RCDs as AFDDs are designed to detect low level hazardous arcing that circuit breakers, fuses and RCDs are not designed to detect. AFDDs detect series and parallel arcs which, for instance, can occur within damaged cables and loose connections.

3.8.1 Precautions where particular risks of fire exist

3.8.1. 1 General

422 The requirements of Regulation 422.1 of BS 7671 shall be applied in addition to those for protection against fire caused by electrical equipment for installations in locations where any of the following conditions of external influence exist (as considered in Regulations 422.2 to 422.6 of BS 7671) which include:

- **(a)** protected escape routes;
- **(b)** locations with risks of fire due to the nature of processed or stored materials;
- **(c)** combustible constructional materials;
- **(d)** fire propagating structures; and
- **(e)** selection and erection of installations in locations of national, commercial, industrial or public significance.

In such locations, the fire safety design of the building(s) should be documented. This information should be included in a fire safety manual produced by or for the person responsible for the building (the 'responsible person') as detailed in local national fire safety legislation or guidance, including, for example, BS 9999.

It is recommended that the electrical system designer/installer shall provide the person responsible for the building with details of the electrical system, setting out the basis of the design with respect to fire safety. It shall explain the operation of all the associated relevant building services systems and give information on routine testing and maintenance requirements.

Where it is determined that cables should have an improved fire performance but are not covered by Regulations 422.2 to 422.6, this may be achieved by using cables with a minimum light transmittance of 60 °/owhen tested in accordance with BS EN 61034-2, and:

- **(a)** limited flame propagation according to the minimum requirements of the relevant part of BS EN 60332-3 (series); or
- **(b)** where cable management systems are used which are either:
  - **(i)** conduit systems classified as non-flame propagating according to BS EN 61386; or
  - **(ii)** cable trunking systems and cable ducting systems classified as non-flame propagating according to BS EN 50085.

  In either case cables to the minimum requirements of BS EN 60332-1-2 are used.

© The Institution of Engineering and Technology

Except for wiring systems meeting the requirements of Regulation 422.3.5 of BS 7671, all electrical equipment shall be restricted to that necessary to the use of the locations given in Regulation 422.1 as listed above.

Electrical equipment shall be selected and erected that its normal temperature rise and foreseeable temperature rise during a fault cannot cause a fire. This shall be achieved by the construction of the equipment or by additional protective measures taken during erection. Special measures are not necessary where the temperature of surfaces is unlikely to cause combustion of nearby substances.

A temperature cut-out device shall have manual reset only.

3.8.1.2 Protected escape routes

Appendix 13

A protected escape route is defined as "a route enclosed with specified fire-resisting construction designated for escape to a place of safety in the event of an emergency", and guidance on protected escape routes is given in Appendix 13 of BS 7671.

Cables or other electrical equipment shall not be installed in a protected escape route unless they are part of an essential fire safety or related safety system.

This generally means that cables in a protected escape route should be limited to lighting, emergency lighting, and fire detection and alarm systems, although cables for other safety systems may be necessary.

Only cables that meet the following requirements shall be installed in protected escape routes:

- **(a)** cables meeting the requirements for wiring systems for safety services Regulation 560.8.1;
- **(b)** resistance to flame propagation according to the recommended requirements of the relevant part of BS EN 60332-3 (series) or, where cable management systems according to (i) or (ii) below are used, to the recommended requirements of BS EN 60332-1-2; and
- **(c)** a minimum of 60 % light transmittance when tested in accordance with BS EN 61034-2.

Where used, cable management systems shall be one or more of the following types and shall be of limited smoke production so as not to inhibit escape:

- **(i)** conduit systems classified as non-flame propagating according to BS EN 61386;
- **(ii)** cable trunking systems and cable ducting systems classified as non-flame propagating according to BS EN 50085;
- **(iii)** cable tray and cable ladder systems classified as non-flame propagating according to BS EN 61537; or
- **(iv)** powertrack systems meeting the requirements of BS EN 61534.

Cables in escape routes shall be as short as practicable. Cables encroaching on escape routes shall not be installed within arm's reach unless they are provided with protection against mechanical damage likely to occur during an evacuation.

© The Institution of Engineering and Technology

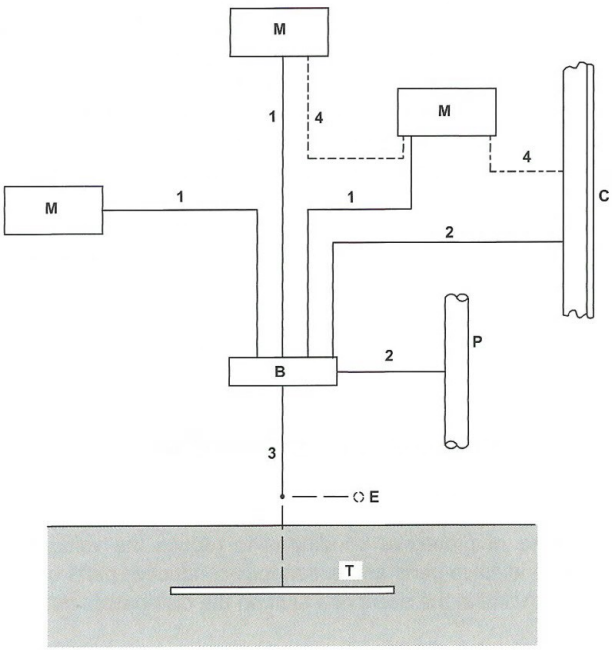
NOTE

© The Institution of Engineering and Technology

Earthing and bonding 4

4.1 Protective earthing

▼ **Figure 4.1** Illustration of earthing and protective conductor terms



1,2,3,4	=	protective conductors
1	=	circuit protective conductor
2	=	main protective bonding conductor
3	=	earthing conductor
4	=	supplementary protective bonding conductors (where required)
B	=	main earthing terminal
M	=	exposed-conductive-part
C	=	extraneous-conductive-part
P	=	main metallic water pipe (extraneous-conductive-part)
T	=	earth electrode (TT and IT systems)
E	=	other means of earthing (TN systems)

© The Institution of Engineering and Technology

The purpose of protective earthing is to ensure that, in the event of a fault, such as between a line conductor and an exposed-conductive-part or circuit protective conductor, sufficient current flows to operate the protective device, within the required time - that is, to cause the fuse to blow or the circuit-breaker or residual current device (RCD) to operate.

411.4.2 411.5.1 Every **exposed-conductive-part** (a conductive part of equipment that can be touched and which is not a live part but which may become live under fault conditions) shall be connected by a protective conductor to the main earthing terminal (MET) and, hence, to the means of earthing for the installation.

4.2 Legal requirements

ESQCR SI 2665 ESQCR (NI) 2012 No. 381 The Electricity Safety, Quality and Continuity Regulations 2002 (ESQCR) (as amended) requires a distributor of electricity to make the supply neutral conductor or protective conductor available for the connection of the consumer's protective conductor where it can be reasonably concluded that such a connection is appropriate. Such a connection may be deemed inappropriate where there is a risk of the loss of the protective earthed-neutral (PEN) conductor, for example, where bare overhead low voltage distribution cables supply a rural building. In such cases, an installation earth electrode must be provided and the installation will then form part of a TT system.

Essentially, permission to connect the consumer's protective conductor to the distributor's neutral can be denied to new installations but, where permission is granted, the distributor has a responsibility to maintain the connection.

NOTE: For some rural installations supplied by a PME arrangement, it may be pertinent to install an additional earth electrode to mitigate the effects of a PEN conductor becoming open-circuit; see IET Guidance Note 5.

4.3 Main protective bonding

(Figures 2.1(i) to 2.1(iii))

The purpose of protective bonding is to reduce the voltages between the various exposed-conductive-parts and extraneous-conductive-parts of an installation, during a fault to earth and in the event of a fault on the distributor's network.

411.3.1.2 Part 2 Main protective bonding conductors are required to connect extraneous-conductive-parts to the MET of the installation. An **extraneous-conductive-part** is a conductive part, such as a metal pipe, liable to introduce earth potential into the installation or building. It is common, particularly under certain fault conditions on the LV supply network, for a potential to exist between true earth, i.e. the conductive mass of the Earth and the earth of the electrical system. Therefore, buried metallic parts that enter the building are to be connected to the MET of the electrical installation.

© The Institution of Engineering and Technology

Examples of extraneous-conductive-parts are:

(i) Metallic water installation pipes;
(ii) Metallic gas installation pipes;
(iii) Other metallic installation pipework and ducting;
(iv) Central heating and air conditioning systems;
(v) Exposed metallic structural parts of the building.

Where non-metallic pipes, for example plastic, enter a building and are then connected to metallic pipes within the building, the metallic pipes within the building do not normally require protective bonding as they are unlikely to be extraneous-conductive-parts.

Connection of a lightning protection system to the protective equipotential bonding shall be made in accordance with BS EN 62305.

Where an installation serves more than one building the above requirement shall be applied to each building.

Where an incoming telecommunication cable has a metallic sheath, equipotential bonding shall be applied. However, the consent of the owner or operator of the cable shall be obtained. Where consent is not granted, and as a consequence this requirement is not met, details shall be recorded in the description section of the appropriate electrical certification specified in Part 6 of BS 7671.

4.4 Earthing conductor and main protective bonding conductor cross-sectional areas

The minimum cross-sectional areas (csa) required for the earthing conductor and main protective bonding conductors are given in Table 4.4(i) and (ii). For TT supplies, refer to Table 4.4(iii).

▼ **Table 4.4(i)** Earthing conductor and main protective bonding conductor sizes (copper equivalent) for TN-S supplies

	CSA line conductor mm²	6	10	16	25	35	50	70
542.3	**CSA earthing conductor**	6	10	16	16	16	25	35
543.1 Table 54.8	**CSA protective bonding conductor**	6	6	10	10	10	16	25

© The Institution of Engineering and Technology

▼ Table 4.4(ii) Earthing conductor and main protective bonding conductor sizes (copper equivalent) for PME (TN-C-S) supplies

544.1.1 / Table 54.8

CSA line conductor mm²	6	10	16	25	35	50	70
CSA earthing conductor	10	10	16	16	16	25	35
CSA protective bonding conductor	10	10	10	10	10	16	25

NOTES:

543.2.4 1 Protective conductors (including earthing and bonding conductors) of 10 mm² csa or less shall be copper.

Table 54.7 2 The distributor may require a minimum size of earthing conductor at the origin of the supply of 16 mm² copper or greater for TN-S and TN-C-S supplies.

542.3.1 / Table 54.1 3 Buried earthing conductors must be at least:

- **i.** 25 mm² copper if not protected against corrosion
- **ii.** 50 mm² steel if not protected against corrosion
- **iii.** 16 mm² copper if not protected against mechanical damage but protected against corrosion
- **iv.** 16 mm² coated steel if not protected against mechanical damage but protected against corrosion.

4 When in doubt, the distributor should be consulted.

5 Tables 4.4(i) and 4.4(ii) refer to the csa of line conductors whilst Table 54.8 of BS 7671 refers to the PEN conductor. For the purposes of this Guide, the line conductor is used as the PEN conductors are not considered.

▼ Table 4.4(iii) Copper earthing conductor cross-sectional area (csa) for TT supplies

Buried			Not buried		
Unprotected	Protected against corrosion	Protected against corrosion and mechanical damage	Unprotected	Protected against corrosion	Protected against corrosion and mechanical damage
mm²	mm²	mm²	mm²	mm²	mm²
25	16	2.5	4	4	2.5

NOTES:

1 Assuming protection against corrosion by a sheath.

544.1.1 2 The main protective bonding conductors shall have a csa of not less than half that required for the earthing conductor and not less than 6 mm².

Note that:

543.2.4 **(a)** only copper conductors should be used; copper covered aluminium conductors, aluminium conductors or structural steel can only be used if special precautions outside the scope of this Guide are taken.

© The Institution of Engineering and Technology

544.1.2 **(b)** where practicable, protective bonding connections to gas, water, oil, and similar services should be within 600 mm of the service meter, or at the point of entry to the building if the service meter is external and must be on the consumer's side before any branch pipework and after any insulating section in the service. The connection must be made to hard pipework and, not to soft or flexible meter connections.

542.3.2 **(c)** the connection must be made using clamps (to BS 951) and be suitably protected against corrosion at the point of contact.

NOTE: Screwed and/or bolted bonding connections must be accessible for inspection and testing.

4.5 Main protective bonding of plastic services

There is no requirement to main bond an incoming service where the incoming service pipe is plastic, for example, where yellow is used for natural gas and blue for potable water.

Where there is a plastic incoming service and a metal installation within the premises, the metal pipework does not require protective bonding. However, main protective bonding is recommended unless it has been confirmed that any metallic pipework within the building is not introducing Earth potential (see 4.3).

4.6 Supplementary bonding

The purpose of supplementary bonding is to reduce the voltage between the various exposed-conductive-parts and extraneous-conductive-parts of a location during a fault to earth.

NOTE: Where a required disconnection time cannot be achieved, supplementary equipotential bonding must be applied. However, this is outside the scope of this Guide. See Regulation 411.3.2.5 and IET Guidance Note 1.

© The Institution of Engineering and Technology

The csa required for supplementary equipotential bonding conductors is given in Table 4.6.

▼ **Table 4.6** Supplementary bonding conductors

544.2

Size of circuit protective conductor (mm^2)	Minimum cross-sectional area of supplementary equipotential bonding conductor (mm^2)					
	Exposed-conductive-part to extraneous-conductive-part		Exposed-conductive-part to exposed-conductive-part		Extraneous-conductive-part to extraneous-conductive-part*	
	mechanically protected	not mechanically protected	mechanically protected	not mechanically protected	mechanically protected	not mechanically protected
	1	2	3	4	5	6
1.0	1.0	4.0	1.0	4.0	2.5	4.0
1.5	1.0	4.0	1.5	4.0	2.5	4.0
2.5	1.5	4.0	2.5	4.0	2.5	4.0
4.0	2.5	4.0	4.0	4.0	2.5	4.0
6.0	4.0	4.0	6.0	6.0	2.5	4.0
10.0	6.0	6.0	10.0	10.0	2.5	4.0
16.0	10.0	10.0	16.0	16.0	2.5	4.0

544.2.3 * If one of the extraneous-conductive-parts is connected to an exposed-conductive-part, the bonding conductor must be no smaller than that required by column 1 or 2.

4.7 Additional protection - supplementary equipotential bonding

415.2 Supplementary equipotential bonding is required in some of the locations and installations falling within the scope of Part 7 of BS 7671.

If the installation meets the requirements of BS 7671 for earthing and bonding, there is no specific requirement for supplementary equipotential bonding of:

- **i.** kitchen pipes, sinks or draining boards;
- **ii.** metallic boiler pipework;
- **iii.** metallic furniture in kitchens;
- **iv.** metallic pipes to wash-hand basins and WCs; or
- 701.415.2 **v.** locations containing a bath or shower, providing the conditions of Regulation 701.415.2 are met.

NOTE: Metallic waste pipes deemed to be extraneous-conductive-parts must be connected by main protective bonding conductors to the MET; see also 4.3.

© The Institution of Engineering and Technology

4.8 Supplementary bonding of plastic pipe installations

Supplementary bonding is not required to metallic parts supplied by plastic pipes, for example, radiators, kitchen sinks or bathroom taps.

4.9 Earth electrode

542.1.2.3 This is connected to the MET by the earthing conductor and provides part of the earth fault loop path for an installation forming part of a TT system; see Figure 2.1(iii).

Table 41.5 Note 2 It is recommended that the earth fault loop impedance for an installation forming part of a TT system does not exceed 200 O.

542.2.6 Metallic gas, water utility or other metallic service pipes are not to be used as earth electrodes, although they must be bonded if they are extraneous-conductive-parts; (see also 4.3).

NOTE: Regulation 542.2.6 permits the use of privately owned water supply pipework for use as an earth electrode where precautions are taken against its removal and it has been considered for such use. This provision will not apply to an installation within a dwelling.

4.10 Types of earth electrode

542.2.2 The following types of earth electrode are recognized:

- **(a)** earth rods or pipes;
- **(b)** earth tapes or wires;
- **(c)** earth plates;
- **(d)** underground structural metalwork embedded in foundations or other metalwork installed in the foundations;
- **(e)** welded metal reinforcement of concrete embedded in the ground (excluding pre-stressed concrete);
- 542.2.5 **(f)** lead sheaths and metal coverings of cables which meet **all** of the following conditions:
  - **(i)** adequate precautions to prevent excessive deterioration by corrosion;
  - **(ii)** the sheath or covering shall be in effective contact with Earth;
  - **(iii)** the consent of the owner of the cable shall be obtained; and
  - **(iv)** arrangements shall exist for the owner of the electrical installation to be warned of any proposed change to the cable which might affect its suitability as an earth electrode.

© The Institution of Engineering and Technology

4.11 Typical earthing arrangements for various types of earthing system

Figures 2.1(i) to 2.1(iii) show single-phase arrangements but three-phase arrangements are similar.

Table 54.7
Table 54.8
544.1.1

The protective conductor sizes as shown in Figures 2.1(i) to 2.1(iii) refer to copper conductors and are related to the supplier's incoming cable, where 25 mm ^{2} supplier's tails are installed.

542.3.1
543.1.3

For TT systems protected by an RCD with an earth electrode resistance 1 O or greater, the earthing conductor size need not exceed 2.5 mm ^{2} if protected against corrosion by a sheath and also protected against mechanical damage; otherwise, see Table 4.4(iii).

542.4.2

The earthing bar is sometimes used as the MET. However, means must be provided in an accessible position for disconnecting the earthing conductor to facilitate the measurement of external earth fault loop impedance, Z_e.

NOTE: For TN-S and TN-C-S installations, advice about the availability of an earthing facility and the precise arrangements for connection should be obtained from the distributor or supplier.

© The Institution of Engineering and Technology

Isolation and switching 5

462 ## 5.1 Isolation

132.15.201 ### 5.1.1 Requirement

Means of isolation should be provided:

(a) at the origin of the installation

A main linked switch or circuit-breaker should be provided as a means of isolation and of interrupting the supply on load.

For single-phase household and similar installations, where the main switch may be operated by ordinary persons, a double-pole device must be used for both TT and TN systems.

For a three-phase supply to an installation forming part of a TT system, an isolator must interrupt the line and neutral conductors. In a TN-S or TN-C-S system only the line conductors need be interrupted.

(b) for every circuit

Other than at the origin of the installation, every circuit or group of circuits that may have to be isolated without interrupting the supply to other circuits should be provided with its own isolating device. The device must switch all live conductors in a TT system and all line conductors in a TN system.

(c) for every item of equipment

(d) for every motor

Every fixed electric motor should be provided with a readily accessible and easily operated device to switch off the motor and all associated equipment including any automatic circuit-breaker. The device must be so placed as to prevent danger.

462.1 **(e) for every supply.**

5.1.2 The switchgear

537.3.2.3 The position of the contacts of the isolator must either be externally visible or be clearly, positively and reliably indicated.

537.2.4 The device must be designed or installed to prevent unintentional or inadvertent closure.

Each device used for isolation must be clearly identified by position or durable marking to indicate the installation or circuit that it isolates.

© The Institution of Engineering and Technology

537.3.2.3 and 514.1.1 If it is installed remotely from the equipment to be isolated, the device must be capable of being secured in the OPEN position.

Guidance on the selection of devices for isolation is given in Appendix J.

464 5.2 Switching off for mechanical maintenance

464.1 A means of switching off for mechanical maintenance is required where mechanical maintenance may involve a risk of injury - for example, from the mechanical movement of machinery or from hot items when replacing lamps.

464.2 The means of switching off for mechanical maintenance must be able to be made secure to prevent electrically powered equipment from becoming unintentionally started during the mechanical maintenance, unless the means of switching off is continuously under the control of the person performing the maintenance.

Each device for switching off for mechanical maintenance must:

537.3.2.2 **(a)** where practicable, be inserted in the main supply circuit;

537.3.2.2 **(b)** be capable of switching the full load current;

537.3.2.3 **(c)** be manually operated;

537.3.2.3 and 537.3.2.4 464.2 **(d)** have either an externally visible contact gap or a clearly and reliably indicated OFF position. An indicator light should not be relied upon;

(e) be designed and/or installed so as to prevent inadvertent or unintentional switching on; and

537.3.2.4 **(f)** be installed and durably marked so as to be readily identifiable and convenient for use.

A plug and socket-outlet or similar device of rating not exceeding 16 A may be used for switching off for mechanical maintenance.

465 5.3 Emergency switching off

465.1 An emergency switch is to be provided for any part of an installation where it may be necessary to control the supply in order to remove an unexpected danger.

461.2 Where there is a risk of electric shock the emergency switch is to disconnect all live conductors, except in three-phase TN-S and TN-C-S systems, where the neutral need not be switched.

465.3 The means of emergency switching must act as directly as possible on the appropriate supply conductors and the arrangement must be such that one single action only will interrupt the appropriate supply.

537.3.3.3 A plug and socket-outlet or similar device must not be selected as a device for emergency switching.

© The Institution of Engineering and Technology

An emergency switch must be:

537.3.3.2 **(a)** capable of cutting off the full load current, taking account of stalled motor currents where appropriate;

537.3.3.4 **(b)** hand operated and directly interrupt the main circuit where practicable;

537.3.3.5 **(c)** clearly identified, preferably by colour. If a colour is used, this should be red with a contrasting background;

537.3.3.6 **(d)** readily accessible at the place where danger might occur and, where appropriate, at any additional remote position from which that danger can be removed;

537.3.3.7 **(e)** of the latching type or capable of being restrained in the 'OFF' or 'STOP' position, unless both the means of operation and re-energizing are under the control of the same person. The release of an emergency switching device must not re-energize the relevant part of the installation; it must be necessary to take a further action, such as pushing a 'start' button; and

537.3.3.6 **(f)** so placed and durably marked so as to be readily identifiable and convenient for its intended use.

463 537.3.1

5.4 Functional switching

463.1.1 A switch must be installed in each part of a circuit which may require to be controlled independently of other parts of the installation.

463.1.2 Switches must not be installed in the neutral conductor alone.

463.1.3 All current-using equipment requiring control shall be controlled by a switch.

537.3.1.1 Table 537.4 Off-load isolators, fuses and links must not be used for functional switching.

NOTE: Table 537.4 of 85 767 1 allows for the use of circuit-breakers for functional switching purposes but, in each case, the manufacturer should be consulted to establish suitability. Part L of the Building Regulations requires local switching to be provided for lighting installations for energy management.

537.4

5.5 Firefighter's switch

537.4.2 A firefighter's switch must be provided to disconnect the supply to any exterior electrical installation operating at a voltage exceeding low voltage, for example, a neon sign or any interior discharge lighting installation operating at a voltage exceeding low voltage.

NOTE: Such installations are outside the scope of this Guide; see Regulations 537.4.2 to 537.4.4 of BS 7671.

© The Institution of Engineering and Technology

NOTE

© The Institution of Engineering and Technology

Labelling 6

The following durable labels are to be securely fixed on or adjacent to installed equipment. Warning notices and other relevant safety signs shall comply with BS ISO 3864, BS EN ISO 7010, and BS EN IEC/IEEE 82079-1. Permission is given for the use of the notice provided with the BS 951 clamp.

6.1 Retention of a dangerous electrical charge

416.2.5 462.4 It behind a barrier or within an enclosure, an item of equipment such as a capacitor is installed which may retain a dangerous electrical charge after it has been switched off, a warning label must be provided. Small capacitors such as those used for arc extinction and for delaying the response of relays, etc., are not considered dangerous.

NOTE: Unintentional contact is not considered dangerous if the voltage resulting from static charge falls below 120 V DC in less than 5 s after disconnection from the power supply.

6.2 Where the operator cannot observe the operation of switchgear and controlgear

514.1.1 Except where there is no possibility of confusion, a label or other suitable means of identification must be provided to indicate the purpose of each item of switchgear and controlgear. Where the operator cannot observe the operation of switchgear and controlgear and where this might lead to danger, a suitable indicator complying, where applicable, with BS EN 60073 and BS EN 60447, should be fixed in a position visible to the operator.

6.3 Unexpected presence of nominal voltage exceeding 230 V

514.10.1 Where a nominal voltage exceeding 230 V to earth exists and it would not normally be expected, a warning notice stating the maximum voltage present must be provided where it can be seen before gaining access to live parts.

Note that a TN/TT, i.e. earthed neutral, three-phase system with 400 V between line conductors will have nominal voltage of 230 V to earth, therefore, a warning notice will not be required for such systems.

© The Institution of Engineering and Technology

6.4 Earthing and bonding connections

514.13.1 A permanent notice to BS 951 (Figure 6.4) or BS EN IEC/IEEE 82079-1 must be permanently fixed in a visible position at or near the point of connection of:

(a) every earthing conductor to an earth electrode;
(b) every protective bonding conductor to extraneous-conductive-parts; and
(c) at the main earth terminal (MET), where it is not part of the main switchgear.

▼ **Figure 6.4** BS 951 label at connection of earthing and bonding conductors

NOTE: An example of a label according to BS EN IEC/IEEE 82079-1 is provided in Figure 11C of Appendix 11 of BS 7671.

6.5 Purpose of switchgear and controlgear

514.1.1 Unless there is no possibility of confusion, a label indicating the purpose of each item of switchgear and controlgear must be fixed on or adjacent to the gear. It may be necessary to label the item controlled, in addition to its controlgear.

6.6 Identification of protective devices

514.8.1 A protective device, for example, a fuse or circuit-breaker, must be arranged and identified so that the circuit protected may be easily recognized.

6.7 Identification of isolators

537.2.7 Where it is not immediately apparent, all isolating devices must be clearly identified by position or durable marking. The location of each disconnector or isolator must be indicated unless there is no possibility of confusion.

6.8 Isolation requiring more than one device

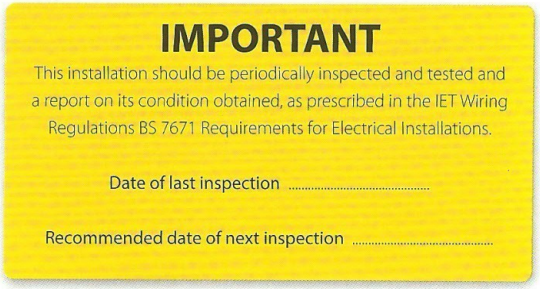
514.11.1 A durable warning notice must be permanently fixed in a clearly visible position to identify the appropriate isolating devices, where equipment or an enclosure contains live parts which cannot be isolated by a single device.

© The Institution of Engineering and Technology

6.9 Periodic inspection and testing

514.12.1 A notice of durable material indelibly marked with the words as Figure 6.9 must be fixed in a prominent position at or near the origin of every installation. The person carrying out the initial verification must complete the notice and it must be updated after each periodic inspection.

▼ **Figure 6.9** Label for periodic inspection and testing



The requirements of Regulation 514.12.1 need not be applied for dwellings or similar installations where:

- the fixing of the notice is not reasonably practicable; for example, where there is insufficient room or the location of the notice is deemed unlikely to be beneficial; and
- an Electrical Installation Certificate, complete with Guidance and Instruction for Recipients, as detailed in Appendix 6 of BS 7671, has been issued to the person ordering the work.

NOTE: Examples and dimensions are provided in Appendix 11 of BS 7671.

6.10 Diagrams

514.9.1 A diagram, chart or schedule must be provided indicating:

(a) the number of points, size and type of cables for each circuit;
(b) the method of providing protection against electric shock;
(c) information to identify devices for protection, isolation and switching; and
(d) any circuit or equipment vulnerable during a typical test, for example, SELV power supply units of lighting circuits which could be damaged by an insulation test.

For simple installations, the foregoing information may be given in a schedule, with a durable copy provided within or adjacent to the distribution board or consumer unit.

NOTE: All diagrams, charts, and information or instruction notices shall comply with BS EN 61082-1, BS EN IEC/IEEE 82079-1, and, where appropriate, BS EN 81346-1.

© The Institution of Engineering and Technology

6.11 Residual current devices (RCDs)

514.12.2 Where an installation incorporates an RCD, a notice with the words shown in Figure 6.11 must be fixed in a permanent position at or near the origin of the installation.

▼ **Figure 6.11** Notice for the testing of an RCD

> This installation, or part of it, is protected by a device which automatically switches off the supply if a fault develops. **Test six-monthly** by pressing the relevant test button(s) which should operate the device. Afterwards, manually switch on the device. If the device does not operate, or indicates a fault, seek expert advice.

The requirements of Regulation 514.12.2 need not be applied for domestic (household) premises or similar installations where:

- the fixing of the notice is not reasonably practicable; for example, where there is insufficient room or the location of the notice is deemed unlikely to be beneficial; and
- an Electrical Installation Certificate, complete with Guidance and Instruction for Recipients, as detailed in Appendix 6 of BS 7671, has been issued to the person ordering the work.

NOTE: Examples and dimensions are provided in Appendix 11 of BS 7671.

6.12 Warning notice: non-standard colours

If additions or alterations have been made to an installation so that some of the wiring complies with the harmonized colours of Table KI in Appendix K, but there is also wiring in the earlier colours, a warning notice may have been affixed at or near the appropriate distribution board using the wording shown in Figure 6.12.

© The Institution of Engineering and Technology

▼ **Figure 6.12** Label advising of wiring colours to two versions of BS 7671

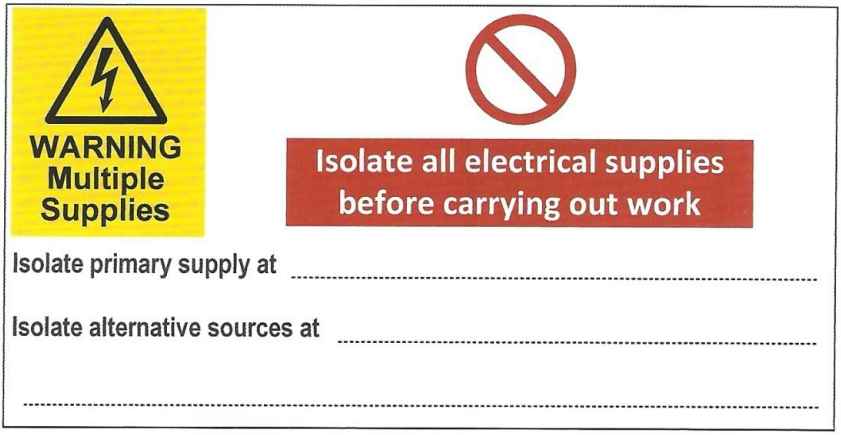
6.13 Warning notice - alternative supplies

514.15.1 Where an installation includes additional or alternative supplies, such as a PV installation, which is used as an additional source of supply in parallel with another source, normally the distributor's supply, warning notices must be affixed at the following locations in the installation:

(a) at the origin of the installation;
(b) at the meter position, if remote from the origin;
(c) at the consumer unit or distribution board to which the additional or alternative supply is connected; and
(d) at all points of isolation of all sources of supply.

The warning notice must use the wording shown in Figure 6.13.

▼ **Figure 6.13** Label advising of multiple supplies



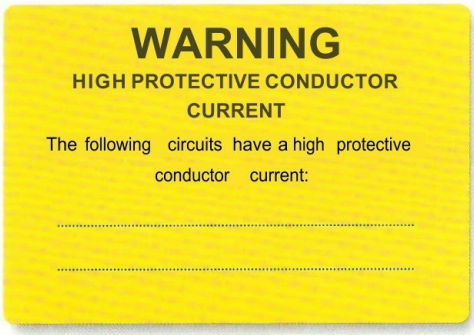
NOTE: Examples and dimensions are provided in Appendix 11 of BS 7671.

© The Institution of Engineering and Technology

6.14 Warning notice - high protective conductor current

543.7.1.205 At the distribution board, information must be provided indicating those circuits having a high protective conductor current. This information must be positioned so as to be visible to a person who is modifying or extending the circuit (see Figure 6.14).

▼ **Figure 6.14** Label advising of high protective conductor current

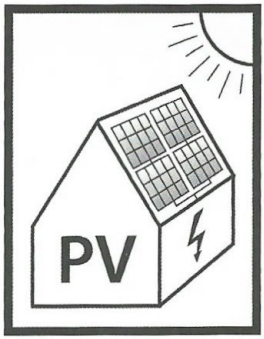


6.15 Warning notice - photovoltaic (PV) systems

712.514.101 An instruction notice indicating the presence of a photovoltaic system on a building shall be fixed:

- **(i)** at the origin of the electrical installation
- **(ii)** at the metering position, if remote from the origin
- **(iii)** at the consumer unit or distribution board to which the supply from the inverter is connected.

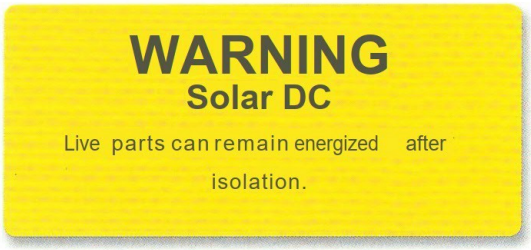
▼ **Figure 6.15 (i)** Indication showing the presence of a photovoltaic installation on a building



© The Institution of Engineering and Technology

712.514.102 Each point of access to live parts on the DC side, such as distribution boards and combiner boxes, shall have a permanent warning notice indicating that live parts may be still energized after isolation, e.g. using the text, 'SOLAR DC - Live parts can remain energized after isolation'.

▼ **Figure 6.15 (ii)** Label advising of live parts within enclosures in a PV system



6.16 Warning and user instruction labels

514.9.2 Regulation 514.9.2 specifies harmonized standards to be used for user instructions and warning signs. This permits more flexibility in the sizing of appropriate labels for particular circumstances.

Appendix 11 of BS 7671 provides particular guidance for the types of safety signs, warning signs and instructions required to be applied to electrical installations. Table 6.16 has been reproduced here from Table 11A of Appendix 11 of BS 7671.

▼ **Table 6.16** Minimum label text and symbol sizes to BS EN IEC/IEEE 82079-1 relevant to electrical installations

Label use	Recommended minimum height of graphical representations			
	Graphical symbols	Graphical safety signs	Dark on light background (e.g. black on white or black on yellow)	Low contrast (e.g. white on blue, white on red, white on black)
General labels	15 mm	15 mm	14 pt (4.9 mm)	16 pt (5.6 mm)
Labels for surfaces less than 10 cm^2	5 mm	10 mm	7 pt (2.5 mm)	12 pt (4.2 mtn)

NOTE: Examples shown here are provided for illustrative purposes and alternative text and symbol sizes and layouts complying with BS EN IEC/IEEE 82079-1 are permitted.

© The Institution of Engineering and Technology

NOTE

© The Institution of Engineering and Technology

Final circuits 7

7.1 Final circuits

411.3.2 411.3.3 525.202 Table 7.1(ii) has been designed to enable a radial or ring final circuit to be installed without calculation where the nominal voltage of the supply is at 230 V single-phase or 400 V three-phase. For other nominal voltages, the maximum circuit length given in the table must be corrected by the application of the formula:

$$L_p = \frac{L_t \times U_0}{230} \times 0.95$$

where:

L_p is the permitted length for voltage U_o

L_t is the tabulated length for 230 V

Uo is the nominal voltage of the supply.

The conditions assumed are that:

(a) the installation forms part of:

(i) a TN-C-S system with a typical maximum external earth fault loop impedance, Z of 0.35 Ω; or

(ii) a TN-S system with a typical maximum external earth fault loop impedance, Z_e of 0.8 Ω; or

(iii) a TT system with residual current devices (RCDs) installed as described in 3.6

(b) the final circuit is connected to a distribution board or consumer unit at the origin of the installation;

(c) the installation method is listed in column 4 of Table 7.1(ii);

Table 4B1 **(d)** the ambient temperature throughout the length of the circuit does not exceed 30 °C;

Appx 3 (e) the characteristics of protective devices are in accordance with Appendix 3 of BS 7671;

(f) the cable conductors are of copper;

Appx 4 (?) for other than lighting circuits, the voltage drop must not exceed 5 %;

© The Institution of Engineering and Technology

(h) the following disconnection times are applicable:
(i) 0.4 s for circuits up to and including 63 A; and

Table 41.1

(i) C_m in is the minimum voltage factor to take account of voltage variations depending on time and place;
(i) changing of transformer taps and other considerations.

NOTE: For a low voltage supply given in accordance with the Electricity Safety, Quality and Continuity Regulations 2002 (ESQCR), as amended, C_{min} is given the value 0.95.

The following maximum loads are assumed per circuit:

▼ Table 7.1 (i) Maximum loads assumed per circuit

Protective device	Rating (A)	Circuit type	Load (A)
BS 3036	30	Ring final circuit	26
BS 60898, BS 61009, BS 88-3, BS 88-2	32	Ring final circuit	26
BS 3036	5	Lighting	5
BS 60898, BS 61009, BS 88-3, BS 88-2	6	Lighting	5
BS 60898, BS 61009, BS 88-3, BS 88-2	10	Lighting	8
BS 60898, BS 61009, BS 88-3, BS 88-2	16	Lighting	12.8
BS 3036, BS 88-3	5	Radial	5
BS 60898, BS 61009, BS 88-2	6	Radial	5
BS 60898, BS 61009, BS 88-2	10	Radial	8
BS 3036	15	Radial	14.6
BS 60898, BS 61009, BS 88-2, BS 88-3	16	Radial	14.6
BS 60898, BS 61009, BS 3036, BS 88-2, BS 88-3	20	Radial	16
BS 60898, BS 61009, BS 88-2	25	Radial	20
BS 3036	30	Radial	26
BS 60898, BS 61009, BS 88-2, BS 88-3	32	Radial	26
BS 60898, BS 61009, BS 88-2	40	Radial	37

© The Institution of Engineering and Technology

▼ **Table 7.1(ii)** Maximum cable length for a 230 V final circuit using 70 °C thermoplastic (PVC) insulated and sheathed flat cable

Protective device		Cable size (mm^2)	Allowed installation methods (NOTE 2)	Maximum length (m) (NOTE 1)			
				$Z_e \leq 0.8\ \Omega$ TN-S		$Z_e \leq 0.35\ \Omega$ TN-C-S	
Rating (A)	Type			RCD 30 mA	No RCD	RCD 30 mA	No RCD
1	2	3	4	5	6	7	8
Ring final circuits (5 % voltage drop, load distributed)							
30	BS 3036	2.5/1.5	100, 102, A, C	106	41zs	106	106
	BS 3036	4.0/1.5	100, 102, A, 101, 103, C	171	48	171	138zs
32	cb/RCBO Type B	2.5/1.5	100, 102, A, C	106	96zs	106	106
	cb/RCBO Type C			106	NPzs	106	56zs
	cb/RCBO Type D			106	NPzs	106	NPzs
32	BS 88-2 (BS EN 60269-2)	2.5/1.5	100, 102, A, C	106vd	32zs	106vd	106vd
32	BS 88-2 (BS EN 60269-2)	4.0/1.5	100, 101, 102, 103, A, C	171	38zs	106vd	127zs
32	BS 88-3	2.5/1.5	100, 102, A, C	106vd	19ad	106	95zs
32	BS 88-3	4.0/1.5	100, 101, 102, 103, A, C	171	22zs	171	112zs
32	cb/RCBO Type B	4.0/1.5	100, 101, 102, 103, A, C	171vd	114zs	171vd	171vd
	cb/RCBO Type C			171vd	NPzs	171vd	66zs
	cb/RCBO Type D			171vd	NPzs	171vd	NPzs

© The Institution of Engineering and Technology

© The Institution of Engineering and Technology

▼ **Table 7.1(ii)** *Continued*

Protective device		Cable size (mm^2)	Allowed installation methods (NOTE 2)	Maximum length (m) (NOTE 1)			
				$Z_e \leq 0.8\ \Omega$ TN-S		$Z_e \leq 0.35\ \Omega$ TN-C-S	
Rating (A)	Type			RCD 30 mA	No RCD	RCD 30 mA	No RCD
1	2	3	4	5	6	7	8
Lighting circuits (3 % voltage drop, load distributed)							
5	BS 3036	1.0/1.0	100, 101, 102, 103, A, C	68	68	68	68
5	BS 3036	1.5/1.0	100, 101, 102, 103, A, C	106	106	106	106
5	BS 88-3	1.0/1.0	100, 101, 102, 103, A, C	68	68	68	68
5	BS 88-3	1.5/1.0	100, 101, 102, 103, A, C	106	106	106	106
6	cb/RCBO Type B	1.0/1.0	100, 101, 102, 103, A, C	68	68	68	68
	cb/RCBO Type C			68	65zs	68	68
	cb/RCBO Type D			68	23zs	68	34zs
6	BS 88-2 (BS EN 60269-2)	1.0/1.0	100,101,102,103, A, C	68	68	68	68
6	cb/RCBO Type B	1.5/1.0	100,101,102,103, A, C	106	106	106	106
	cb/RCBO Type C			106	78zs	106	91zs
	cb/RCBO Type D			106	28zs	106	41zs
6	BS 88-2 (BS EN 60269-2)	1.5/1.0	100, 101, 102, 103, A, C	106	106	106	106
10	cb/RCBO Type B	1.0/1.0	100, 101, 102, A, C	42vd	42vd	42vd	42vd
	cb/RCBO Type C			42vd	32zs	42vd	42vd
	cb/RCBO Type D			42vd	23zs	42vd	34zs

▼ Table 7.1(H) *Continued*

Protective device		Cable size (mm^2)	Allowed installation methods (NOTE 2)	Maximum length (m) (NOTE 1)			
				$Z_e \leq 0.8\ \Omega$ TN-S		$Z_e \leq 0.35\ \Omega$ TN-C-S	
Rating (A)	Type			RCD 30 mA	No RCD	RCD 30 mA	No RCD
1	2	3	4	5	6	7	8
10	cb/RCBO Type B cb/RCBO Type C cb/RCBO Type D	1.5/1.0	100, 101, 102, A, C	65vd 65vd 65vd	65vd 38zs 28zs	65vd 65vd 65vd	65vd 51zs 41zs
10	BS 88-2 (BS EN 60269-2)	1.0/1.0	100, 101, 102, A, C	42	42	42	42
10	BS 88-2 (BS EN 60269-2)	1.5/1.0	100, 101, 102, A, C	65	65	65	65
16	cb/RCBO Type B cb/RCBO Type C cb/RCBO Type D	1.5/1.0	100, 102, C	34 34 34	34 15sc NPad	34 34 34	34 28zs 9zs
16	cb/RCBO Type B cb/RCBO Type C cb/RCBO Type D	2.5/1.5	100, 101, 102, A, C	49 49 49	49 24zs NPad	49 49 49	49 44zs 14zs
16	BS 88-2 (BS EN 60269-2)	1.5/1.0	100, 102, C	20	20	20	20
16	BS 88-2 (BS EN 60269-2)	2.5/1.5	100, 101, 102, A, C	49	49	49	49
16	BS 88-3	1.5/1.0	100, 102, C	34	34	34	34
16	BS 88-3	2.5/1.5	100, 101, 102, A, C	34	34	34	34
Radial final circuits (5 % voltage drop, terminal load)							
5	BS 3036	1.0/1.0	100, 101, 102, 103, A, C	56	56	56	56

© TheInstitutionof Engineeringand Technology

© The Institution of Engineering and Technology

▼ **Table 7.1(ii)** *Continued*

Protective device		Cable size (mm^2)	Allowed installation methods (NOTE 2)	Maximum length (m) (NOTE 1)			
				$Z_e \leq 0.8\ \Omega$ TN-S		$Z_e \leq 0.35\ \Omega$ TN-C-S	
Rating (A)	Type			RCD 30 mA	No RCD	RCD 30 mA	No RCD
1	2	3	4	5	6	7	8
5	BS 88-3	1.0/1.0	100, 101, 102, 103, A, C	56	56	56	56
5	BS 3036	1.5/1.0	100, 101, 102, 103, A, C	88	88	88	88
5	BS 88-3	1.5/1.0	100, 101, 102, 103, A, C	88	88	88	88
6	cb/RCBO Type B	1.0/1.0	100, 101, 102, 103, A, C	56	56	56	56
	cb/RCBO Type C			56	56	56	56
	cb/RCBO Type D			56	23zs	56	33zs
6	BS 88-2 (BS EN 60269-2)	1.0/1.0	100, 101, 102, 103, A, C	56	56	56	56
6	BS 88-2 (BS EN 60269-2)	1.5/1.0	100, 101, 102, 103, A, C	88	88	88	88
6	cb/RCBO Type B	1.5/1.0	100, 101, 102, 103, A, C	88	88	88	88
	cb/RCBO Type C			88	78zs	88	88
	cb/RCBO Type D			88	28zs	88	40zs
10	cb/RCBO Type B	1.0/1.0	100, 101, 102, A, C	35	35	35	36
	cb/RCBO Type C			35	31zs	35	36
	cb/RCBO Type D			35	6zs	18ad	17zs
10	cb/RCBO Type B	1.5/1.0	100, 101, 102, 103, A, C	52	52	52	52
	cb/RCBO Type C			52	38zs	52	50zs
	cb/RCBO Type D			10ad	8zs	52	20zs
10	BS 88-2 (BS EN 60269-2)	1.0/1.0	100, 101, 102, A, C	35	35	35	35
10	BS 88-2 (BS EN 60269-2)	1.5/1.0	100, 101, 102, 103, A, C	52	52	52	52

▼ **Table 7.1(ii)** *Continued*

Protective device		Cable size (mm^2)	Allowed installation methods (NOTE 2)	Maximum length (m) (NOTE 1)			
				$Z_e \leq 0.8\ \Omega$ TN-S		$Z_e \leq 0.35\ \Omega$ TN-C-S	
Rating (A)	Type			RCD 30 mA	No RCD	RCD 30 mA	No RCD
1	2	3	4	5	6	7	8
15	BS 3036	1.0/1.0	NP	NP	NP	NP	NP
15	BS 3036	1.5/1.0	NP	NP	NP	NP	NP
15	BS 3036	2.5/1.5	100, 102, C	47	47	47	47
15	BS 3036	4.0/1.5	100, 101, 102, A, C	76	76	76	76
16	cb/RCBO Type B cb/RCBO Type C cb/RCBO Type D	1.0/1.0	C	18 18 18	18 13zs 7	18 18 8ad	18 13 NPad
16	BS 88-2 (BS EN 60269-2)	1.5/1.0	100, 102, C	27	27	27	27
16	BS 88-2 BS EN 60269-2)	2.5/1.5	100, 101, 102, A, C	45	45	45	45
16	BS 88-2 BS EN 60269-2)	4.0/1.5	100, 101, 102, 103, A, C	74	74	74	74
16	BS 88-3	1.5/1.0	100, 102, C	27	27	27	27
16	BS 88-3	2.5/1.5	100, 101, 102, A, C	45	45	45	45
16	BS 88-3	4.0/1.5	100, 101, 102, 103, A, C	74	74	74	74
16	cb/RCBO Type B cb/RCBO Type C cb/RCBO Type D	1.5/1.0	100, 102, C	27 27 27	27 15zs NPad	27 27 27	27 27 9zs

© The Institution of Engineering and Technology

© The Institution of Engineering and Technology

▼ **Table 7.1(ii)** *Continued*

Protective device		Cable size (mm^2)	Allowed installation methods (NOTE 2)	Maximum length (m) (NOTE 1)			
				$Z_e \leq 0.8\ \Omega$ TN-S		$Z_e \leq 0.35\ \Omega$ TN-C-S	
Rating (A)	Type			RCD 30 mA	No RCD	RCD 30 mA	No RCD
1	2	3	4	5	6	7	8
16	cb/RCBO Type B cb/RCBO Type C cb/RCBO Type D	2.5/1.5	100, 101, 102, A, C	45 45 45	45 24zs NPzs	45 45 45	45 43zs 14zs
16	cb/RCBO Type B cb/RCBO Type C cb/RCBO Type D	4.0/1.5	100, 101, 102, 103, A, C	69 32ad NPad	32ad 16zs NPad	69 54ad 18ad	69 36zs 9zs
20	BS 3036 cb/RCBO Type B cb/RCBO Type C cb/RCBO Type D	2.5/1.5	100, 101, 102, A 100, 102, A, C	NP 42 42 42	NP 42 12zs NPad	NP 42 42 42	NP 42 31zs 8zs
20	BS 3036 cb/RCBO Type B cb/RCBO Type C cb/RCBO Type D	4.0/1.5	C 100, 101, 102, A, C	69 69 69 69	43zs 69 14zs NPad	73 69 69 69	66zs 69 36zs 9zs
20	BS 3036 cb/RCBO Type B cb/RCBO Type C cb/RCBO Type D	6.0/2.5	100, 102, A, C 100, 101, 102, 103, A, C	105 105 105 105	69zs 107 23zs NPzs	105 105 105 105	105 105 58zs 15zs
20	BS 88-2 (BS EN 60269-2)	2.5/1.5	100, 102, A, C	42	42	42	42
20	BS 88-2 BS EN 60269-2)	4.0/1.5	100, 101, 102, A, C	69	43zs	69	66zs
20	BS 88-2 (BS EN 60269-2)	6.0/2.5	100, 101, 102, 103, A, C	105	69zs	105	105
20	BS 88-3	2.5/1.5	100, 102, A, C	42	42	42	42

▼ Table 7.1(H) *Continued*

Protective device		Cable size (mm^2)	Allowed installation methods (NOTE 2)	Maximum length (m) (NOTE 1)			
				$Z_e \leq 0.8\ \Omega$ TN-S		$Z_e \leq 0.35\ \Omega$ TN-C-S	
Rating (A)	Type			RCD 30 mA	No RCD	RCD 30 mA	No RCD
1	2	3	4	5	6	7	8
20	BS 88-3	4.0/1.5	100, 101, 102, A, C	69	56zs	69	69
20	BS 88-3	6.0/2.5	100, 101, 102, 103, A, C	105	89zs	105	105
25	cb/RCBO Type B	2.5/1.5	C	33	33	33	33
	cb/RCBO Type C			33	2zs	33	22zs
	cb/RCBO Type D			33	NPad	33	4zs
25	cb/RCBO Type B	4.0/1.5	100, 102, A, C	55	47zs	55	55
	cb/RCBO Type C			55	3zs	55	26sc
	cb/RCBO Type D			55	NPad	55	4zs
25	cb/RCBO Type B	6.0/2.5	100, 101, 102, A, C	83	75zs	83	83
	cb/RCBO Type C			83	5zs	83	43zs
	cb/RCBO Type D			83	NPzs	83	7zs
25	BS 88-2 BS EN (60269-2)	2.5/1.	C	31	20zs	31	31
25	BS 88-2 BS EN 60269-2)	4.0/1.5	100, 102, A, C	53	24zs	53	46zs
25	BS 88-2 BS EN 60269-2)	6.0/2.5	100, 101, 102, A, C	82	38zs	82	76zs
30	BS 3036	4.0/1.5		NP	NP	NP	NP
30	BS 3036	6.0/2.5	C	66	19zs	66	54zs
30	BS 3036	10.0/4.0	100, 102, A, C	110	31zs	110	89zs

© The Institution of Engineering and Technology

▼ **Table 7.1(ii)** *Continued*

Protective device		Cable size (mm^2)	Allowed installation methods (NOTE 2)	Maximum length (m) (NOTE 1)			
				$Z_e \leq 0.8\ \Omega$ TN-S		$Z_e \leq 0.35\ \Omega$ TN-C-S	
Rating (A)	Type			RCD 30 mA	No RCD	RCD 30 mA	No RCD
1	2	3	4	5	6	7	8
32	cb/RCBO Type B	4.0/1.5	C	43	28zs	43	43
	cb/RCBO Type C			43	NPad	43	16zs
	cb/RCBO Type D			43	NPad	43	NPad
32	cb/RCBO Type B	6.0/2.5	100,102, A, C	63	45zs	63	63
	cb/RCBO Type C			63	NPzs	63	26zs
	cb/RCBO Type D			63	NPzs	63	NPzs
32	cb/RCBO Type B	10.0/4.0	100, 101, 102, 103, A, C	105	74zs	105	105zs
	cb/RCBO Type C			105	NPad	105	42zs
	cb/RCBO Type D			105	NPad	105	NPsc
32	BS 88-2 (BS EN 60269-2)	4.0/1.5	C	43	9zs	43	31zs
32	BS 88-2 (BS EN 60269-2)	6.0/2.5	100, 102, A, C	63	15zs	63	50zs
32	BS 88-2 (BS EN 60269-2)	10/4.0	100, 101, 102, 103, A, C	105	24zs	105	82zs
32	BS 88-3	4.0/1.5	C	43	5zs	43	27zs
32	BS 88-3	6.0/2.5	100, 102, A, C	63	8zs	63	44zs
32	BS 88-3	10/4.0	100, 101, 102, 103, A, C	105	14zs	105	72zs
40	cb/RCBO Type B	6.0/2.5	C	46	23zs	46	46
	cb/RCBO Type C			46	NPzs	46	15zs
	cb/RCBO Type D			46	NPzs	46	NPzs
40	cb/RCBO Type B	10.0/4.0	100, 102, A, C	72	37zs	72	72
	cb/RCBO Type C			72	NPzs	72	25zs
	cb/RCBO Type D			72	NPzs	72	NPzs

▼ Table 7.1(ii) *Continued*

Protective device		Cable size (mm^2)	Allowed installation methods (NOTE 2)	Maximum length (m) (NOTE 1)			
				$Z_e \leq 0.8\ \Omega$ TN-S		$Z_e \leq 0.35\ \Omega$ TN-C-S	
Rating (A)	Type			RCD 30 mA	No RCD	RCD 30 mA	No RCD
1	2	3	4	5	6	7	8
40	cb/RCBO Type B cb/RCBO Type C cb/RCBO Type D	16.0/6.0	100, 101, 102, 103, A, C	118 118 118	57zs NPzs NPzs	118 118 118	118 39zs NPad
40	BS 88-2 (BS EN 60269-2)	6.0/2.5	C	46	NPzs	46	32zs
40	BS 88-2 (BS EN 60269-2)	10.0/4.0	100, 102, A, C	72	NPzs	72	52zs
40	BS 88-2 (BS EN 60269-2)	16.0/6.0	100, 101, 102, 103, A, C	118	NPzs	118	79zs

NOTES to Table 7.1(ii):

1 Voltage drop is the limiting constraint on the circuit cable length unless marked as follows:
- ad limited by the reduced csa of the protective conductor (adiabatic limit);
- ol Cable/device/load combination not allowed in any of the installation conditions;
- zs limited by earth fault loop impedance Z_s; and
- sc limited by line-to-neutral loop impedance (short-circuit).

2 The allowed installation methods are listed, see Tables 7.1(iii) and 7.1(iv) for further description.

3 NP - Not Permitted, prohibiting factor as NOTE 1.

4 For application of RCDs and RCBOs, see 3.6.4.

© The Institution of Engineering and Technology

▼ **Table 7.1(iii)** Installation reference methods and cable ratings for 70 °C thermoplastic (PVC) insulated and sheathed flat cable with protective conductor

Installation reference method		Conductor cross-sectional area (mm^2)						
Ref.	Description	1.0	1.5	2.5	4	6	10	16
		A	A	A	A	A	A	A
C	Clipped direct	16	20	27	37	47	64	85
B«	Enclosed in conduit or trunking on a wall, etc.	13	16.5	23	30	38	52	69
102	In a stud wall with thermal insulation with cable touching the wall	13	16	21	27	35	47	63
100	In contact with plasterboard ceiling or joists covered by thermal insulation not exceeding 100 mm	13	16	21	27	34	45	57
A	Enclosed in conduit in an insulated wall	11.5	14.5	20	26	32	44	57
101	In contact with plasterboard ceiling or joists covered by thermal insulation exceeding 100 mm	10.5	13	17	22	27	36	46
103	Surrounded by thermal insulation including in a stud wall with thermal insulation with cable not touching a wall	8	10	13.5	17.5	23.5	32	42.5

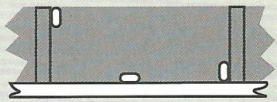
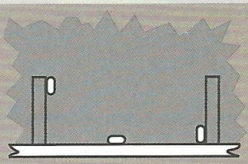
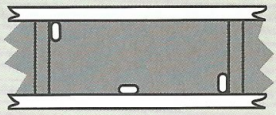
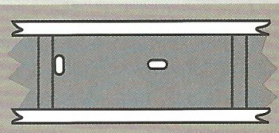
NOTES:

1 Cable ratings taken from Table 4D5 of BS 7671.

2 B* taken from Table 4D2A of BS 767 1, see Appendix F.

© The Institution of Engineering and Technology

▼ **Table 7.1(iv)** Installation methods specifically for flat twin and earth cables in thermal insulation

Installation method			Reference method to be used to determine current-carrying capacity
Number	Examples	Description	
100		Installation methods for flat twin and earth cable clipped direct to a wooden joist, or touching the plasterboard ceiling surface, above a plasterboard ceiling with thermal insulation not exceeding 100 mm in thickness having a minimum U value of 0.1 W/m^{2}K	Table 4D5
101		Installation methods for flat twin and earth cable clipped direct to a wooden joist, or touching the plasterboard ceiling surface, above a plasterboard ceiling with thermal insulation exceeding 100 mm in thickness having a minimum U value of 0.1 W/m^{2}K	Table 4D5
102		Installation methods for flat twin and earth cable in a stud wall with thermal insulation with a minimum U value of 0.1 W/m^{2}K with the cable touching the inner wall surface, or touching the plasterboard ceiling surface, and the inner skin having a minimum U value of 10 W/m^{2}K	Table 4D5
103		Installation methods for flat twin and earth cable in a stud wall with thermal insulation with a minimum U value of 0.1 W/m^{2}K with the cable not touching the inner wall surface	Table 4D5

NOTES:

1 Wherever practicable, a cable should be fixed in a position such that it will not be covered with thermal insulation.

2 Regulation 523.9 refers: for further information, see Appendix C (Avoidance of overheating of electric cables) of BS 5803-5:1985, Building Regulations Approved Document B and the Building Research Establishment publication *Thermal Insulation: avoiding risks.*

© The Institution of Engineering and Technology

7.2 Standard final circuits

7.2.1 Grouping of circuit cables

The tables assume that heating cables (including water heating cables) are not grouped.

For cables of household or similar installations (heating and water heating excepted), derating for grouping is not necessary if the following rules are followed:

(a) cables are not grouped, that is, they are separated by at least two cable diameters when installed under thermal insulation, namely installation methods 100, 101, 102 and 103;

(b) cables clipped direct (including in cement or plaster) are clipped side by side in one layer and separated by at least one cable diameter; and

(c) cables above ceilings are clipped to joists as per installation methods 100 to 103 of Table 4A2 of BS 7671.

For other groupings, for ambient temperatures higher than 30 °C or for enclosure in thermal insulation, the cable csa will need to be increased as per Appendix F of this Guide.

7.2.2 Socket-outlet circuits

The length represents the total ring cable loop length and does not include any spurs.

As a rule of thumb for rings, unfused spur lengths should not exceed l/8' [h] of the cable length from the spur to the furthest point of the ring.

The total number of fused spurs is unlimited but the number of non-fused spurs is not to exceed the total number of socket-outlets and items of stationary equipment connected directly in the circuit.

A non-fused spur feeds only one single or twin socket-outlet or one permanently connected item of electrical equipment. Such a spur is connected to a circuit at the terminals of socket-outlets or at junction boxes or at the origin of the circuit in the distribution board.

A fused spur is connected to the circuit through a fused connection unit, with the rating of the fuse in the unit not exceeding that of the cable forming the spur and, in any event, not exceeding 13 A. The number of socket-outlets that may be supplied by a fused spur is unlimited.

The circuit is assumed to have a load of 20 A at the furthest point with the balance to the rating of the protective device evenly distributed. (For a 32 A device this equates to a load of 26 A at the furthest point.)

7.2.3 Lighting circuits

A maximum voltage drop of 3 °/oo of the 230 V nominal supply voltage has been allowed in the circuits; see Appendix F.

© The Institution of Engineering and Technology

The circuit is assumed to have a load equal to the rated current (I_n) of the circuit protective device, evenly distributed along the circuit. Where this is not the case, circuit lengths will need to be reduced where voltage drop is the limiting factor, or halved where the load is all at the extremity.

The most onerous installation condition acceptable for the load and device rating is presumed when calculating the limiting voltage drop. If the installation conditions are not the most onerous allowed (see column 4 of Table 7.1(ii)) the voltage drop will not be as great as presumed in the table.

7.2.4 Residual current devices (RCDs)

Where circuits have residual-current protection, the limiting factor is often the maximum loop impedance that will result in operation of the overcurrent device within 5 s for a short-circuit (line to neutral) fault. (See NOTE 1 to Table 7.1(ii) and limiting factor sc.)

7.2.5 Requirement for RCDs

RCDs are required:

411.5 **(a)** where the earth fault loop impedance is too high to provide the required disconnection, for example, where the distributor does not provide a connection to the means of earthing - TT earthing arrangement;

411.3.3(i) **(b)** for socket-outlets with a rated current not exceeding 32 A in locations where they are liable to be used by persons of capability BAI, BAS or children (BA2, BA3);

411.3.4 **(c)** for lighting circuits in domestic (household) premises;

701.411.3.3 **(d)** for all circuits of locations containing a bath or shower or passing through zones 1 and/or 2 not serving the location;

411.3.3(ii) **(e)** for circuits supplying mobile equipment not exceeding 32 A for use outdoors;

522.6.202 **(f)** for cables without earthed metallic covering installed in walls or partitions at a depth of less than 50 mm and not protected by earthed steel conduit or similar; and

522.6.203 **(g)** for cables without earthed metallic covering installed in walls or partitions with metal parts (not including screws or nails) and not protected by earthed steel conduit and the like.

NOTE: Metallic capping does not meet the requirements for mechanical protection as required b Regulation 522.6.204. Metallic capping is used to protect the cables during the installation process and, once plastered over, does not provide any further protection. Similarly, metallic capping would not meet the requirements of Regulation 522.6.204, (ii) or (iii) and would not satisfy the requirements of BS 7671 for a protective conductor.

A single layer of steel with a minimum thickness of 3 mm is generally considered to provide sufficient mechanical protection against penetration by nails, screws and the like in accordance with Regulation 522.6.204(iv), except where shot-fired nails are likely to be used.

Omission of RCD protection

411.3.3 **(a)** Other than in locations where they are liable to be used by persons of capability BAI, BA3 or children (BA2, BA3), RCD additional protection for socket-outlets with a rated current not exceeding 32 A can be omitted where a documented risk assessment determines that such protection is not necessary (i.e. the risk to users is sufficiently low). This dispensation does not apply for an installation in a dwelling.

© The Institution of Engineering and Technology

The risk assessment needs to be carried out by a skilled person (electrically) together with the responsible person and must be appended to the appropriate Electrical Installation Certificate (EIC).

411.5.2 Cables installed on the surface do not specifically require RCD protection, however, RCD protection may be required for other reasons, such as, where the installation forms part of a TT system and the earth fault loop impedance values for the overcurrent protective device cannot be met.

7.2.6 TT systems

For TT systems the figures for TN-C-S systems, with RCDs, may be used provided that:

(a) the circuit is protected by an RCD to BS 4293, BS EN 61008, BS EN 61009 or BS EN 62423 with a rated residual operating current not exceeding that required for its circuit position;

(b) the total earth fault loop impedance is verified as being less than 200 O; and

(c) a device giving both overload and short-circuit protection is installed in the circuit. This may be an RCBO or a combination of a fuse or circuit-breaker with an RCCB.

7.2.7 Choice of protective device

The selection of protective device depends upon:

i. prospective fault current;
ii. circuit load characteristics;
iii. cable current-carrying capacity; and
iv. disconnection time limit.

Whilst these factors have generally been allowed for in the standard final circuits in Table 7.1(ii), the following additional guidance is given:

i Prospective fault current

434.5.1 If a protective device is to operate safely, its rated short-circuit capacity must be not less than the prospective fault current at the point where it is installed. See Table 7.2.7(i).

313.1 The distributor needs to be consulted as to the prospective fault current at the origin of the installation. Except for London and some other major city centres, the maximum fault current for 230 V single-phase supplies up to 100 A will not exceed 16 kA. In general, the fault current is unlikely to exceed 16.5 kA.

© The Institution of Engineering and Technology

7

▼ **Table 7.2.7(i)** Rated short-circuit capacities

Device type	Device designation	Rated short-circuit capacity (kA)
Semi-enclosed fuse to BS 3036 with category of duty	S1A S2A S4A	1 2 4
Cartridge fuse to BS 1361 type 1 type II		16.5 33.0
General-purpose fuse to BS 88-2 (BS EN 60269-2)		50 at 415 V
BS 88-3 type 1 type II		16 31.5
General-purpose fuse to BS 88-6		16.5 at 240 V 80 at 415 V
Circuit-breakers to BS 3871 (replaced by BS EN 60898)	M1 M1.5 M3 M4.5 M6 M9	1 1.5 3 4.5 6 9
Circuit-breakers to BS EN 60898* and RCBOs to BS EN 61009		I_{cn} I_{cs} 1.5 (1.5) 3.0 (3.0) 6 (6.0) 10 (7.5) 15 (7.5) 20 (10.0) 25 (12.5)

* Two short-circuit capacities 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 is the condition of the circuit-breaker after manufacturer's testing.

- I_{cn} is the maximum fault current the breaker can interrupt safely, although the breaker may no longer be usable.
- I_{cs} is the maximum fault current the breaker can interrupt safely without loss of performance.

The I_{cn} value (in amperes) is normally marked on the device in a rectangle, for example, |6000|A. 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 the I_{cn} will equal I_{cs}.

© The Institution of Engineering and Technology

The short-circuit capacity of devices to BS EN 60947-2 is as specified by the manufacturer.

ii Circuit load characteristics

533.1.2.3

(a) Semi-enclosed fuses: fuses should preferably be of the cartridge type. However, semi-enclosed fuses to BS 3036 are still permitted for use in domestic and similar premises if fitted with a fuse element which, in the absence of more specific advice from the manufacturer, meets the requirements of Table 53.1.

(b) *Cartridge fuses to BS 1361 (now withdrawn, replaced by BS HD 60269-3:2010/ BS 88-3:2010):* these are for use in domestic and similar premises.

(c) *Cartridge fuses to the BS 88 series:* three types are specified:

(i) gC fuse links with a full-range breaking capacity for general application;

(ii) gM fuse links with a full-range breaking capacity for the protection of motor circuits; and

(iii) a M fuse links for the protection of motor circuits.

(d) *Circuit-breakers to BS EN 60898 (or BS 3871-1) and RCBOs to BS EN 61009:* guidance on selection is given in Table 7.2.7(H).

▼ **Table 7.2.7(H)** Application of circuit-breakers

Circuit-breaker type	Trip current	Application
1 B	2.7 to 4 I_n 3 to 5 I_n	Domestic and commercial installations having little or no switching surge
2 C 3	4 to 7 I_n 5 to 10 I_n 7 to 10 I_n	General use in commercial/industrial installations where the use of fluorescent lighting, small motors, etc., can produce switching surges that would operate a Type 1 or B circuit-breaker. Type C or 3 may be necessary in highly inductive circuits such as banks of fluorescent lighting
4 D	10 to 50 I_n 10 to 20 I_n	Not suitable for general use Suitable for transformers, X-ray machines, industrial welding equipment, etc., where high inrush currents may occur

NOTE: I_n is the nominal rating of the circuit-breaker.

iii Cable current-carrying capacities

For guidance on the coordination of device and cable ratings see Appendix F.

iv Disconnection times

411.3.2.2
411.3.2.3
411.3.2.4
411.8.3

The protective device must operate within the required disconnection time as appropriate for the circuit. Appendix B provides maximum permissible measured earth fault loop impedances for fuses, circuit-breakers and RCBOs.

© The Institution of Engineering and Technology

7.3 Installation considerations

7.3.1 Floors and ceilings

522.6.201 Where a low voltage cable is installed under a floor or above a ceiling it must be run in such a position that it is not liable to be damaged by contact with the floor or ceiling or the fixings thereof. A cable passing through a joist, under floorboards or ceiling support must:

522.6.201
522.6.204(i) **(a)** be at least 50 mm from the top or bottom, as appropriate; or

(b) have earthed armouring or an earthed metal sheath; or

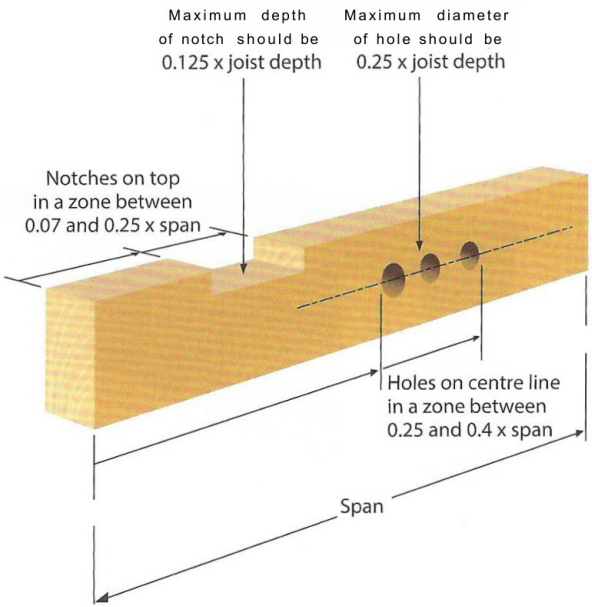
522.6.204
(ii) or (iii) **(c)** be enclosed in earthed steel conduit or trunking; or

522.6.204(iv) **(d)** be provided with mechanical protection sufficient to prevent penetration of the cable by nails, screws and the like (note that the requirement to prevent penetration is difficult to meet); or

414
522.6.204(v) **(e)** form part of a SELV or PELV circuit.

See Figure 7.3.1.

▼ **Figure 7.3.1** Cables through joists



NOTES:

1 Maximum diameter of hole should be 0.25 x joist depth.
2 Holes on centre line in a zone between 0.25 and 0.4 x span.
3 Maximum depth of notch should be 0.125 x joist depth.
4 Notches on top in a zone between 0.07 and 0.25 x span.
5 Holes in the same joist should be at least 3 diameters apart.

© The Institution of Engineering and Technology

7.3.2 Walls and partitions

522.6.202 A cable installed in a wall or partition must:

522.6.202 **(a)** be buried at least 50 mm from the surface; or

(b) be protected by a 30 mA RCD and installed in a zone either horizontally within 150 mm of the top of the wall or partition or vertically within 150 mm of the angle formed by two walls, or run horizontally or vertically to an accessory or consumer unit (see Figure 7.3.2). Where the wall is 100 mm thick or less and the location of the accessory or consumer unit can be determined from the 522.6.204(i) reverse side, the zoning arrangement is projected through the wall.

(c) have earthed armouring or an earthed metal sheath; or

522.6.204(iv) **(d)** be enclosed in earthed steel conduit or trunking; or

522.6.204(ii) or (iii) (e) be provided with mechanical protection sufficient to prevent penetration of the cable by nails, screws and the like (note that the requirement to prevent penetration is difficult to meet); or

414 **(f)** form part of a SELV or PELV circuit.

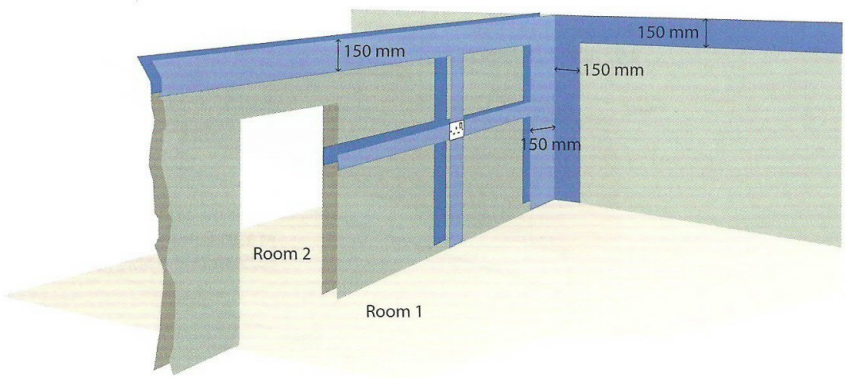
522.6.202

522.6.203 Cables installed in walls or partitions with a metal or part metal construction must:

(i) be protected by a 30 mA RCD and, if they are at a buried depth of less than 522.6.203 50 mm, be installed as (b); or

522.6.202 (ii) be installed as (c), (d), (e) or (f).

▼ **Figure 7.3.2** Zones prescribed in Regulation 522.6.202(i) (see b above)



© The Institution of Engineering and Technology

528 # 7.4 Proximity to electrical and other services

528.3 Electrical and all other services must be protected from any harmful mutual effects foreseen as likely under conditions of normal service. For example, cables should not be in contact with or run alongside hot pipes.

7.4.1 Segregation of Band I and Band II circuits

528.1 Part 2 Band I (extra-low voltage) circuits must not be contained within the same wiring system (for example, trunking) as Band II (low voltage) circuits unless:

- **(a)** every cable is insulated for the highest voltage present; or
- **(b)** each conductor of a multicore cable is insulated for the highest voltage present; or
- **(c)** the cables are installed in separate compartments; or
- **(d)** the cables fixed to a cable tray are separated by a partition; or
- **(e)** for a multicore cable, they are separated by an earthed metal screen of equivalent current-carrying capacity to that of the largest Band II circuit.

Definitions of voltage bands are as follows:

- **(a)** Band I circuit: a circuit that is nominally extra-low voltage, i.e. not exceeding 50 V AC or 120 V DC: for example, SELV, PELV, information and communication, data and signalling; and
- **(b)** Band II circuit: a circuit that is nominally low voltage, i.e. 51 to 1000 V AC and 121 to 1500 V DC.

528.1, Note 2 **NOTE:** fire alarm and emergency lighting circuits must be separated from other cables and from each other, in compliance with BS 5839 and BS 5266 respectively.

7.4.2 Proximity to information and communication cables

528.2 Adequate separation between information and communication wiring (Band I) and electric power and lighting (Band II) circuits must be maintained. This is to prevent mains voltage appearing in telecommunication circuits with consequent danger to personnel. BS 6701 :201 6+A1 :2017 requires that external cables have minimum separation distances according to BS EN 50174-3, and that internal cables are separated by the greater of the requirements presented by either BS EN 50174-2 for electromagnetic compatibility, or the following requirements for safety:

- **(a)** at least 50 mm where one or more of the following conditions are met:
  - **(i)** the LV electricity supply cables are enclosed in a separate conduit or trunking which, if metallic, is bonded in accordance with BS 7671;
  - **(ii)** the LV electricity supply cables are of a mineral-insulated type;
  - **(iii)** the LV electricity supply cables are of an earthed armoured construction;
  - **(iv)** the LV electricity supply cables are of a flexible, insulated and sheathed type (e.g. "kettle leads" supplying LV mains power to telecommunications equipment in cabinets); or
  - **(v)** where the separation is provided and maintained by a protective partition as specified in BS 7671; or
- **(b)** at least 150 mm in all other cases.

© The Institution of Engineering and Technology

7.4.3 Separation of gas installation pipework

Gas installation pipes must be spaced:

(a) at least 150 mm away from electricity supply equipment, such as metering equipment, main service cut-outs or supplier (main) isolation switches and distribution boards or consumer units; and

(b) at least 25 mm away from electrical switches, sockets and electricity supply and distribution cables. The installation pipework shall not be positioned in a manner that prevents the operation of any electrical accessory, i.e. a switch or socket-outlet.

See also 2.3 and Figure 2.3.

5283.4 Note The cited distances are quoted within BS 6891:2015+A1:2019. *Specification for the installation and maintenance of low pressure gas installation pipework of up to 35 mm (R1'/i) on premises,* Clause 8.4.2.

7.4.4 Induction loops

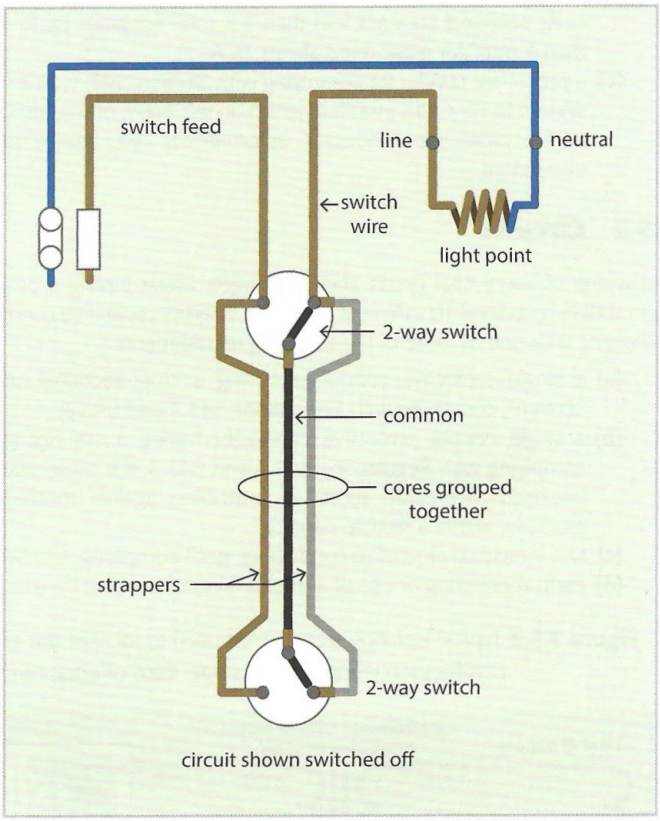
A particular form of harmful effect may occur when an electrical installation shares the space occupied by a hearing aid induction loop.

Under these circumstances, if line and neutral conductors or switch feeds and switch wires are not run close together, there may be interference with the induction loop.

This can occur when a conventional two-way lighting circuit is installed. The effect can be reduced by connecting as shown in Figure 7.4.4.

© The Institution of Engineering and Technology

Tablesi ▼ Figure 7.4.4 Circuit for reducing interference with induction loop



NOTE: Black/grey switch conductors are to be identified in accordance with Table KI.

543.7 # 7.5 Earthing requirements for the installation of equipment having high protective conductor current

7.5.1 Equipment

543.7.1.202 Equipment having a protective conductor current exceeding 10 mA should be connected by one of the following methods:

(a) permanently connected to the wiring of the installation, with the protective conductor selected in accordance with Regulation 543.7.1.203. The permanent connection to the wiring may be by means of a flexible cable.

© The Institution of Engineering and Technology

(b) a flexible cable with an industrial plug and socket to BS EN 60309-2, provided that the protective conductor of the associated flexible cable is of cross-sectional area not less than 2.5 mm ^{2} for plugs up to 16 A and not less than 4 mm ^{2} for plugs rated above 16 A.

(c) a protective conductor complying with Section 543, with an earth monitoring system to BS4444 installed, which, in the event of a continuity fault occurring in the protective conductor, automatically disconnects the supply to the equipment.

7.5.2 Circuits

543.7.1.203 The wiring of every final circuit and distribution circuit having a protective conductor current likely to exceed 10 mA must have high integrity protective conductor connections complying with one or more of the following requirements:

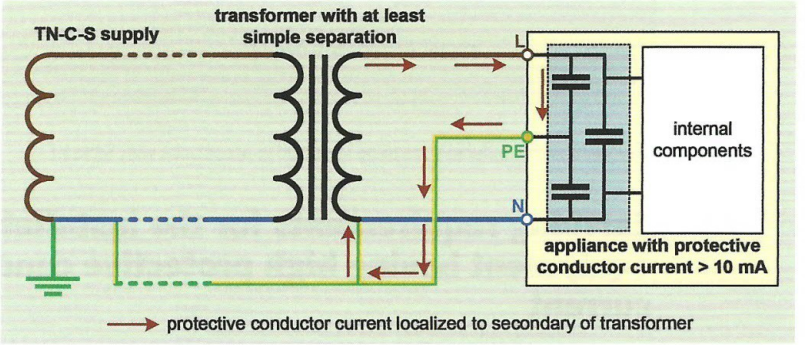
(a) a single protective conductor having a cross-sectional area not less than 10 mm ^{2}, complying with Regulations 543.2 and 543.3;

(b) a single copper protective conductor having a csa not less than 4 mm ^{2}, complying with Regulations 543.2 and 543.3, the protective conductor being enclosed to provide additional protection against mechanical damage, for example, within a flexible conduit;

543.7.1.203 **(c)** two individual protective conductors, each complying with Section 543; and/or

543.7.1.203 **(d)** earth monitoring or use of a double-wound isolating transformer.

▼ **Figure 7.5.2** Typical isolation transformer used to localize the effect of protective conductor currents from a single item of equipment



NOTE: Information should be provided at distribution boards to indicate circuits with high protective conductor currents (see 6.15).

© The Institution of Engineering and Technology

7.5.3 Socket-outlet final circuits

For a final circuit with socket-outlets or connection units, where the protective conductor current in normal service is likely to exceed 10 mA, the following arrangements are acceptable:

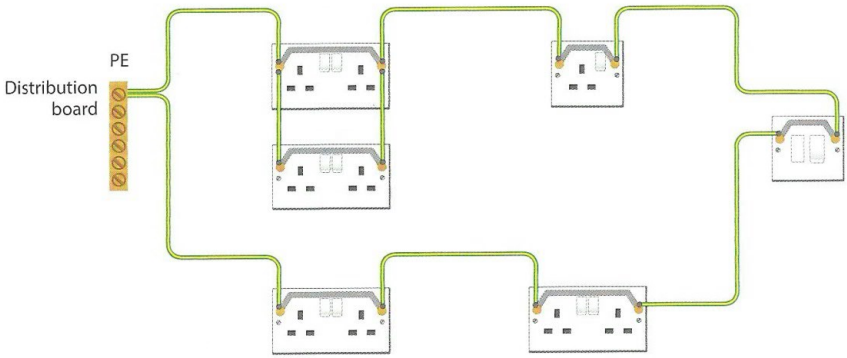
(a) a ring final circuit with a ring protective conductor. Spurs, if provided, require high integrity protective conductor connections (Figure 7.5.3(i)); or

(b) a radial final circuit with:

(i) a protective conductor connected as a ring (Figure 7.5.3(ii)); or

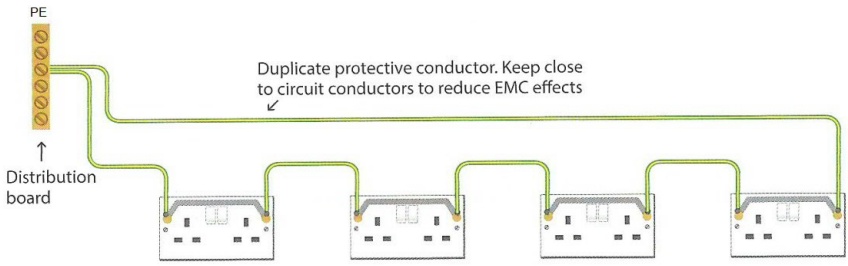
(ii) an additional protective conductor provided by metal conduit, trunking or ducting.

▼ **Figure 7.5.3(i)** Ring final circuit supplying socket-outlets



NOTE: Separate terminals for connections at the socket outlets is not a requirement.

▼ **Figure 7.5.3(H)** Radial final circuit supplying socket-outlets with duplicate protective conductors



NOTE: Separate terminals for connections at the socket outlets is not a requirement.

© The Institution of Engineering and Technology

7.6 Electrical supplies to furniture

Where electrical equipment is installed within purpose-built items of furniture, such as cupboards, shop displays or lecterns, and supplied from a plug and socket arrangement, no specific standard exists for such installations, therefore guidance is given here which, essentially, follows the principles of BS 7671. For electrical systems in office furniture and educational furniture, BS 6396:2OO8+A1:2015 currently applies for installations supplied via a 13 A BS 1363 plug.

The following points should be adhered to:

415.1.1
- ► socket-outlets supplying items of furniture must be protected by a 30 mA RCD providing additional protection.
- ► cables of Band I and Band II circuits are to be kept apart as far as is reasonably practicable, see also 7.4.1.
- ► cables of Band I and Band II circuits, which are often hidden beneath desks, should be sufficiently mechanically protected from damage caused by movement of chairs, storage of materials and the movement of feet and legs.
- ► cable management systems or containment, such as conduit or trunking, should be installed to allow the safe routing, protection and separation of cables through the equipment.
- ► the long-term use of multi-gang extension leads should be avoided by installing a sufficient number of socket-outlets to supply the equipment to be used; employers should not allow ad hoc solutions to be created by users, (see also BS 6396:2008+Al:2015).
- ► cables should be suitably located and sufficiently protected so that they cannot become trapped or damaged where desks are designed to be extended or altered to suit different activities or users.

543.2.1
543.2.6
There is no general requirement to ensure electrical continuity across the metallic frame of an item 'of furniture unless the frame has been designed to be used as a protective conductor or the manufacturer's instructions require it.

Where luminaires are installed in display stands, one of two methods of protection against electric shock must be used:

559.8
414
415.1
(a) SELV or PELV; or
(b) protected by a 30 mA RCD.

521.10.1
7.7 Trunking installations

All current-carrying single-core non-sheathed cables must be enclosed within conduit, ducting or trunking having at least the degree of protection IPXXD or IP4X and covers must only be removable by the use of a tool. It is very important that the IP rating of IPXXD or IP4X is maintained where site-fabricated joints are utilized.

© The Institution of Engineering and Technology

132.16
421.1.201

7.8 Additions and alterations

Where an addition or alteration is required, there are a number of issues to keep in mind. The designer/insta ller takes responsibility for all aspects of the installation relevant to the planned work. The following elements must be adequate for the altered circumstances:

(a) the rating of the existing equipment must be suitable for the addition or alteration, including the distributor's equipment and metering equipment;
(b) the existing equipment is suitable for continued use, including the distributor's equipment and metering equipment; and
(c) the earthing and bonding arrangements, if necessary for the protective measure applied to the addition or alteration, are adequate.

Where the work is an addition to an existing circuit, the designer/installer takes responsibility for the circuit, so far as is reasonably practicable, in addition to the items (a) - (c) above, not just the not just the small addition or alteration they are undertaking. There is no difference as to whether the addition or alteration is temporary or permanent and compliance with BS 7671 must be ensured in all circumstances.

Consumer units in dwellings

BS 7671 requires non-combustible consumer units to be installed in domestic (household) premises; see 2.2.6 of this Guide.

Installers adding or amending circuits in dwellings will encounter older consumer units, i.e. those not complying with Regulation 421.1.201, for many years to come. It is important that installers do not advise the replacement of consumer units simply because they do not comply with the current version of BS 7671. To ensure the ongoing use of such enclosures and assemblies, the installer must ensure the following:

(a) confirmation that **all** conductor connections are correctly located in terminals and are tight and secure; this may involve seeking the advice of the manufacturer of the equipment to establish correct torque settings for screwdrivers when checking terminals. This applies to all conductor/busbar connections within the consumer unit, and not just those relating to the addition or alteration;
(b) there are no signs of overheating; and
(c) all covers, shields and barriers supplied when originally installed are present and in a good, serviceable condition.

It must be verified for all conductor/busbar connections that:

(i) terminals are not clamping onto insulation;
(ii) conductor are not damaged, for example, through cuts or nicks on a solid conductor during insulation removal, or strands removed;
(iii) conductors are correctly placed, for example on the correct side of a moving plate in a cage-clamp terminal;
(iv) the permitted number of conductors per terminal is not exceeded; and
(v) no undue mechanical strain is placed on the electrical connection, particularly incoming tails.

© The Institution of Engineering and Technology

So far as is reasonably practicable, confirm that incorporated components such as a main switch, circuit-breakers, RCBOs, RCCBs, etc., are not the subject of any product recall. This could be achieved by direct questioning to the manufacturer.

133.1.1
511.1
511.2

7.9 Installation and use of non-standard cables

For the purposes of this Guidance Publication and to ensure compliance with BS 7671, the installation and use of non-standard cables, such as SY, CY and YY cables is discouraged.

The letters signify the following:

S - steel braid

Y - PVC

C - copper braid

They are used to identify the following:

SY cables: steel braided, usually translucent sheath, PVC insulated flexible conductors

YY cables: usually grey PVC sheath, PVC insulated flexible conductors

CY cables: tinned copper wire braid, usually grey PVC sheath, PVC insulated flexible conductors

To meet the requirements of BS 7671, every item of equipment must comply with a British or Harmonized Standard, in the absence of such, reference can be made to IEC standards or the appropriate standard of another country. SY, YY and CY cables are not made to British or Harmonized Standards. Some manufacturers state that their cables generally comply with a British Standard; this is not deemed sufficient for the purposes of BS 7671.

It is important that cables have approval from an independent testing organization and installers should ensure that all cables purchased have manufacturers' identification and a specification reference/standard number printed on the sheath to enable testing, if necessary, and traceability.

512.1.5

7.10 EMC Directive and compatibility

The designer of the fixed installation shall ensure that the installed fixed equipment, where relevant, is designed and manufactured in accordance with the Electromagnetic Compatibility (EMC) Regulations 2016 and, upon request, the responsible person for the fixed installation shall provide the required documentation.

For straightforward situations, installations composed solely of CE marked apparatus installed in accordance with the manufacturer's instructions, with the instructions for installation, use and maintenance being available for inspection, would conform to these Regulations.

© The Institution of Engineering and Technology

7.11 Wiring systems in escape routes

422.2.1 Appx 5 In buildings where evacuation is declared as via designated escape routes cables must not encroach on escape routes unless they meet the recommended requirements of the relevant part of BS EN 60332-3 series and achieve at least 60 % light transmittance when tested in accordance with BS EN 61034-2. Cables in escape routes must be as short as practicable. Cables encroaching on escape routes must not be installed within arm's reach unless they are provided with protection against mechanical damage likely to occur during an evacuation.

Where used, cable management systems must be one or more of the following types:

(i) conduit systems classified as non-flame propagating according to BS EN 61386;
(ii) cable trunking systems and cable ducting systems classified as non-flame propagating according to BS EN 50085;
(iii) cable tray and cable ladder systems classified as non-flame propagating according to BS EN 61537; or
(iv) powertrack systems meeting the requirements of BS EN 61534.

If the cables are completely enclosed and protected by any of the cable management systems (i) and (ii) above, they do not have to meet the recommended requirements of the relevant part of BS EN 60332-3 series.

NOTE: Cables need to satisfy the requirements of the CPR in respect of their reaction to fire. See BS 7671 Appendix 2, item 17.

Cables supplying safety circuits must have a resistance to fire rating of either the time authorized by regulations for building elements or, one hour in the absence of such regulations.

7.11.1 Protected escape routes

Appx 13 A protected escape route is defined as:

"A route enclosed with specified fire-resisting construction designated for escape to a place of safety in the event of an emergency", and guidance on protected escape routes is given in Appendix 13 of BS 7671.

Cables or other electrical equipment shall not be installed in a protected escape route unless they are part of an essential fire safety or related safety system. There may also be socket-outlets provided for cleaning or maintenance.

This generally means that cables in a protected escape route should be limited to lighting, emergency lighting and fire detection and alarm systems, although cables for other safety systems may be necessary.

© The Institution of Engineering and Technology

Only cables that meet the following requirements shall be installed in protected escape routes:

- resistance to flame propagation according to the recommended requirements of the relevant part of BS EN 60332-3 (series) or, where cable management systems according to (i) or (ii) below are used, to the recommended requirements of BS EN 60332-1-2; and
- a minimum of 60 °/olight transmittance when tested in accordance with BS EN 61034-2.

Where used, cable management systems shall be one or more of the following types and shall be of limited smoke production so as not to inhibit escape:

(i) conduit systems classified as non-flame propagating according to BS EN 61386;
(ii) cable trunking systems and cable ducting systems classified as non-flame propagating according to BS EN 50085;
(iii) cable tray and cable ladder systems classified as non-flame propagating according to BS EN 61537; or
(iv) powertrack systems meeting the requirements of BS EN 61534.

Cables in escape routes shall be as short as practicable. Cables encroaching on escape routes shall not be installed within arm's reach unless they are provided with protection against mechanical damage likely to occur during an evacuation.

© The Institution of Engineering and Technology

Locations containing a bath or shower 8

8.1 Summary of requirements

701 Due to the presence of water, locations containing a bath or shower are onerous for equipment and there is an increased danger of electric shock.

The additional requirements can be summarized as follows:

701.411.3.3 **(a)** all low voltage circuits serving the location must be protected by 30 mA residual current devices (RCDs);

701.411.3.3 **(b)** all low voltage circuits passing through zones 1 and 2 but not serving the location must be protected by 30 mA RCDs;

701.512.3 **(c)** socket-outlets, for example, BS 1363, are not allowed within 2.5 m of zone 1 (the edge of the bath or shower basin);

701.512.2 **(d)** protection against ingress of water is specified for equipment within the zones, see Table 8.1 and Figures 8.1(i) to 8.1(iii); and

701.512.3 **(e)** there are restrictions as to where appliances, switchgear and wiring accessories may be installed, see Table 8.1 and Figures 8.1(i) to 8.1(iii).

701 701.32.3 701.512.3 The space under the bathtub or shower basin is considered to be zone 1. However, where the space under a bath is only accessible by a means of a tool, this is considered to be outside the zones. Should it be necessary to connect electrical equipment beneath a bath, for example, whirlpool units, the connection must comply with Regulation 701.512.3, meaning that socket-outlets would not be permitted beneath a bath.

701 701.32.3 701.512.3 415.1.1 The inside of an airing cupboard in a bathroom is deemed to be outside the location and must effectively limit the extent of the location, just as a bathroom door separates the bathroom as a special location from the rest of the property. However, it is strongly recommended where an airing cupboard opens into zone 1 or zone 2, that circuits supplying equipment in the airing cupboard are provided with additional protection by an RCD rated at 30 mA.

701.414.3 Where SELV or PELV is used in zones 0, 1 and 2, a source described in Regulation 414.3(iv) shall not be used.

© The Institution of Engineering and Technology

701.415.2 Supplementary bonding of locations containing a bath or shower is required unless all of the following requirements are met:

411.3.2.2 ([a]) all circuits of the location meet the required disconnection times;

701.411.3.3 **(b)** all circuits of the location have additional protection by 30 mA RCDs; and

(c) all extraneous-conductive-parts within the location are effectively connected by main protective bonding conductors to the MET of the installation.

NOTE: An example of this is where a metallic water service pipe enters the building in the bathroom and would be connected to the MET of the electrical installation by means of a main protective bonding conductor.

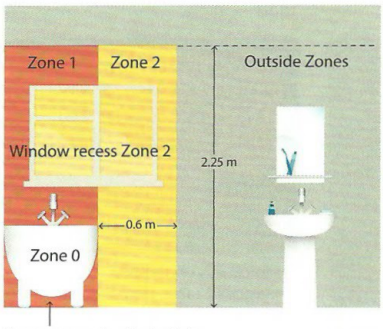
▼ **Table 8.1** Requirements for equipment (current-using and accessories) in a location containing a bath or shower

Zone	Minimum degree of protection	Current-using equipment	Switchgear and accessories
0	IPX7	Only 12 V AC rms or 30 V ripple-free DC SELV, the safety source installed outside the zones.	None allowed.
1	IPX4 (IPX5 if water jets)	25 V AC rms or 60 V ripple-free DC SELV or PELV, the safety source installed outside the zones. The following mains voltage fixed, permanently connected equipment allowed: whirlpool units, electric showers, shower pumps, ventilation equipment, towel rails, water heaters, luminaires.	Only 12 V AC rms or 30 V ripple-free DC SELV switches, the safety source installed outside the zones.
2	IPX4 (IPX5 if water jets)	Fixed permanently connected equipment allowed. General rules apply.	Only switches and sockets of SELV circuits allowed, the source being outside the zones, and shaver supply units complying with BS EN 61558-2-5 if fixed where direct spray is unlikely.
Outside zones	IPXXB or IP2X	General rules apply.	Accessories, SELV socket-outlets and shaver supply units to BS EN 61558-2-5 allowed. Socket-outlets allowed 2.5 m horizontally from the boundary of zone 1.

© The Institution of Engineering and Technology

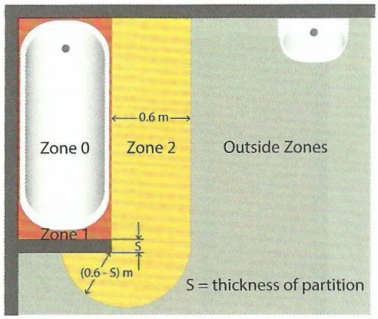
▼ **Figure 8.1 (i)** Zone dimensions in a location containing a bath

Section



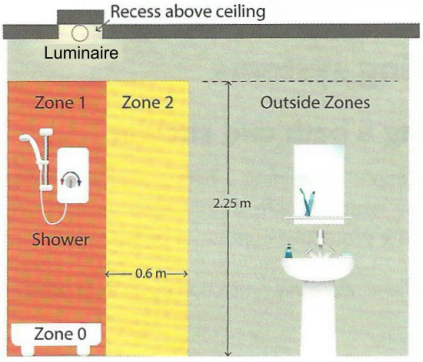
The space under the bath is:
Zone 1 if accessible without the use of a tool
outside the zones if accessible only with the use of a tool

Plan

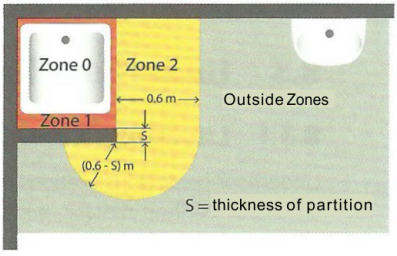


▼ **Figure 8.1 (ii)** Zones in a location containing a shower with basin and with permanent fixed partition

Section

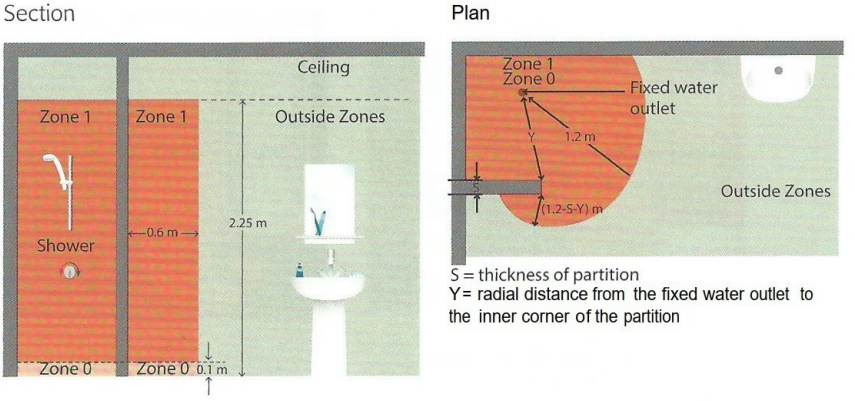


Plan



© The Institution of Engineering and Technology

▼ **Figure 8.1 (iii)** Zones in a location containing a shower without a basin, but with a partition



8.2 Shower cubicle in a room used for other purposes

Where a shower cubicle is installed in a room other than a bathroom or shower room the requirements for bathrooms and shower rooms must be complied with.

8.3 Underfloor heating systems

8.3.1 Locations containing a bath and shower

701.753 Underfloor heating installations in locations containing a bath and shower should have an overall earthed metallic grid or the heating cable should have an earthed metallic sheath, which must be connected to the protective conductor of the supply circuit.

753.411.3.2 415.1.1 All underfloor heating installations must have additional protection by an RCD rated at 30 mA.

8.3.2 Other areas

753.411.3.2 415.1.1 In areas other than special locations, Class I heating units that do not have an exposed-conductive-part, i.e. integrated earth screen or sheath, must have a metallic grid, with a spacing of not more than 30 mm, installed above the floor heating elements. The grid must be connected to the protective conductor of the electrical installation and the heating system protected by an RCD with a rated residual operating current not exceeding 30 mA.

753.415.1 701.753 In areas where occupants are not expected to be completely wet, a circuit supplying heating equipment of Class II construction or equivalent insulation should be provided with additional protection by the use of an RCD with a rated residual operating current not exceeding 30 mA.

© The Institution of Engineering and Technology

Inspection and testing 9

9.1 Inspection and testing

641.1 Every installation must be inspected and tested during erection and on completion before being put into service to verify, so far as is reasonably practicable, that the requirements of the Regulations have been met.

Precautions must be taken to avoid danger to persons and damage to property and installed equipment during inspection and testing.

644.4.202 644.1 644.4 If the inspection and tests are satisfactory, a signed Electrical Installation Certificate (EIC) together with a Schedule® of Circuit Details and a Schedule® of Test Results (as in Appendix G), are to be given to the person ordering the work.

9.2 Inspection

9.2.1 Procedure and purpose

642.1 Inspection must precede testing and must normally be done with that part of the installation under inspection disconnected from the supply.

642.2 The purpose of the inspection is to verify that equipment is:

(a) correctly selected and erected in accordance with BS 7671 (and, if appropriate, its own standard); and

(b) not visibly damaged or defective so as to impair safety.

9.2.2 Inspection checklist

642.3 The inspection must include at least the checking of relevant items from the following checklist:

526 **(a)** connection of conductors;

514.3 **(b)** identification of conductors;

522.6 **(c)** routing of cables in safe zones or protection against mechanical damage;

433 525 **(d)** selection of conductors for current-carrying capacity and voltage drop, in accordance with the design;

132.14.1 **(e)** connection of single-pole devices for protection or switching in line conductors only;

© The Institution of Engineering and Technology

526 **(f)** correct connection of accessories and equipment (including polarity);
527.2 **(g)** presence of fire barriers, suitable seals and protection against thermal effects;
410.3.3 **(h)** methods of protection against electric shock:
410.3.3 **(i)** basic protection and fault protection, i.e.;
414 ► SELV;
► PELV;
412 ► double insulation; and
► reinforced insulation.
(ii) basic protection, i.e.;
416.1 ► insulation of live parts;
416.2 ► barriers or enclosures.
(iii) fault protection;
► automatic disconnection of supply.

411 The following are to be confirmed for presence and sized in accordance with the design:

- Earth electrode(s) (where applicable);
- earthing conductor;
- circuit protective conductors;
- protective bonding conductors;
- earthing arrangements for combined protective and functional purposes;
- presence of adequate arrangements for alternative source(s), where applicable;
- FELV;
- choice and setting of protective and monitoring devices (for fault and/or overcurrent protection).

413 ► electrical separation.
418.3 **(iv)** additional protection by RCDs;
415.1 **(i)** prevention of mutual detrimental influence (refer to 7.4);
132.11 **(j)** presence of appropriate devices for isolation and switching correctly located;
537 **(k)** presence of undervoltage protective devices (where appropriate);
445 **(l)** labelling of protective devices including circuit-breakers, RCDs, fuses, switches
514 and terminals, main earthing and bonding connections;
522 **(m)** selection of equipment and protective measures appropriate to external influences;
643.10 **(n)** manual operation of circuit-breakers, RCDs and AFDDs to prove functionality;
643.10 **(o)** confirmation that integral test button/switch causes RCD(s) to trip when operated (functional check);
534.4.1.1 **(p)** confirmation overvoltage protection (SPDs) provided where specified;
132.12 **(q)** adequacy of access to switchgear and equipment;
514 **(r)** presence of danger notices and other warning signs (see Section 6);
514.9 **(s)** presence of diagrams, instructions and similar information; and
522 **(t)** erection methods.

© The Institution of Engineering and Technology

9.3 Testing

Testing must include the relevant tests from the following checklist.

643.1 When a test shows a failure to comply, the failure must be corrected. The test must then be repeated, as must any earlier test that could have been influenced by the failure.

9.3.1 Testing checklist

643.2
643.2.1
(i) and (ii)
643.2
643.2.1
(i) and (ii)
643.3.1
643.3.1

(a) Continuity of conductors:
- **(i)** protective conductors including main and supplementary bonding conductors; and
- **(ii)** ring final circuit conductors including protective conductors.

(b) The insulation resistance shall be measured between:
- **(i)** live conductors; and
- **(ii)** live conductors and the protective conductor connected to the earthing arrangement. During this measurement, line and neutral conductors may be connected together.

643.6 **(c)** Polarity: this includes checks that single-pole control and protective devices, for example, switches, circuit-breakers and fuses, are connected in the line conductor only, that bayonet and Edison screw lampholders (except for E14 and E27 to BS EN 60238) have their outer contacts connected to the neutral conductor and that wiring has been correctly connected to socket-outlets and other accessories.

643.7.2 **(d)** Earth electrode resistance (TT systems).

643.7.3 **(e)** Earth fault loop impedance (TN systems).

643.7.3.201 **(f)** Prospective short-circuit current and prospective earth fault current, if not determined by enquiry of the distributor.

643.9 **(g)** Phase sequence testing.

643.10 **(h)** Functional testing, including:
- 643.10 **(i)** testing of RCDs; and
- **(ii)** operation of all switchgear.

643.11 **(i)** Verification of voltage drop (not normally required during initial verification).

© The Institution of Engineering and Technology

NOTE

© The Institution of Engineering and Technology

Guidance on initial testing of installations

10

10.1 Safety and equipment

HSR25, EAWR Regulation 14

Electrical testing involves danger. The Electricity at Work Regulations 1989 state that working on a live conductors is permissible provided that:

(a) it is unreasonable in all the circumstances for it to be dead;
(b) it is reasonable in all the circumstances for the work to be carried out; and
(c) suitable precautions are taken to prevent injury.

Live testing of electrical installations is, therefore, reasonable as it is a recognized method of assessing the suitability and safety of an electrical installation. However, suitable precautions must be taken including employing the correct test equipment and suitable personal protective equipment.

Although live testing and diagnosis for fault finding may be justifiable, there could be no justification for any subsequent repair work to be carried out live.

641.1
643.1

It is the test operative's duty to ensure their own safety, and the safety of others, while working through test procedures. When using test instruments, this is best achieved by precautions such as:

(a) knowledge and experience of the correct application and use of the test instrumentation, leads, probes and accessories (this is of the greatest importance);

643.1

(b) checking that the test instrumentation is made in accordance with the appropriate safety standards such as BS EN 61243-3 for two-pole voltage detectors and BS EN 61010 or BS EN 61557 for instruments;

(c) checking before each use that all leads, probes, accessories (including all devices such as crocodile clips used to attach to conductors) and instruments including the proving unit are clean, undamaged and functioning, also checking that isolation can be safely effected and that any locks or other means necessary for securing the isolation are available and functional; and

GS38

(d) observing the safety measures and procedures set out in HSE Guidance Note GS 38 for all instruments, leads, probes and accessories. Some test instrument manufacturers advise that their instruments be used in conjunction with fused test leads and probes. Others 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.

© The Institution of Engineering and Technology

10.2 Sequence of tests

NOTE: The advice given does not preclude other test methods.

643.1 Tests should be carried out in the following sequence:

10.2.1 Before the supply is connected (i.e. isolated)

643.2.1(i) **(a)** continuity of protective conductors, including main and supplementary bonding;

643.2.1(ii) **(b)** continuity of ring final circuit conductors, including protective conductors;

643.3 **(c)** insulation resistance;

643.6 **(d)** polarity (by continuity method); and

643.7.2 **(e)** earth electrode resistance, using an earth electrode resistance tester (see g also).

10.2.2 With the supply connected and energized

GS38 **(f)** check polarity of supply, using an approved voltage indicator;

643.7.2 **(g)** earth electrode resistance, using a loop impedance tester;

643.7.3 **(h)** earth fault loop impedance;

643.7.3.201 **(i)** prospective fault cunent measurement, if not determined by enquiry of the distributor; and

643.10 **(j)** functional testing, including residual current devices (RCDs) and switchgear.

Results obtained during the various tests should be recorded on the Schedule of Test Results (see Appendix G) for future reference and checked for acceptability against prescribed criteria.

10.3 Test procedures

643.2.1 ### 10.3.1 Continuity of circuit protective conductors and protective bonding conductors (for ring final circuits, see 10.3.2)

Test methods 1 and 2 are alternative ways of testing the continuity of protective conductors.

Every protective conductor, including circuit protective conductors, the earthing conductor, and the main and supplementary bonding conductors, should be tested to verify that the conductors are electrically sound and correctly connected.

Test method 1 detailed below, in addition to 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 10.3.6. One other advantage of test method 1 is that it confirms polarity at each point on the circuit and this can also be recorded on the certification.

NOTE: (R_1 + R_2) is the sum of the resistances of the line conductor (R_1) and the circuit protective conductor (R_2) between the point of utilisation and origin of the installation.

© The Institution of Engineering and Technology

Use an ohmmeter capable of measuring a low resistance for these tests.

Test method 1 can only be used to measure ($R_1 + R_2$) for an 'all-insulated' installation, such as an installation wired in 'twin and earth'. Installations incorporating steel conduit, steel trunking, MICC and PVC/SWA cables will produce parallel paths to protective conductors. Such installations should be inspected for soundness of construction and Test method 1 or 2 used to prove continuity.

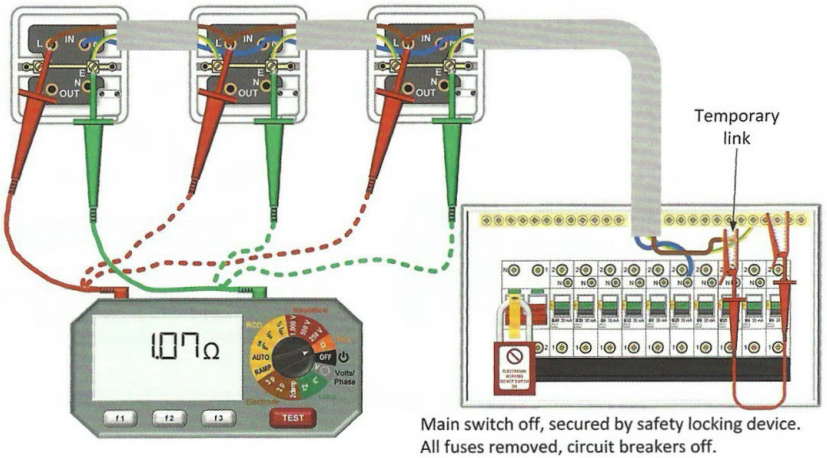
643.2.1 i Continuity of circuit protective conductors

Continuity Test method 1

Bridge the line conductor to the protective conductor at the distribution board so as to include all the circuit. Then test between the line and earth terminals at each point in the circuit. The measurement at the circuit's extremity should be recorded and is the value of (R, + Rj) for the circuit under test (see Figure 10.3.1(i)).

If the instrument does not include an 'auto-null' facility, or this is not used, the resistance of the test leads should be measured and deducted from the resistance readings obtained.

▼ **Figure 10.3.1 (i)** Connections for testing continuity of circuit protective conductors using Test method 1



Main switch off, secured by safety locking device.
All fuses removed, circuit breakers off.
Zero instrument across test link.
Note: remember to remove temporary link after test.

© The Institution of Engineering and Technology

Continuity Test method 2

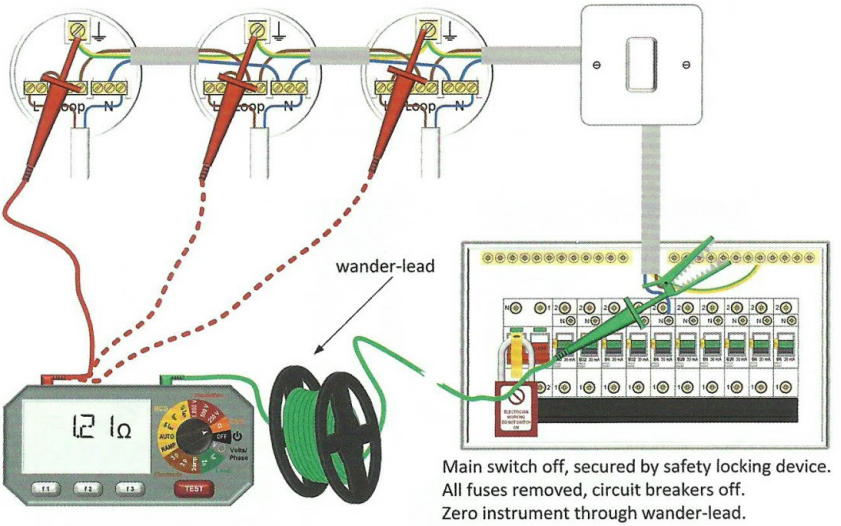
Connect one terminal of the test instrument to a long test lead and connect this to the installation MET.

Connect the other terminal of the instrument to another test lead and use this to make contact with the protective conductor at various points on the circuit, such as luminaires, switches, spur outlets, etc. (see Figure 10.3.1(ii)).

If the instrument does not include an 'auto-null' facility, or if this is not used, the resistance of the test leads should be measured and deducted from the resistance readings obtained.

The resistance of the protective conductor R_2 is recorded on the Schedule of Test Results (see Appendix G).

▼ **Figure 10.3.1(ii)** Continuity Test method 2



Main switch off, secured by safety locking device.
All fuses removed, circuit breakers off.
Zero instrument through wander-lead.

ii Continuity of the earthing conductor and protective bonding conductors

Continuity Test method 2

For main bonding, connect one terminal of the test instrument to a long test lead and connect this to the protective bonding conductor disconnected from the installation MET. Connect the other terminal of the instrument to another test lead and use this to make contact with the protective bonding conductor at its further end, such as at its connection to the extraneous-conductive-parts.

NOTE: One end of the main protective bonding conductor must be disconnected for the continuity test to eliminate any parallel paths and confirm actual continuity of the conductor.

© The Institution of Engineering and Technology

The continuity and connection verified boxes on the Electrical Installation Certificate (EIC) should be ticked if the continuity and connection of the earthing conductor and of each main bonding conductor are satisfactory. The details of the material and the cross-sectional areas of the conductors must also be recorded.

643.2.1

10.3.2 Continuity of ring final circuit conductors

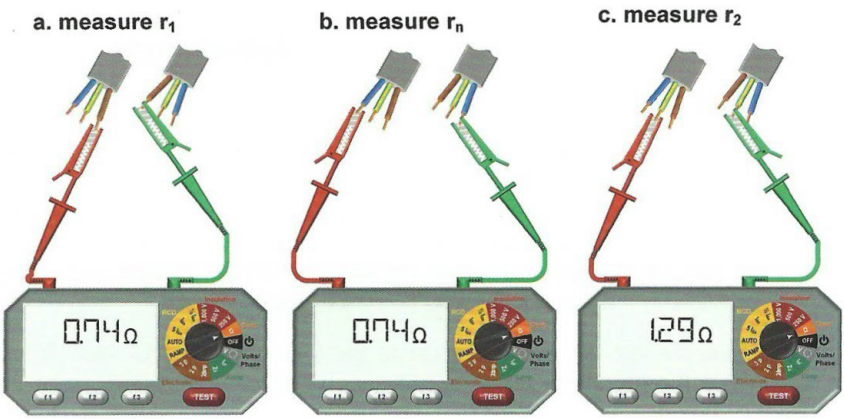
A three-step test is required to verify the continuity of the line, neutral and protective conductors and the correct wiring of a ring final circuit. The test results show if the ring has been interconnected to create an apparently continuous ring circuit which is in fact broken, or wrongly wired.

Use a low resistance ohmmeter for this test.

Step 1

The line, neutral and protective conductors are identified at the distribution board and the end-to-end resistance of each is measured separately (see Figure 10.3.2(i)). These resistances are r_{lz} r_n and r_2, respectively. A finite reading confirms that there is no open circuit on the ring conductors under test. The resistance values obtained should be the same (within 0.05 O) if the conductors are all of the same size. If the protective conductor has a reduced csa the resistance, r_2, of the protective conductor loop will be proportionally higher than that of the line and neutral loops, for example, 1.67 times for 2.5/1. 5 mm ^{2} cable. If these relationships are not achieved, then either the conductors are incorrectly identified or there is something wrong at one or more of the accessories.

▼ **Figure 10.3.2(i)** Step 1: The end-to-end resistances of the line, neutral and protective conductors are measured separately



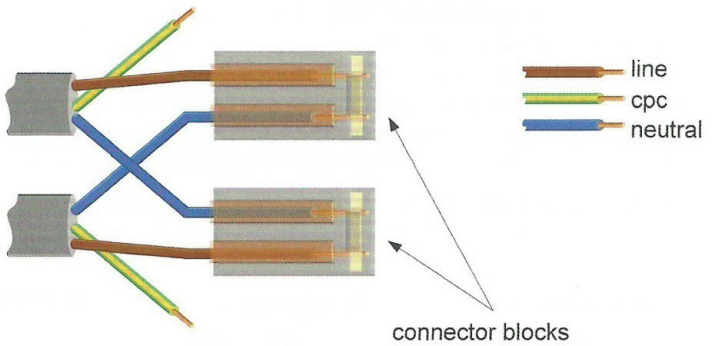
© The Institution of Engineering and Technology

Step 2

The line and neutral conductors are then connected together at the distribution board so that the outgoing line conductor is connected to the returning neutral conductor and vice versa (see Figure 10.3.2(ii)). The resistance between the line and neutral conductors is measured at each socket-outlet. The readings at each of the socket-outlets wired into the ring will 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 $(r_1 + r_n)/4$. Any socket-outlets wired as spurs will have a higher resistance value, due to the resistance of the spur conductors.

NOTE: 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, with these progressively increasing in value as readings are taken towards the midpoint of the ring, then decreasing again towards the other end of the ring.

▼ **Figure 10.3.2(ii)** Step 2: The line and neutral conductors are cross-connected and the resistance measured at each socket-outlet



Step 3

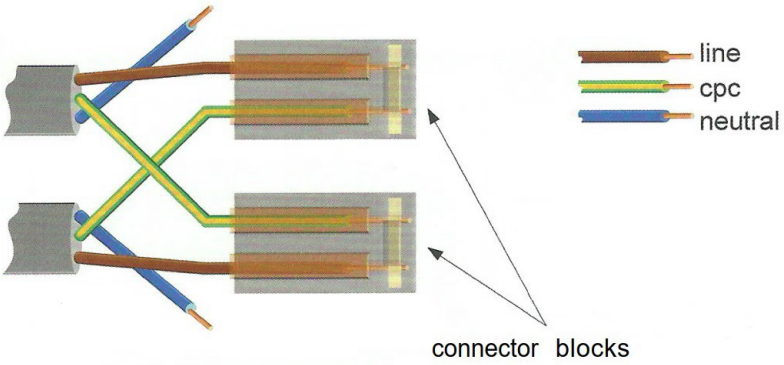
The above step is then repeated, this time with the line and cpc cross-connected at the distribution board (see Figure 10.3.2(iii)). The resistance between the line and cpc is measured at each socket-outlet. Where the line and cpc conductors are the same copper equivalent csa the readings obtained at each of the socket-outlets wired into the 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. $(r_1 + r_2)/4$.

Where the cpc has a different csa to the line conductors, for example where flat twin-and-earth cable is used, the resistance will increase as the tests move around the ring from the origin of the circuit, to a maximum of approximately $(r_1 + r_2)/4$ at the mid-point of the ring, and decrease as the test point moves back towards the origin of the circuit. Information on the expected maximum and minimum values can be found in Table 2.8 IET Guidance Note 3.

© The Institution of Engineering and Technology

As before, a higher resistance value will be measured at any socket-outlets wired as spurs. The highest value recorded represents the maximum (R_1 + R2) 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 BS 7671 (see 10.3.6).

▼ **Figure 10.3.2(iii)** Step 3: The line conductors and cpcare cross-connected and the resistance measured at each socket-outlet



This sequence of tests also verifies the polarity of each socket-outlet, except that where the testing has been carried out at the terminals on the reverse of the accessories, a visual inspection is then required to confirm the correct polarity of the connections, and dispenses with the need for a separate polarity test.

643.3

10.3.3 Insulation resistance

i Pre-test checks

(a) Pilot or indicator lamps and capacitors are disconnected from circuits to prevent misleading test values from being obtained; and

(b) Where connected equipment is likely to influence the measurement or result of the test, or be damaged, the test shall be applied prior to the connection of such equipment, in accordance with Table 64 of BS 7671.

ii Tests

The insulation resistance shall be measured between:

(i) live conductors; and

(ii) live conductors and the protective conductor connected to the earthing arrangement. During this measurement, line and neutral conductors may be connected together.

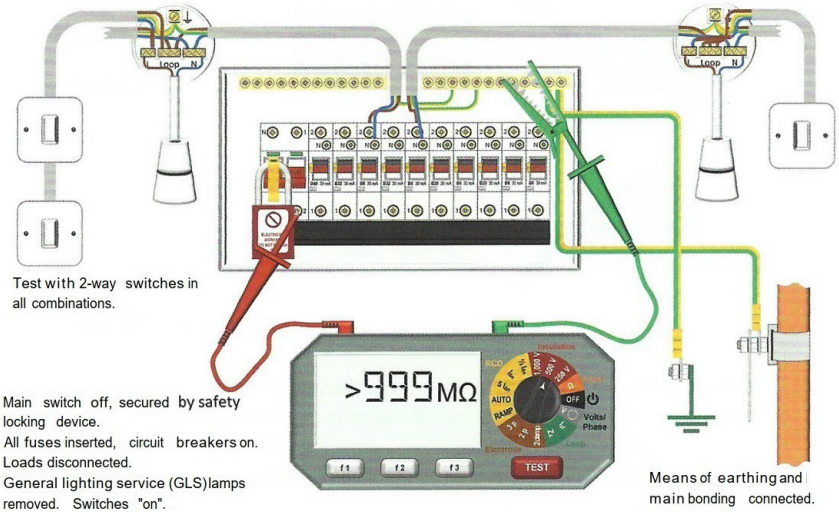
Tests should be carried out using the appropriate DC test voltage specified in Table 10.3.3.

© The Institution of Engineering and Technology

The tests should be made at the distribution board or consumer unit with the main switch off.

When testing simple installations, i.e. those consisting of one consumer unit only, the installation could be tested as a whole with all fuses in place, switches and circuit breakers closed, lamps removed and other current-using equipment disconnected; see Figure 10.3.3(i).

▼ **Figure 10.3.3(i)** Insulation resistance test of the whole installation



When testing individual circuits, it is important to remove the fuse or open the circuit breaker of that circuit; this ensures that no other circuits at the board influence the result of the test.

Where a circuit contains two-way switching, the two-way switches must be operated one at a time and further insulation resistance tests carried out to ensure that all the circuit wiring is tested.

▼ **Table 10.3.3** Minimum values of insulation resistance

Table 64

Circuit nominal voltage	Test voltage (V DC)	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

NOTES:

1 Insulation resistance measurements are usually much higher than those of Table 10.3.3.

2 More stringent requirements are applicable for the wiring of fire alarm systems in buildings; see BS 5839-1 .

© The Institution of Engineering and Technology

For an installation operating at 400/230 V, an insulation resistance value of only 1 MΩ complies with BS 7671. However, where the insulation resistance measured is less than 20 MΩ the possibility of a latent defect exists. In these circumstances, each circuit should then be tested separately.

643.3.3 Where connected equipment is likely to influence the measurement or result of the test, or be damaged, the test shall be applied prior to the connection of such equipment, in accordance with Table 64 of BS 7671. Following connection of the equipment, a test at 250 V DC shall be applied between live conductors and the protective conductor connected to the earthing arrangement. The insulation resistance shall have a value of at least 1 MΩ.

iii Insulation resistance between live conductors

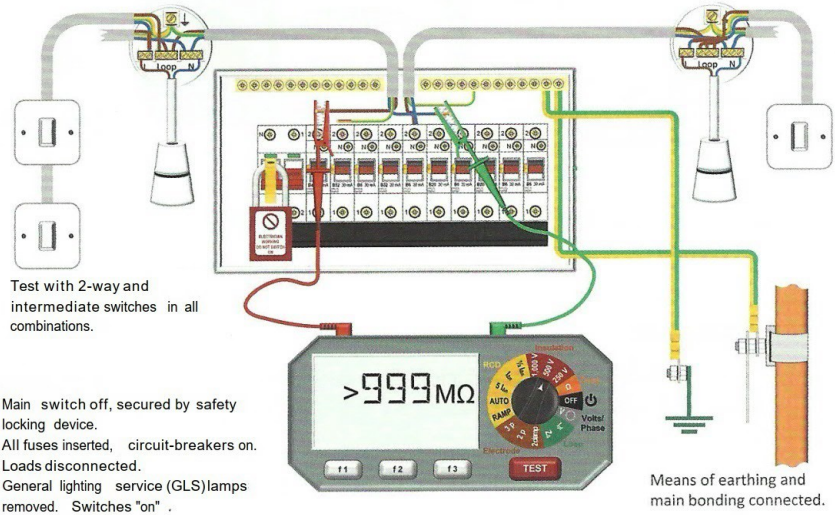
Single-phase and three-phase

Test between all the live (line and neutral) conductors at the distribution board (see Figure 10.3.3(i)).

Figure 10.3.3(ii) shows an insulation resistance test performed between live conductors of a single circuit.

Resistance readings obtained should be not less than the value stated in Table 10.3.3.

▼ **Figure 10.3.3(ii)** Insulation resistance test between live conductors of a circuit



NOTE: The test may initially be carried out on the complete installation.

© The Institution of Engineering and Technology

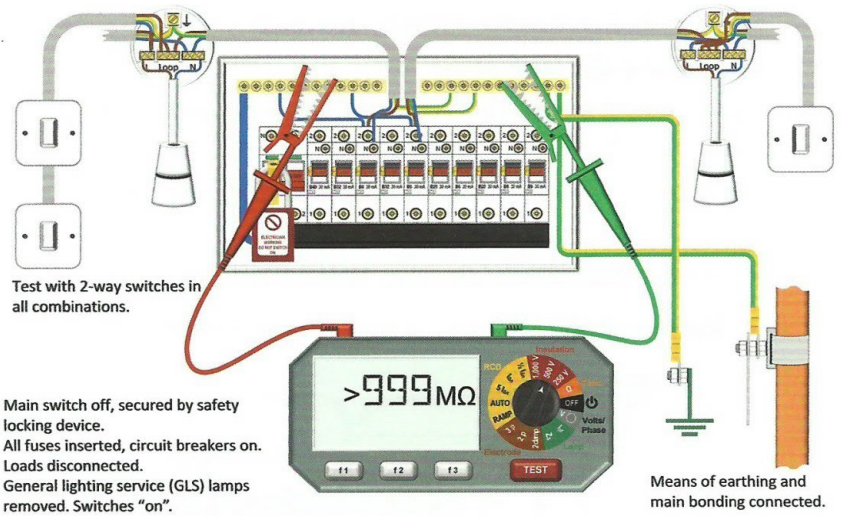
iv Insulation resistance to earth

Single-phase

Test between the live conductors (line and neutral) and the circuit protective conductors at the distribution board (Figure 10.3.3(iii) illustrates neutral to earth only).

For a circuit containing two-way switching or two-way and intermediate switching, the switches must be operated one at a time and the circuit subjected to additional insulation resistance tests.

▼ **Figure 10.3.3(iii)** Insulation resistance test between neutral and earth



NOTES:

1 The test may initially be carried out on the complete installation.
2 Earthing and bonding connections are in place.
643.3.1 3 The earthing conductor must connect the MET to the means of earthing when testing for certification purposes is carried out.

Three-phase

Test to earth from all live conductors (including the neutral) connected together. Where a low reading is obtained it is necessary to test each conductor separately to earth, after disconnecting all equipment.

Resistance readings obtained should be not less than the value stated in Table 10.3.3.

v SELV and PELV circuits

643.4.1 Test between SELV and PELV circuits and live parts of other circuits at 250 V DC.

643.4.2 Test between SELV or PELV conductors at 250 V DC and between PELV conductors and protective conductors of the PELV circuit at 250 V DC.

© The Institution of Engineering and Technology

Resistance readings obtained should be not less than the value stated in Table 10.3.3.

NOTE: In situations whete the SELV and/or PELV conductors are separated by just insulation, such as within a multicore cable with LV circuits, then the test voltage shall be increased to 500 V DC and the insulation resistance shall be not less than 1 MΩ.

vi FELV circuits

643.3.2 FELV circuits are tested as low voltage circuits at 500 V DC.

10.3.4 Polarity

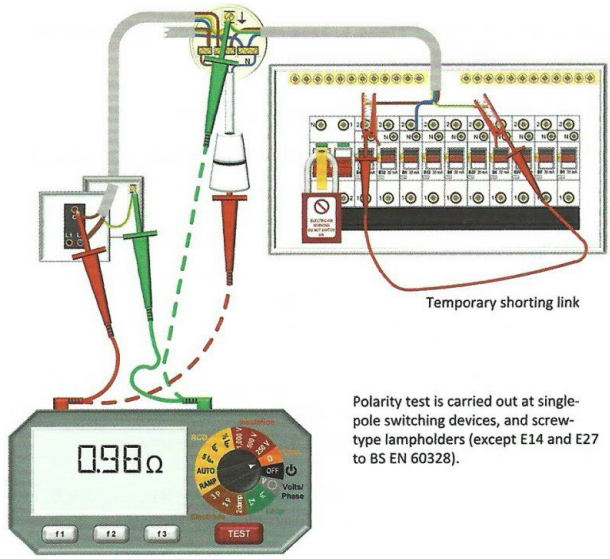
See Figure 10.3.4.

The method of test prior to connecting the supply is the same as test method 1 for checking the continuity of protective conductors which should already have been carried out (see 10.3.1). For ring final circuits a visual check may be required (see 10.3.2 following step 3). When testing polarity on lighting circuits it is important to ensure all lamps are removed prior to testing. This will enable any reverse polarity issues to be identified.

It is important to confirm that:

(a) overcurrent devices and single-pole controls are in the line conductor;
(b) except for E14 and E27 lampholders to BS EN 60238, centre contact screw lampholders have the outer threaded contact connected to the neutral; and
(c) socket-outlet and similar accessory polarities are correct.

▼ **Figure 10.3.4** Polarity test on a lighting circuit



NOTE: The test may be carried out either at lighting points or switches.

© The Institution of Engineering and Technology

GS 38 After connection of the supply, correct polarity must be confirmed at the incoming terminals of the main isolator using a voltage indicator or a test lamp (in either case with leads complying with the recommendations of HSE Guidance Note GS 38).

10.3.5 Earth electrode resistance measurement

10.3.5.1 Loop impedance method

If the electrode under test is being used in conjunction with an RCD protecting an installation forming part of a TT system, the following method of test may be applied.

A loop impedance tester is connected between the line conductor at the origin of the installation and the earth electrode with the test link open, where fitted, and a test performed. Alternatively, a test is made with the installation isolated from the source of supply and secured and the connection to the earthing conductor disconnected from the installation. This impedance reading is treated as the electrode resistance and is added to the resistance of the protective conductor for the protected circuits. The test should be carried out before energizing the remainder of the installation.

Table 41.5 Note 2 The measured resistance should meet the following criteria and those of 10.3.6 but, in any event, should not exceed 200 Ω.

411.5.3 For TT systems, the value of the earth electrode resistance R_A in Ω multiplied by the operating current, in amperes, of the protective device I_n, should not exceed 50 V.

For example, if R_A = 200 Ω , then the maximum RCD operating current should not exceed 250 mA.

REMEMBER TO RECONNECT THE EARTHING CONDUCTOR OR REPLACE THE TEST LINK AFTER THE TEST.

10.3.5.2 Proprietary earth electrode test instrument

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

Connection to the earth electrode, E, is made using terminals CI and PI of a four-terminal earth tester. To exclude the resistance of the test leads from the resistance reading, individual leads should be taken from these terminals and connected separately to the electrode. If the test lead resistance is insignificant, the two terminals may be short-circuited at the tester and connection made with a single test lead, with the same being true if using a three-terminal tester. Connection to the temporary spikes is made as shown in Figure 10.3.5.2. The distance between the test spikes is important. If they are too close together, their resistance areas will overlap.

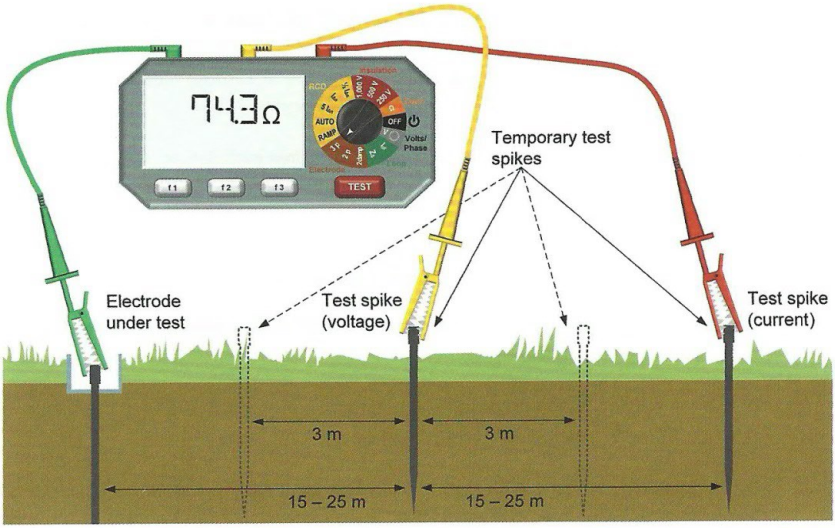
In general, reliable results may be expected if the distance between the electrode under test and the current spike T1 is at least ten times the maximum dimension of the electrode system, for example, 30 m for a 3 m long rod electrode. With an auxiliary electrode, T2, inserted halfway between the electrode under test, E, and temporary

© The Institution of Engineering and Technology

electrode T1, the voltage drop between E and T2 is measured. The resistance of the electrode is then obtained by the test instrument from the voltage between E and T2, divided by the current flowing between E and T1, provided there is no overlap of the resistance areas.

To confirm that the electrode resistance obtained above is a true value, two further readings are taken, firstly with electrode T2 moved « 6 m further from electrode E and secondly, with electrode T2 moved 6 m closer to electrode E. If the results obtained from the three tests are substantially the same, the average of the three readings is taken as the resistance of the earth electrode under test. If the results obtained are significantly different, the above procedure should be repeated with test electrode T1 placed further from the electrode under test.

▼ **Figure 10.3.5.2** Earth electrode test



The instrument output current may be AC or reversed DC to overcome electrolytic effects. As these types of test instrument employ phase-sensitive detectors (PSDs), 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. If the temporary spike resistance is too high, measures to reduce the resistance will be necessary, such as driving the spikes deeper into the ground.

© The Institution of Engineering and Technology

10.3.6 Earth fault loop impedance

The effectiveness of the distributor's earth must be confirmed by a test.

The external impedance (Z may be measured using a line-earth loop impedance tester.

The main switch is opened and made secure to isolate the installation from the source of supply. The earthing conductor is disconnected from the main earthing terminal and the measurement made between line and earth of the supply.

REMEMBER TO RECONNECT THE EARTHING CONDUCTOR TO THE MAIN EARTHING TERMINAL AFTER THE Z_e TEST.

643.7.3 The earth fault loop impedance (Zg) is required to be determined for the furthest point of each circuit. It may be determined by:

- **(a)** direct measurement of Z_s; or
- **(b)** direct measurement of Z_e at the origin and adding (R, + Rj) measured during the continuity tests (see 10.3.1 and see 10.3.2) {$Z_s = Z_e + (R_1 + R2)$); or
- **(c)** adding ($R_1 + R_2$) measured during the continuity tests to the value of Z_e declared by the distributor (see 1.1(d) and 1.3(d)).

Direct measurement of Z_s can only be made on a live installation. Neither the connection with earth nor the bonding conductors are disconnected. The reading given by the loop impedance tester will usually be less than $Z_e + (R_1 + R2)$ because of parallel earth return paths provided by any bonded extraneous-conductive-parts. This must be taken into account when comparing the results with design data.

641.1 Care should be taken to avoid any shock hazard to the testing personnel and to other persons on site during the tests.

The value of Z_s determined for each circuit should not exceed the value given in Appendix B for the particular overcurrent device and cable.

411.4.204 For TN systems, when protection is afforded by an RCD, the rated residual operating current in amperes times the earth fault loop impedance in O should not exceed 50 V. This test should be carried out before energizing other parts of the system.

NOTE: For further information on the measurement of earth fault loop impedance, refer to IET Guidance Note 3.

643.7.3.201 ## 10.3.7 Measurement of prospective fault current

It is not recommended that installation designs are based on measured values of prospective fault current, as changes to the distribution network subsequent to completion of the installation may increase fault levels.

Designs should be based on the maximum fault current provided by the distributor (see 72.7(1)).

© The Institution of Engineering and Technology

If it is desired to measure prospective fault levels this should be done with all main bonding in place. Measurements are made at the distribution board between live conductors and between line conductors and earth.

For three-phase supplies, the maximum possible fault level will be approximately twice the single-phase to neutral value. (For three-phase to earth faults, neutral and earth path impedances have no influence.)

10.3.8 Check of phase sequence

643.9 In the case of three-phase circuits, it should be verified that the phase sequence is maintained.

10.3.9 Functional testing

643.10 RCDs should be tested as described in Section 11.

Switchgear and controls, etc., should be functionally tested; that is, operated to check that they work and are properly mounted and installed.

10.3.10 Verification of voltage drop

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

643.11 Where required, it should be verified that voltage drop does not exceed the limits stated in the relevant product standards of installed equipment.

525.201 Where no such limits are stated, voltage drop should be such that it does not impair the proper and safe functioning of installed equipment.

Typically, voltage drop will be evaluated using the measured circuit impedances.

The requirements for voltage drop are deemed to be met where the voltage drop between the origin and the relevant piece of equipment does not exceed the values stated in Appendix 4 of BS 7671.

Appx 4 Table 4Ab Appendix 4, paragraph 6.4, gives maximum values of voltage drop for both lighting and other uses and depending upon whether the installation is supplied directly from an LV distribution system or from a private LV supply.

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

© The Institution of Engineering and Technology

NOTE

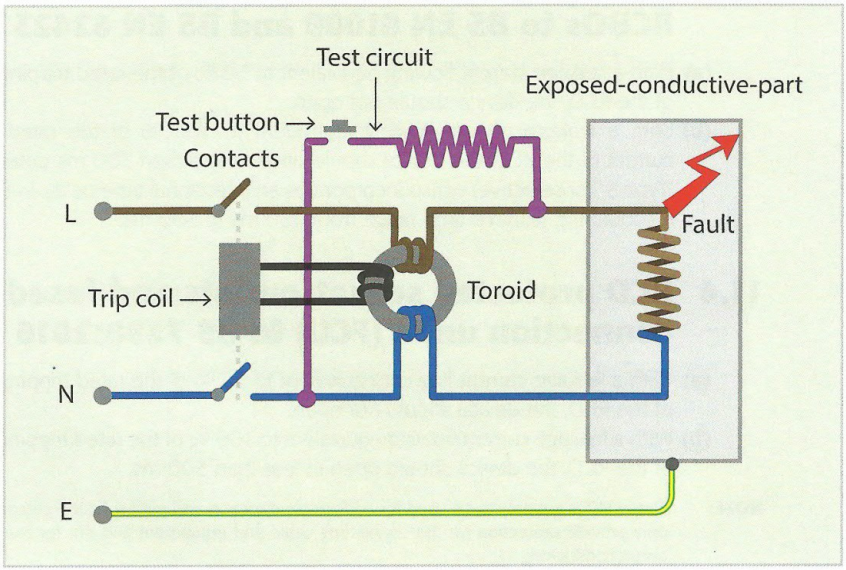
© The Institution of Engineering and Technology

Operation of RCDs

11

Residual current device (RCD) is the generic term for a device that operates when the residual current in the circuit reaches a predetermined value. An RCD is a protective device used to automatically disconnect the electrical supply when an imbalance is detected between the line and neutral conductors. In the case of a single-phase circuit, (see Figure 11.0), the device monitors the difference in currents between the line and neutral conductors. In a healthy circuit, where there is no earth fault current or protective conductor current, the sum of the currents in the line and neutral conductors is zero. If a line to earth fault develops, a portion of the line conductor current will not return through the neutral conductor. The device monitors this difference, operates and disconnects the circuit when the residual current reaches a pre-set limit, the residual operating current ($I_{\triangle n}$).

▼ **Figure 11.0** RCD operation



© The Institution of Engineering and Technology

643.7

11.1 General test procedure

The tests are made on the load side of the RCD, as near as practicable to its point of installation and between the line conductor of the protected circuit and the associated circuit protective conductor. The load supplied should be disconnected during the test.

11.2 General-purpose RCCBs to BS 4293 and RCD protected socket-outlets and fused connection units to editions of BS 7288 earlier than 2018

NOTE: These standards have been withdrawn and replaced by BS EN 61008-1:2004+703:2012 and BS 7288:2016; however, RCCBs, SRCDs and FCURCDs to these standards may still be found in older installations.

(a) With a leakage current flowing equivalent to 50 °/o of the rated tripping current of the RCD, the device should not open.

(b) With a leakage current flowing equivalent to 100 °/o of the rated tripping current of the RCD, the device should open in less than 200 ms. Where the RCD incorporates an intentional time delay it should trip within a time range from '50 % of the rated time delay plus 200 ms' to '100 °/o of the rated time delay plus 200 ms'.

11.3 General-purpose RCCBs to BS EN 61008 or RCBOs to BS EN 61009 and BS EN 62423

(a) With a leakage current flowing equivalent to 50 % of the rated tripping current of the RCD, the device should not open.

(b) With a leakage current flowing equivalent to 100 °/o of the rated tripping current of the RCD, the device should open in less than 300 ms unless it is of 'Type S' (or selective) which incorporates an intentional time delay. In this case, it should trip within a time range from 130 ms to 500 ms.

11.4 RCD protected socket-outlets and fused connection units (FCU) to BS 7288:2016

(a) With a leakage current flowing equivalent to 50 °/o of the rated tripping current of the RCD, the device should not open.

(b) With a leakage current flowing equivalent to 100 °/o of the rated tripping current of the RCD, the device should open in less than 300 ms.

NOTE: These RCDs are only to be used for additional protection and not for fault protection as they only provide protection for the connecting cable and equipment and not for the upstream circuit conductors.

© The Institution of Engineering and Technology

11.5 Additional protection

NOTE: Regardless of RCO type, effectiveness is deemed to have been verified where an RCD disconnects within the time stated below with an alternating current test at rated residual operating current (Izx_n):

- For general non-delay type, 300 ms maximum.

11.6 Integral test device

643.10 An integral test device is incorporated in each RCD. This device enables the electrical and mechanical parts of the RCD to be verified, by pressing the button marked T or 'Test' (see Figure 11.0).

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;
(b) any earth electrode or other means of earthing; or
(c) any other part of the associated installation earthing.

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

Confirm that the notice to test RCDs six-monthly (by pressing the test button) is fixed in a prominent position (see 6.11).

11.7 Multipole RCDs

As each live conductor of the RCD is incorporated in the magnetic sensing circuit it is not necessary to perform the test for poles L2 and L3. However, if there is any doubt as to the authenticity of the device in question - in terms of a fake or counterfeit device - the advice would be to repeat the test for poles L2 and L3. It goes without saying that such important devices, designed to protect life and property, should be obtained from trusted sources and made by reputable manufacturers.

If a decision is made to test the RCD on all three lines, there should be little or no discernible difference in operating times as each pole is incorporated in the magnetic sensing circuit. If, for example, the test performed on one pole does not meet the required disconnection time, yet the tests on the other two poles are satisfactory, the device should be considered faulty and replaced.

© The Institution of Engineering and Technology

NOTE

© The Institution of Engineering and Technology

Prosumer's electrical installations 12

12.1 Prosumer's installations

Chapter 82

Chapter 82 of BS 7671 provides the additional requirements, measures and recommendations for the design, erection and verification of all types of low voltage electrical installations identified in the Scope (Chapter 11) of BS 7671, including the local production and/or storage of energy in order to ensure compatibility with existing and future ways to deliver electrical energy to:

(a) current-using equipment; or

(b) the public network

by means of local sources of electrical energy.

Such electrical installations are designated as prosumer's electrical installations (PEIs).

A PEI is a set of electrical equipment having the following functions (see Figure 12.1):

(i) supply (e.g. connection to a public power supply, local generator, photovoltaic systems, wind turbines, batteries);

(ii) distribution (e.g. distribution panel, wiring systems);

(iii) consumption (e.g. motors, heating systems, lighting, lifts); and

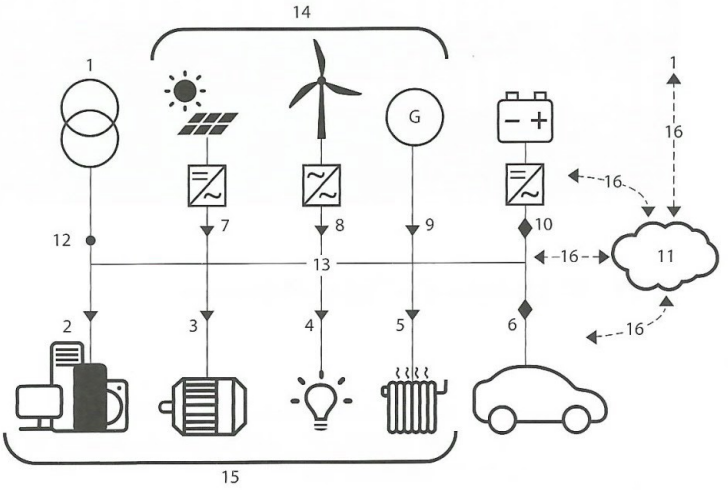
(iv) electrical energy management system (EEMS) (e.g. load shedding equipment, monitoring device).

NOTE: A battery can be considered as a generator and as a load.

An uninterruptible power supply (UPS) is not considered to form part of a PEI as the purpose of a UPS is only to supply downstream critical loads and is not capable of reverse feeding the public network and/or current-using equipment in the upstream part of the electrical installation.

© The Institution of Engineering and Technology

▼ **Figure 12.1** Example of prosumer's electrical installations



Key

1	Public network	9	Other generators
2	Home appliances and electronic devices	10	Electric storage
3	Motors	11	EEMS
4	Lighting	12	Origin of installation
5	Heaters	13	Local distribution
6	Electric vehicles	14	Local generation
7	Solar inverter	15	Local consumption
8	Wind inverter	16	Management signals

In a PEI, an installation owner may consider independently the supervision and the control of different power supplies connected to the electrical installation in order to supply efficiently and cost-effectively all the electrical loads connected to this low voltage electrical installation.

Chapter 82 of BS 7671 provides requirements for PEIs to achieve safe operation, sustainability and efficient use of energy when integrated into smart grids.

It does not cover electrical sources for safety services, including associated electrical installations and standby electrical supply systems for a secure continuity of supply, which are operated only occasionally and for short periods, in parallel with the distribution grid, for testing purposes.

© The Institution of Engineering and Technology

12.2 Types of prosumer's electrical installation

There are different types of PEI:

(i) individual (see Regulation 824.3);
(ii) collective (see Regulation 824.4); and
(iii) shared (see Regulation 824.5).

12.3 Operating modes

The main operating modes that may be adopted for each type of PEI (individual, collective or shared) are:

(i) direct feeding mode;
(ii) reverse feeding mode; and
(iii) island mode.

Storage units can:

(i) supply current-using equipment;
(ii) be charged by local power supplies; or
(iii) be charged by the public network.

Except when operating in island mode.

Local power supplies can supply:

(i) current-using equipment;
(ii) local storage units; or
(iii) the public network.

Except when operating in island mode.

Transfer both from and to the direct feeding mode to island mode and vice versa can be achieved by operating the switching device for islanding; this can be either directly controlled (manually or remotely) or automatically controlled.

Switching from one mode to another can be done if the generators and/or converters are synchronized with the network (providing the requirements of Regulation 551 are met).

Selection of the possible operating modes may depend on the contract with the distribution network operator (DNO).

Technical requirements for the design of the PEI according to the selected operating mode are provided in Section 826 of BS 7671.

The general principles and types of PEI are described in BS 7671: Annex A82.

Examples of operating modes are contained in BS 7671: Annex B82.

© The Institution of Engineering and Technology

NOTE

© The Institution of Engineering and Technology

Appendix A
Maximum demand and diversity

3n This appendix provides information on the determination of the maximum demand for an installation and includes the current demand to be assumed for commonly used equipment. It also includes some notes on the application of allowances for diversity.

The information and values given in this appendix are intended only for guidance, because it is impossible to specify the appropriate allowances for diversity for every type of installation and such allowances call for special knowledge and experience. The values given in Table A2, therefore, may be increased or decreased as decided by the installation designer concerned. No guidance is given for blocks of residential dwellings, large hotels or industrial and large commercial premises; such installations should be assessed on a case-by-case basis.

The current demand of a final circuit is determined by adding the current demands of all points of utilization and equipment in the circuit and, where appropriate, making an allowance for diversity. Typical current demands to be used for this addition are given in Table A1.

The current demand of an installation consisting of a number of final circuits may be assessed using the allowances for diversity given in Table A2, which are applied to the total current demand of all the equipment supplied by the installation. The current demand of the installation should not be assessed by adding the current demands of the individual final circuits obtained as outlined above. In Table A2 the allowances are expressed either as percentages of the current demand or, where followed by the letters 'f.l.' (full load), as percentages of the rated full load current of the current-using equipment. The current demand for any final circuit that is a standard circuit arrangement complying with Appendix H is the rated current of the overcurrent protective device of that circuit.

An alternative method of assessing the current demand of an installation supplying a number of final circuits is to add the diversified current demands of the individual circuits and then apply a further allowance for diversity. In this method the allowances given in Table A2 should not be used, the values chosen will be the responsibility of the installation designer.

© The Institution of Engineering and Technology

A Appendix

The use of other methods of determining maximum demand is not precluded where specified by the installation designer. After the design currents for all the circuits have been determined, enabling the conductor sizes to be chosen, it is necessary to check that the limitation on voltage drop has been met.

▼ **Table AI** Current demand to be assumed for points of utilization and current-using equipment

Point of utilization or current-using equipment	Current demand to be assumed
Socket-outlets other than 2 A socket-outlets and other than 13 A socket-outlets See NOTE 1	Rated current
2 A socket-outlets	At least 0.5 A
Lighting outlet See NOTE 2	Current equivalent to the connected load, with a minimum of 100 W per lampholder
Electric clock, shaver supply unit (complying with BS EN 61558-2-5), shaver socket-outlet (complying with BS 4573), bell transformer, and current-using equipment of a rating not greater than 5 VA	May be neglected for the purpose of this assessment
Household cooking appliance	The first 10 A of the rated current plus 30 % of the remainder of the rated current plus 5 A if a socket-outlet is incorporated in the control unit
All other stationary equipment	British Standard rated current, or normal current

NOTES:

1 See Appendix H for the design of standard circuits using socket-outlets to BS 1363-2 and 8S EN 60309-2 (BS 4343).

2 Final circuits for discharge lighting must be arranged so as to be capable of carrying the total steady current, which is made up of the lamp(s) and any associated controlgear and also their harmonic currents. Where more exact information is not available, the demand in volt-amperes (VA) is taken as the rated lamp watts multiplied by not less than 1.8. This multiplier is based upon the assumption that the circuit is corrected to a power factor (PF) of not less than 0.85 lagging, and takes into account controlgear losses and harmonic current.

© The Institution of Engineering and Technology

▼ **Table A2** Allowances for diversity (see opposite for NOTES * and †)

Purpose of the final circuit fed from the conductors or switchgear to which the diversity applies	Type of premises		
	Individual household installations, including individual dwellings of a block	Small shops, stores, offices and business premises	Small hotels, boarding houses, guest houses, etc.
1 Lighting	66 % of total current demand	90 % of total current demand	75 % of total current demand
2 Heating and power (but see 3 to 8 below)	100 % of total current demand up to 10 A +50 % of any current demand in excess of 10 A	100 % f.l. of largest appliance +75 % f.l. of remaining appliances	100 % f.l. of largest appliance +80 % f.l. of second largest appliance +60 % f.l. of remaining appliances
3 Cooking appliances	10 A + 30 % f.l. of connected cooking appliances in excess of 10 A + 5 A if a socket-outlet is incorporated in the control unit	100 % f.l. of largest appliance +80 % f.l. of second largest appliance +60 % f.l. of remaining appliances	100 % f.l. of largest appliance +80 % f.l. of second largest appliance +60 % f.l. of remaining appliances
4 Motors (other than lift motors, which are subject to special consideration)	Not applicable	100 % f.l. of largest motor +80 % f.l. of second largest motor +60 % f.l. of remaining motors	100 % f.l. of largest motor +50 % f.l. of remaining motors
5 Water heaters (instantaneous type)*	100 % f.l. of largest appliance +100 % f.l. of second largest appliance +25 % f.l. of remaining appliances	100 % f.l. of largest appliance +100 % f.l. of second largest appliance +25 % f.l. of remaining appliances	100 % f.l. of largest appliance +100 % f.l. of second largest appliance +25 % f.l. of remaining appliances
6 Water heaters (thermostatically controlled)	No diversity allowable†	No diversity allowable†	No diversity allowable†
7 Floor warming installations	No diversity allowable†	No diversity allowable†	No diversity allowable†
8 Thermal storage space heating installations	No diversity allowable†	No diversity allowable†	No diversity allowable†

© The Institution of Engineering and Technology

© The Institution of Engineering and Technology

▼ **Table A2** *continued*

Purpose of the final circuit fed from the conductors or switchgear to which the diversity applies	Type of premises		
	Individual household installations, including individual dwellings of a block	Small shops, stores, offices and business premises	Small hotels, boarding houses, guest houses, etc.
9 Standard arrangement of final circuits in accordance with Appendix H	100 % of current demand of largest circuit +40 % of current demand of every other circuit	100 % of current demand of largest circuit +50 % of current demand of every other circuit	
10 Socket-outlets (other than those included in 9 above and stationary equipment other than those listed above)	100 % of current demand of largest point of utilization +40 % of current demand of every other point of utilization	100 % of current demand of largest point of utilization +70 % of current demand of every other point of utilization	100 % of current demand of largest point of utilization +75 % of current demand of every other point in main rooms (dining rooms, etc.) +40 % of current demand of every other point of utilization

NOTES to Table A2:

* In this context an instantaneous water heater is considered to be a water heater of any loading that heats water only while the tap is turned on and therefore uses electricity intermittently.

† It is important to ensure that distribution boards or consumer units are of sufficient rating to take the total load connected to them without the application of any diversity.

Appendix B
Maximum permissible measured earth fault loop impedance

643.7.3 411.4.201 411.4.203 The tables in this appendix provide maximum permissible measured earth fault loop impedances (Z_s) for compliance with BS 7671 where the standard final circuits of Table 7.1(ii) are used. The values are those that must not be exceeded in the tests carried out under 10.3.6 at an ambient temperature of 10 °C. Table B8 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.I 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 B1-B5 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 (csa); and

(b) an overcurrent protective device (i.e. a fuse) to:

- **(i)** BS 3036 (Table BI);
- **(ii)** BS 88-2.2 and BS 88-6 (Table B2);
- **(iii)** BS 88-2 (BS EN 60269-2) (Table B3);
- **(iv)** BS 88-3 (Table B4); or
- **(v)** BS 1361 (Table B5).

For each type of fuse, two tables are given:

411.3.2.2 ► 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 ► 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 equation given in Regulation 543.1.3.

The tabulated values apply only when the nominal voltage to Earth (U_o) is 230 V.

© The Institution of Engineering and Technology

B Appendix

Table B6 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.

NOTE: The impedances tabulated in this appendix are lower than those in Tables 41.2, 41.3 and 41.4 of BS 7671 as the impedances in this appendix are measured values at an assumed conductor temperature of 10 °C while those in BS 7671 are design figures at the conductor maximum permitted operating temperature. The correction factor (divisor) used is 1.25. For smaller section conductors 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 767 1 is used. This is suitable for PVC insulated and sheathed cables to Table 4, 7 or 8 of BS 6004 and for thermosetting (LSHF) insulated and sheathed cables to Table 3, 5, 6 or 7 of BS 7211. The k value is based on both the thermoplastic (PVC) and LSHF cables operating at a maximum temperature of 70 °C.

▼ Table B1 Semi-enclosed fuses. Maximum measured earth fault loop impedance (in Ω) at ambient temperature where the overcurrent protective device is a semi-enclosed fuse to BS 3036

i 0.4 s 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	7.3	1.9	1.3	NP
≥ 1.5	7.3	1.9	1.3	0.83

ii 5 s 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.

© The Institution of Engineering and Technology

▼ **Table B2** BS 88-2.2 and BS 88-6 fuses. Maximum measured earth fault loop impedance (in Ω) at ambient temperature where the overcurrent protective device is a fuse to BS 88-2.2 or BS 88-6

i 0.4 s disconnection (final circuits not exceeding 32 A in TN systems)

Protective conductor (mm^2)	Fuse rating					
	6 A	10 A	16 A	20 A	25 A	32 A
1.0	6.47	3.9	2.06	1.34	1.09	0.62
1.5	6.47	3.9	2.06	1.34	1.09	0.79
≥ 2.5	6.47	3.9	2.06	1.34	1.09	0.79

ii 5 s 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	1.17	0.62	NP	NP	NP	NP	NP
1.5	2.03	1.4	1.0	0.6	NP	NP	NP	NP
2.5	2.21	1.75	1.4	0.81	0.7	0.34	NP	NP
4.0	2.21	1.75	1.4	1.03	0.76	0.49	0.24	NP
6.0	2.21	1.75	1.4	1.03	0.79	0.62	0.34	0.19
10.0	2.21	1.75	1.4	1.03	0.79	0.62	0.44	0.29
16.0	2.21	1.75	1.4	1.03	0.79	0.62	0.44	0.32

NOTE: NP means that the combination of the protective conductor and the fuse is Not Permitted.

© The Institution of Engineering and Technology

▼ **Table B3** BS 88-2 (BS EN 60269-2) fuses. Maximum measured earth fault loop impedance (in Ω) at ambient temperature where the overcurrent protective device is a fuse to BS 88-2 (BS EN 60269-2)

i 0.4 s 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 s 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	1.7	1.4	1.0	0.5	0.3	NP	NP
4.0	2.24	1.7	1.4	1.0	0.76	0.49	0.22	0.12
6.0	2.24	1.7	1.4	1.0	0.79	0.62	0.3	0.19
10.0	2.24	1.7	1.4	1.0	0.79	0.62	0.44	0.32
16.0	2.24	1.7	1.4	1.0	0.79	0.62	0.44	0.34

NOTE: NP means that the combination of the protective conductor and the fuse is Not Permitted.

© The Institution of Engineering and Technology

▼ **Table B4** BS 88-3 fuses. Maximum measured earth fault loop impedance (in Ω) at ambient temperature where the overcurrent protective device is a fuse to BS 88-3

i 0.4 s 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	7.9	1.84	1.55	0.6
1.5 to 16	7.9	1.84	1.55	0.73

ii 5 s 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.

© The Institution of Engineering and Technology

▼ Table B5 BS 1361 fuses. Maximum measured earth fault loop impedance (in Ω) at ambient temperature where the overcurrent protective device is a fuse to BS 1361

i 0.4 s 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	7.95	2.50	1.29	0.77
1.5 to 16	7.95	2.50	1.29	0.86

ii 5 s 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	80 A	100 A
1.0	1.46	0.77	NP	NP	NP	NP
1.5	1.98	0.97	0.32	NP	NP	NP
2.5	2.13	1.4	0.49	0.20	NP	NP
4.0	2.13	1.4	0.67	0.35	0.20	NP
6.0	2.13	1.4	0.73	0.47	0.27	0.13
10.0	2.13	1.4	0.73	0.53	0.38	0.20
16.0	2.13	1.4	0.73	0.53	0.38	0.28

NOTE: NP means that the combination of the protective conductor and the fuse is Not Permitted.

© The Institution of Engineering and Technology

▼ **Table B6** Circuit-breakers. Maximum measured earth fault loop impedance (in Ω) at ambient temperature where the overcurrent device is a circuit-breaker to BS 3871 or BS EN 60898 or RCBO to BS EN 61009

0.1 to 5 second disconnection times

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	5.87	3.5	2.3	2.2	1.75	1.4	1.17	1.1	0.88	0.78	0.7	0.56	0.35
3&C	5.82	3.49	2.91	1.75	1.16	1.09	0.87	0.7	0.58	0.55	0.44	0.38	0.35	0.27	0.17

Circuit-breakers. Maximum measured earth fault loop impedance (in Ω) 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 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 B7 are for energy limiting class 3, Types B and C devices only.

© The Institution of Engineering and Technology

▼ **Table B7** Minimum protective conductor size (mm ^{2})*

Energy limiting class 3 device rating	Fault level (kA)	Protective conductor csa (mm^2)	
		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's *Electrical Installation Design Guide.*

▼ **Table B8** 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))/(I +0.004(10-20)1 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 to those of Table 12 because Table B8 corrects from 10 °C and Table 12 from 20 °C.

The appropriate ambient correction factor from Table B8 is applied to the earth fault loop impedances of Tables B1-B6 if the ambient temperature is other than 10 °C when the circuit loop impedances are measured.

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 x 1.06 = 1.17 Ω.

© The Institution of Engineering and Technology

Appendix C
Selection of types of cable for particular uses and external influences

Chapter 52

For compliance with the requirements of Chapter 52 for the selection and erection of wiring systems in relation to risks of mechanical damage and corrosion, this appendix lists, in two tables, types of cable for the uses indicated. These tables are not intended to be exhaustive and other limitations may be imposed by the relevant regulations of BS 7671, in particular, those concerning maximum permissible operating temperatures.

Information is also included in this appendix on protection against corrosion of the exposed metalwork of wiring systems.

© The Institution of Engineering and Technology

▼ **Table C1** Applications of cables for fixed wiring

Type of cable (NOTE 7)	Uses	Comments
Thermoplastic (PVC) or thermosetting insulated non-sheathed cable (BS 7211, BS EN 50525 series)	For use in conduits, cable ducting or trunking	Intermediate support may be required on long vertical runs 70 °C maximum conductor temperature for normal wiring grades including thermosetting types (NOTE 4) Cables run in PVC conduit should not operate with a conductor temperature greater than 70 °C (NOTE 4)
Flat thermoplastic (PVC) or thermosetting insulated and sheathed cable (BS 6004)	For general indoor use in dry or damp locations May be embedded in plaster For use on exterior surface walls, boundary walls and the like For use as overhead wiring between buildings For use underground in conduits or pipes For use in building voids or ducts formed in-situ	Additional mechanical protection may be necessary where exposed to mechanical stresses Protection from direct sunlight may be necessary. Black sheath colour is better for cables exposed to sunlight May need to be hard drawn (HD) copper conductors for overhead wiring (NOTE 6) Unsuitable for embedding directly in concrete Not recommended for underground ducts liable to become wet as unsuitable for that environment
Mineral insulated (BS EN 60702-1)	General	MI cables should have overall PVC covering where exposed to the weather or risk of corrosion, or where installed underground, or in concrete ducts
Thermoplastic or thermosetting insulated, armoured, thermoplastic sheathed (BS 5467, BS 6346, BS 6724, BS 7846)	General	Additional protection may be necessary where exposed to mechanical stresses Protection from direct sunlight may be necessary. Black sheath colour is better for cables exposed to sunlight

NOTES:

1 The use of cable covers or equivalent mechanical protection is desirable for all underground cables that might otherwise subsequently be disturbed. Route marker tape should also be installed, buried just below ground level. Cables should be buried at a sufficient depth.

2 Cables having thermoplastic (PVC) insulation or sheath should preferably not be used where the ambient temperature is consistently below 0 °C or has been within the preceding 24 hours. Where they are to be installed during a period of low temperature, precautions should be taken to avoid risk of mechanical damage during handling. A minimum ambient temperature of 5 °C is advised in BS EN 50565-1:2014 *Electric cables. Guide to use for cables with a rated voltage not exceeding 450/750 V (Uc/U). General guidance* for some types of PVC insulated and sheathed cables.

3 Cables must be suitable for the maximum ambient temperature and must be protected from any excess heat produced by other equipment, including other cables.

© The Institution of Engineering and Technology

4 Thermosetting cable types (to BS 7211:2012+A1:2020 or BS EN 50525 series or BS 5467) can operate with a conductor temperature of 90 °C. This must be limited to 70 °C where drawn into a conduit, etc., with thermoplastic (PVC) insulated conductors or connected to electrical equipment (Regulations 512.1.5 and 523.1), or where such cables are installed in plastic conduit or trunking.

5 For cables to BS 6004, BS EN 50525, BS 7211, BS 5467 and BS 6724, further guidance may be obtained from those standards. Additional advice is given in the BS 7540:2005 series *Guide to use for cables with a rated voltage not exceeding 450/750 V* for cables to BS 6004, BS 6007 and BS 7211.

6 Cables for overhead wiring between buildings must be able to support their own weight and any imposed wind or ice/snow loading. A catenary support is usual but hard drawn copper types may be used.

7 **BS 5467: Electric cables.** *Thermosetting insulated, armoured cables for voltages of 600/1000 V and 1900/5500 V for fixed installations;*
BS 6004: Electric cables. *PVC insulated and PVC sheathed cables for voltages up to and including 500/500 V for electric power and lighting*
BS 6346: Electric cables. *PVC insulated, armoured cobles for voltages of 600/1000 V and 1900/3300 V (withdrawn)*
BS 6724: Electric cables. *Thermosetting insulated, armoured cables for voltages of 600/1000 V and 1900/3500 V, for fixed installations having low emission of smoke and corrosive gases when affected by fire*
BS 7211: Electric cables. *Thermosetting insulated, and thermoplastic sheathed cables for voltages up to and including 450/750 V, for electric power and lighting and having low emission of smoke and corrosive gases when affected by fire*
BS 7846: Electric cables. *Thermosetting insulated, armoured, fire-resistant cables of rated voltage 600/1000 V for fixed installations, having low emission of smoke and corrosive gases when affected by fire*
BS EN 60702-1: *Mineral-insulated cables and their terminations with a rated voltage not exceeding 750* IX *Cables*

Migration of plasticizer from thermoplastic (PVC) materials

Thermoplastic (PVC) sheathed cables, including thermosetting insulated with thermoplastic sheath (for example, LSHF cables), must be separated from expanded polystyrene materials to prevent take-up of the cable plasticizer by the polystyrene, as this will reduce the flexibility of the cables.

Thermal insulation

Thermoplastic (PVC) sheathed cables in roof spaces must be clipped clear of any insulation made of expanded polystyrene granules.

Cable clips

Thermoplastic (PVC) cable clips are softened by contact with polystyrene. Nylon and polypropylene are unaffected.

Grommets

Natural rubber grommets can be softened by contact with thermoplastic (PVC). Synthetic rubbers are more resistant. Thermoplastic (PVC) grommets are not affected, but could affect other plastics.

© The Institution of Engineering and Technology

Wood preservatives

Thermoplastic (PVC) sheathed cables should be covered to prevent contact with preservative fluids during application. After the solvent has evaporated (good ventilation is necessary) the preservative has no effect.

Creosote

Creosote should not be applied to thermoplastic (PVC) sheathed cables because it causes decomposition, solution, swelling and loss of pliability.

▼ **Table C2** Applications of flexible cables to BS 6500:2000 and BS 7919:2001 (both superseded by the BS EN 50525 Series)

Type of flexible cable	Uses
Light thermoplastic (PVC) insulated and sheathed flexible cable	Indoors in household or commercial premises in dry situations, for light duty
Ordinary thermoplastic (PVC) insulated and sheathed flexible cable	Indoors in household or commercial premises, including damp situations, for medium duty For cooking and heating appliances where not in contact with hot parts For outdoor use other than in agricultural or industrial applications For electrically powered hand tools
60 °C thermosetting (rubber) insulated braided twin and three-core flexible cable	Indoors in household or commercial premises where subject only to low mechanical stresses
60 °C thermosetting (rubber) insulated and sheathed flexible cable	Indoors in household or commercial premises where subject only to low mechanical stresses For occasional use outdoors For electrically powered hand tools
60 °C thermosetting (rubber) insulated oil-resisting with flame-retardant sheath	For general use, unless subject to severe mechanical stresses For use in fixed installations where protected by conduit or other enclosure
90 °C thermosetting (rubber) insulated HOFR sheathed	General, including hot situations, e.g. night storage heaters, immersion heaters and boilers
90 °C heat-resisting thermoplastic (PVC) insulated and sheathed	General, including hot situations, e.g. for pendant luminaires
150 °C thermosetting (rubber) insulated and braided	For use at high ambient temperatures For use in or on luminaires
185 °C glass-fibre insulated single-core, twisted twin and three-core	For internal wiring of luminaires only and then only where permitted by BS 4533
185 °C glass-fibre insulated braided circular	For dry situations at high ambient temperatures and not subject to abrasion or undue flexing For the wiring of luminaires

© The Institution of Engineering and Technology

NOTES:

1 Cables should be suitable for the maximum ambient temperature, and should be protected from any excess heat produced by other equipment, including other cables.

2 For flexible cables to BS EN 50525 series further guidance may be obtained from those standards, or from BS EN 50565-1 :20 14 *Electric cables. Guide to use for cables with a rated voltage not exceeding 450/750 V (Uq/U). General guidance.*

5 Where used as connections to equipment, flexible cables should, where possible, be of the minimum practicable length to minimize danger. The length of the flexible cable must be such that will permit correct operation of the protective device.

4 Where attached to equipment flexible cables should be protected against tension, crushing, abrasion, torsion and kinking, particularly at the inlet point to the electrical equipment. At such inlet points it may be necessary to use a device that ensures that the cable is not damaged through bending. Strain relief, clamping devices or cable guards should not damage the cable.

5 Flexible cables should not be run under carpets or other floor coverings where furniture or other equipment may rest on them or where heat dissipation from the cable will be affected. Flexible cables should not be placed where there is a risk of damage from traffic passing over them, unless they are suitably protected.

6 Flexible cables should not be used in contact with or close to heated surfaces, especially if the surface approaches the upper thermal limit of the cable.

Protection of exposed metalwork and wiring systems against corrosion

522.3 522.5 In damp situations, where metal cable sheaths and armour of cables, metal conduit and conduit fittings, metal ducting and trunking systems, and associated metal fixings, are liable to chemical deterioration or electrolytic attack by materials of a structure with which they may come in contact, it is necessary to take suitable precautions against corrosion.

Materials likely to cause such attack include:

(a) materials containing magnesium chloride, which are used in the construction of floors and plaster mouldings;
(b) plaster undercoats which may include corrosive salts;
(c) lime, cement and plaster, for example on unpainted walls;
(d) oak and other acidic woods; and
(e) dissimilar metals likely to set up electrolytic action.

Application of suitable coatings before erection or the prevention of contact by separation with plastics, are recognized as effective precautions against corrosion.

Special care is required in the choice of materials for clips and other fittings for bare aluminium sheathed cables and for aluminium conduit, to avoid the risk of local corrosion in damp situations. Examples of suitable materials for this purpose include:

(a) porcelain;
(b) plastics;
(c) aluminium;
(d) corrosion-resistant aluminium alloys;
(e) zinc alloys; and
(f) iron or steel protected against corrosion by galvanizing, sherardizing, etc.

© The Institution of Engineering and Technology

522.5.2 Contact between bare aluminium sheaths or aluminium conduits and any parts made of brass or other metal having a high copper content should be especially avoided in damp situations, unless the parts are suitably plated. If such contact is unavoidable, the joint should be completely protected against ingress of moisture. Wiped joints in aluminium sheathed cables should always be protected against moisture by a suitable paint, by an impervious tape, or by embedding in bitumen.

© The Institution of Engineering and Technology

Appendix D
Methods of support for cables, conductors and wiring systems

522.8 This appendix describes examples of methods of support for cables, conductors and wiring systems that should satisfy the relevant requirements of Chapter 52 of BS 7671. The use of other methods is not precluded where specified by a suitably qualified electrical engineer.

Cables generally

Items (a) to (h) below are generally applicable to supports on structures that are subject only to vibration of low severity and a low risk of mechanical impact.

(a) For non-sheathed cables, installation in conduit without further fixing of the cables, precautions being taken against undue compression or other mechanical stressing of the insulation at the top of any vertical runs exceeding 5 m in length.

(b) For cables of any type, installation in ducting or trunking without further fixing of the cables, vertical runs not exceeding 5 m in length without intermediate support.

(c) For sheathed and/or armoured cables installed in accessible positions, support by clips at spacings not exceeding the appropriate value stated in Table D1.

(d) For cables of any type, resting without fixing in horizontal runs of ducts, conduits, cable ducting or trunking.

(e) For sheathed and/or armoured cables in horizontal runs that are inaccessible and unlikely to be disturbed, resting without fixing on part of a building, the surface of that part being reasonably smooth.

(f) For sheathed-and-armoured cables in vertical runs that are inaccessible and unlikely to be disturbed, supported at the top of the run by a clip and a rounded support of a radius not less than the appropriate value stated in Table D5.

(g) For sheathed cables without armour in vertical runs that are inaccessible and unlikely to be disturbed, supported by the method described in Item (f) above; the length of run without intermediate support not exceeding 5 m for a thermosetting or thermoplastic sheathed cable.

(h) For thermosetting or thermoplastic (PVC) sheathed cables, installation in conduit without further fixing of the cables, any vertical runs being in conduit of suitable size and not exceeding 5 m in length.

© The Institution of Engineering and Technology

Particular applications

721.522.8 **(i)** In caravans, for sheathed cables in inaccessible spaces such as ceiling, wall and floor spaces, support at intervals not exceeding 0.4 m for vertical runs and 0.25 m for horizontal runs.

(j) In caravans, for horizontal runs of sheathed cables passing through floor or ceiling joists in inaccessible floor or ceiling spaces, securely bedded in thermal insulating material, no further fixing is required.

(k) Forflexible cables used as pendants, attachmentto a ceiling rose or similar accessory by the cable grip or other method of strain relief provided in the accessory.

(l) For temporary installations and installations on construction sites, supports so arranged that there is no appreciable mechanical strain on any cable termination or joint.

Overhead wiring

(m) For cables sheathed with thermosetting or thermoplastic material, supported by a separate catenary wire, either continuously bound up with the cable or attached thereto at intervals, the intervals not exceeding those stated in column 2 of Table D1.

(n) Support by a catenary wire incorporated in the cable during manufacture, the spacings between supports not exceeding those stated by the manufacturer and the minimum height above ground being in accordance with Table D2.

(o) For spans without intermediate support (for example, between buildings) of thermoplastic (PVQ insulated thermoplastic (PVC) sheathed cable, or thermosetting insulated cable having an oil-resisting and flame-retardant or HOFR sheath, terminal supports so arranged that:

- **(i)** no undue strain is placed upon the conductors or insulation of the cable;
- **(ii)** adequate precautions are taken against any risk of chafing of the cable sheath; and
- **(iii)** the minimum height above ground and the length of such spans are in accordance with the appropriate values indicated in Table D2.

(p) Bare or thermoplastic (PVC) covered conductors of an overhead line for distribution between a building and a remote point of utilization (for example, another building) supported on insulators, the lengths of span and heights above ground having the appropriate values indicated in Table D2 or otherwise installed in accordance with the Electricity Safety, Quality and Continuity Regulations (ESQCR) (as amended).

(q) For spans without intermediate support (for example, between buildings) and in situations inaccessible to vehicular traffic, cables installed in heavy gauge steel conduit, the length of span and height above ground being in accordance with Table D2.

© The Institution of Engineering and Technology

Conduit and cable trunking

(r) Rigid conduit supported in accordance with Table D3.

(s) Cable trunking supported in accordance with Table D4.

(t) Conduit embedded in the material of the building.

(u) Pliable conduit embedded in the material of the building or in the ground, or supported in accordance with Table D3.

© The Institution of Engineering and Technology

© The Institution of Engineering and Technology

▼ **Table D1** Spacings of supports for cables in accessible positions

Overall diameter of cable, d* (mm)	Maximum spacings of clips (mm)							
	Non-armoured thermosetting or thermoplastic (PVC) sheathed cables				Armoured cables		Mineral insulated copper sheathed or aluminium sheathed cables	
	Generally		In caravans					
1	Horizontal † 2	Vertical † 3	Horizontal † 4	Vertical † 5	Horizontal † 6	Vertical † 7	Horizontal † 8	Vertical † 9
$d \leq 9$	250	400	250 (for all sizes)	400 (for all sizes)	–	–	600	800
$9 < d \leq 15$	300	400			350	450	900	1200
$15 < d \leq 20$	350	450			400	550	1500	2000
$20 < d \leq 40$	400	550			450	600	–	–

NOTES:

For the spacing of supports for cables having an overall diameter exceeding 40 mm, the manufacturer's recommendations should be observed.

* For flat cables taken as the dimension of the major axis.

† The spacings stated for horizontal runs may also be applied to runs at an angle of more than 30 ° from the vertical. For runs at an angle of 30 ° or less from the vertical, the vertical spacings are applicable.

▼ **Table D2** Maximum lengths of span and minimum heights above ground for overhead wiring between buildings, etc.

Type of system	Maximum length of span (m)	Minimum height of span above ground (m)†		
		At road crossings	In positions accessible to vehicular traffic, other than crossings	In positions inaccessible to vehicular traffic*
1	2	3	4	5
Cables sheathed with thermoplastic (PVC) or having an oil-resisting and flame-retardant or HOFR sheath, without intermediate support.	3	5.8	5.8	3.5
Cables sheathed with thermoplastic (PVC) or having an oil-resisting and flame-retardant or HOFR sheath, in heavy gauge steel conduit of diameter not less than 20 mm and not jointed in its span.	3	5.8	5.8	3
Thermoplastic (PVC) covered overhead lines on insulators without intermediate support.	30	5.8	5.8	3.5
Bare overhead lines on insulators without intermediate support.	30	5.8	5.8	5.2
Cables sheathed with thermoplastic (PVC) or having an oil-resisting and flame-retardant or HOFR sheath, supported by a catenary wire.	No limit	5.8	5.8	3.5
Aerial cables incorporating a catenary wire.	Subject to Item 14	5.8	5.8	3.5
A bare or insulated overhead line for distribution between buildings and structures must be installed to the standard required by the ESQCR.				

* Column 5 is not applicable in agricultural premises.

† In some special cases, such as where cranes are present, it will be necessary to increase the minimum height of span above ground. It is preferable to use underground cables in such locations.

© The Institution of Engineering and Technology

▼ **Table D3** Spacings of supports for conduits

Nominal diameter of conduit, d (mm)	Maximum distance between supports (m)					
	Rigid metal		Rigid insulating		Pliable	
	Horizontal	Vertical	Horizontal	Vertical	Horizontal	Vertical
1	2	3	4	5	6	7
$d \leq 16$	0.75	1.0	0.75	1.0	0.3	0.5
$16 < d \leq 25$	1.75	2.0	1.5	1.75	0.4	0.6
$25 < d \leq 40$	2.0	2.25	1.75	2.0	0.6	0.8
$d > 40$	2.25	2.5	2.0	2.0	0.8	1.0

NOTES:

1 The spacings tabulated allow for the maximum fill of cables permitted by the Regulations and the thermal limits specified in the relevant British Standards. They assume that the conduit is not exposed to other mechanical stress.

2 Supports should be positioned within 300 mm of bends or fittings. A flexible conduit should be of such length that it does not need to be supported in its run.

3 The inner radius of a conduit bend should be not less than 2.5 times the outside diameter of the conduit.

▼ **Table D4** Spacings of supports for cable trunking

Cross-sectional area of trunking, A (mm^2)	Maximum distance between supports (m)			
	Metal		Insulating	
	Horizontal	Vertical	Horizontal	Vertical
1	2	3	4	5
$300 < A \leq 700$	0.75	1.0	0.5	0.5
$700 < A \leq 1500$	1.25	1.5	0.5	0.5
$1500 < A \leq 2500$	1.75	2.0	1.25	1.25
$2500 < A \leq 5000$	3.0	3.0	1.5	2.0
$A > 5000$	3.0	3.0	1.75	2.0

NOTES:

1 The spacings tabulated allow for the maximum fill of cables permitted by the Regulations and the thermal limits specified in the relevant British Standards. They assume that the trunking is not exposed to other mechanical stress.

2 The above figures do not apply to lighting suspension trunking, where the manufacturer's instructions must be followed, or where special strengthening couplers are used. Supports should be positioned within 300 mm of bends or fittings.

© The Institution of Engineering and Technology

▼ **Table D5** Minimum internal radii of bends in cables for fixed wiring

Insulation	Finish	Overall diameter, d* (mm)	Factor to be applied to overall diameter of cable to determine minimum internal radius of bend
Thermosetting or thermoplastic (PVC) (circular, or circular stranded copper or aluminium conductors)	Non-armoured	$d \leq 10$	3(2)†
		$10 < d \leq 25$	4(3)†
		$d > 25$	6
	Armoured	Any	6
Thermosetting or thermoplastic (PVC) (solid aluminium or shaped copper conductors)	Armoured or non-armoured	Any	8
Mineral	Copper sheath with or without covering	Any	6‡

* For flat cables the diameter refers to the major axis.

† The value in brackets relates to single-core circular conductors of stranded construction installed in conduit, ducting or trunking.

‡ Mineral insulated cables may be bent to a radius not less than three times the cable diameter over the copper sheath, provided the bend is not reworked, i.e. straightened and re-bent.

© The Institution of Engineering and Technology

NOTE

© The Institution of Engineering and Technology

Appendix E
Cable capacities of conduit and trunking

A number of variable factors affect any attempt to arrive at a standard method of assessing the capacity of conduit or trunking.

Some of these are:

(a) reasonable care (of drawing-in);
(b) acceptable use of the space available;
(c) tolerance in cable sizes; and
(d) tolerance in conduit and trunking.

The following tables can only give guidance on the maximum number of cables that should be drawn in. The sizes should ensure an easy pull with low risk of damage to the cables.

Only the ease of drawing-in is taken into account. The electrical effects of grouping are not. As the number of circuits increases the installed current carrying capacity of the cable decreases. Cable sizes have to be increased with consequent increase in the cost of cable and conduit.

It may sometimes be more attractive economically to divide the circuits concerned between two or more enclosures.

If thermosetting cables are installed in the same conduit or trunking as thermoplastic (PVC) insulated cables, the conductor operating temperature of any of the cables must not exceed that for thermoplastic (PVC), i.e. thermosetting cables must be rated as thermoplastic (PVC).

The following three cases are dealt with. Single-core thermoplastic (PVC) insulated cables in:

(a) straight runs of conduit not exceeding 3 m in length (Tables E1 and E2);
(b) straight runs of conduit exceeding 3 m in length, or in runs of any length incorporating bends or sets (Tables E3 and E4); and
(c) trunking (Tables E5 and E6).

For cables and/or conduits not covered by this appendix, advice on the number of cables that can be drawn in should be obtained from the manufacturer.

® The Institution of Engineering and Technology

i Single-core thermoplastic (PVC) insulated cables in straight runs of conduit not exceeding 3 m in length

For each cable it is intended to use, obtain the appropriate factor from Table E1.

Add the cable factors together and compare the total with the conduit factors given in Table E2.

The minimum conduit size is that having a factor equal to or greater than the sum of the cable factors.

▼ **Table E1** Cable factors for use in conduit in short straight runs

Type of conductor	Conductor cross-sectional area (mm^2)	Cable factor
Solid	1	22
	1.5	27
	2.5	39
Stranded	1.5	31
	2.5	43
	4	58
	6	88
	10	146
	16	202
	25	385

▼ **Table E2** Conduit factors for use in short straight runs

Conduit diameter (mm)	Conduit factor
16	290
20	460
25	800
32	1400
38	1900
50	3500
63	5600

© The Institution of Engineering and Technology

ii Single-core thermoplastic (PVC) insulated cables in straight runs of conduit exceeding 3 m in length, or in runs of any length incorporating bends or sets

For each cable it is intended to use, obtain the appropriate factor from Table E3.

Add the cable factors together and compare the total with the conduit factors given in Table E4, taking into account the length of run it is intended to use and the number of bends and sets in that run.

The minimum conduit size is that size having a factor equal to or greater than the sum of the cable factors. For the larger sizes of conduit, multiplication factors are given relating them to 32 mm diameter conduit.

▼ **Table E3** Cable factors for use in conduit in long straight runs over 3 m, or runs of any length incorporating bends

Type of conductor	Conductor cross-sectional area (mm^2)	Cable factor
Solid	1	16
or	1.5	22
Stranded	2.5	30
	4	43
	6	58
	10	105
	16	145
	25	217

The inner radius of a conduit bend should be not less than 2.5 times the outside diameter of the conduit.

© The Institution of Engineering and Technology

© The Institution of Engineering and Technology

Table E4 Conduit factors for runs incorporating bends and long straight runs

Length of run (m)	Conduit diameter (mm)																			
	16	20	25	32	16	20	25	32	16	20	25	32	16	20	25	32	16	20	25	32
	Straight				One Bend				Two Bends								Four Bends			
1	Covered by Tables E1 and E2				188	303	543	947	177	286	514	900	158	256	463	818	130	213	388	692
1.5					182	294	528	923	167	270	487	857	143	233	422	750	111	182	333	600
2					177	286	514	900	158	256	463	818	130	213	388	692	97	159	292	529
2.5					171	278	500	878	150	244	442	783	120	196	358	643	86	141	260	474
3					167	270	487	857	143	233	422	750	111	182	333	600				
3.5	179	290	521	911	162	263	475	837	136	222	404	720	103	169	311	563				
4	177	286	514	900	158	256	463	818	130	213	388	692	97	159	292	529				
4.5	174	282	507	889	154	250	452	800	125	204	373	667	91	149	275	500				
5	171	278	500	878	150	244	442	783	120	196	358	643	86	141	260	474				
6	167	270	487	857	143	233	422	750	111	182	333	600								
7	162	263	475	837	136	222	404	720	103	169	311	563								
8	158	256	463	818	130	213	388	692	97	159	292	529								
9	154	250	452	800	125	204	373	667	91	149	275	500								
10	150	244	442	783	120	196	358	643	86	141	260	474								

Additional factors:

- For 38 mm diameter use 1.4 x (32 mm factor)
- For 50 mm diameter use 2.6 x (32 mm factor)
- For 63 mm diameter use 4.2 x (32 mm factor)

iii Single-core thermoplastic (PVC) insulated cables in trunking

For each cable it is intended to use, obtain the appropriate factor from Table E5.

Add the cable factors together and compare the total with the factors for trunking given in Table E6.

The minimum size of trunking is that size having a factor equal to or greater than the sum of the cable factors.

▼ **Table E5** Cable factors for trunking

Type of conductor	Conductor cross-sectional area (mm^2)	PVC BS 6004 cable factor	Thermosetting BS 7211 cable factor
Solid	1.5	8.0	8.6
	2.5	11.9	11.9
Stranded	1.5	8.6	9.6
	2.5	12.6	13.9
	4	16.6	18.1
	6	21.2	22.9
	10	35.3	36.3
	16	47.8	50.3
	25	73.9	75.4

NOTES:

1 These factors are for metal trunking and may be optimistic for plastic trunking, where the cross-sectional area available may be significantly reduced from the nominal by the thickness of the wall material.

2 The provision of spare space is advisable; however, any circuits added at a later date must take into account grouping, (see Regulation 523.5).

© The Institution of Engineering and Technology

▼ **Table E6** Factors for trunking

Dimensions of trunking (mm × mm)	Factor	Dimensions of trunking (mm × mm)	Factor
50 x 38	767	200 x 100	8572
50 x 50	1037	200 X 150	13001
75 x 25	738	200 X 200	17429
75 x 38	1146	225 x 38	3474
75 x 50	1555	225 x 50	4671
75 x 75	2371	225 x 75	7167
100 x 25	993	225 x 100	9662
100 x 38	1542	225 x 150	14652
100 x 50	2091	225 x 200	19643
100 x 75	3189	225 x 225	22138
100 x 100	4252	300 x 38	4648
150 x 38	2999	300 x 50	6251
150 x 50	3091	300 x 75	9590
150 x 75	4743	300 x 100	12929
150 x 100	6394	300 x 150	19607
150 x 150	9697	300 X 200	26285
200 x 38	3082	300 x 225	29624
200 x 50	4145	300 x 300	39428
200 x 75	6359		

NOTE: Space factor is 45 % with trunking thickness taken into account.

Other sizes and types of cable or trunking

For sizes and types of cable or trunking other than those given in Tables E5 and E6, the number of cables installed should be such that the resulting space factor does not exceed 45 °/o of the net internal cross-sectional area.

Space factor is the ratio (expressed as a percentage) of the sum of the overall cross-sectional areas of cables (including insulation and any sheath) to the internal cross-sectional area of the trunking or other cable enclosure in which they are installed. The effective overall cross-sectional area of a non-circular cable is taken as that of a circle of diameter equal to the major axis of the cable.

Care should be taken to use trunking bends etc. that do not impose bending radii on cables less than those required by Table D5.

© The Institution of Engineering and Technology

Appendix F
Current-carrying capacities and voltage drop for copper conductors

523 ## Current-carrying capacity

435.1 In this simplified approach the assumption is made that the overcurrent protective device provides both fault current and overload current protection.

For cables buried in the ground, refer to BS 7671, Appendix 4.

Procedure

Appx 3 & 4 **(a)** The design current, 1 of the circuit must first be established;

433.1.1 **(b)** The overcurrent device rating, I_n, is then selected so that I_n is greater than or equal to I_b.

$$I_n \geq I_b$$

The tabulated current-carrying capacity of the selected cable, I_t, is then given by:

$$I_t \geq \frac{I_n}{C_a C_g C_i C_f}$$

for simultaneously occurring factors.

C is a rating factor to be applied where the installation conditions differ from those for which values of current-carrying capacity are tabulated in this appendix. The various rating factors are identified as follows:

- C_a for ambient temperature, see Table Fl;
- C_g for grouping, see Table F3;
- C_i for thermal insulation, see Table F2 (NOTE: For cables installed in thermal insulation as described in Tables F4(i), F5(i) and F6, C, = 1); and
- C_f for the type of protective device, i.e.:

433.1.202
  - where the protective device is a semi-enclosed fuse to BS 3036, C_f = 0.725; and
  - for all other devices Cf = 1.

© The Institution of Engineering and Technology

F Appendix

Voltage drop

525 Appx 4 & 6 To calculate the voltage drop in volts the tabulated value of voltage drop (mV/A/m) has to be multiplied by the design current of the circuit, I_b, and the length of run in metres, L, and then divided by 1000 (to convert to V):

$$\text{voltage drop} = \frac{(\text{mV/A/m}) \times I_b \times L}{1000}$$

The requirements of BS 7671 are deemed to be satisfied if the voltage drop between the origin of the installation and a lighting point does not exceed 3 %/o of the nominal voltage (6.9 V) and for other current-using equipment or socket-outlets does not exceed 5 % (11.5 V single-phase).

Table 4B1 ▼ **Table F1** Rating factors (C_a) for ambient air temperatures other than 30 °C to be applied to the current-carrying capacities for cables in free air

Ambient temperature (°C)	Insulation			
			Mineral	
	70 °C thermoplastic	90 °C thermosetting	Thermoplastic covered or bare and exposed to touch 70 °C	Bare and not exposed to touch 105 °C
25	1.03	1.02	1.07	1.04
30	1.00	1.00	1.00	1.00
35	0.94	0.96	0.93	0.96
40	0.87	0.91	0.85	0.92

© The Institution of Engineering and Technology

523.9

Thermal insulation

Where a cable is to be run in a space to which thermal insulation is likely to be applied, the cable should, wherever practicable, be fixed in a position such that it will not be covered by the thermal insulation. Where fixing in such a position is impracticable, the cross-sectional area of the cable must be increased appropriately.

For a cable installed in thermal insulation as described in Tables F4(i), F5(i) and F6 no correction is required.

NOTE: Reference methods 100, 101 and 102 require the cable to be in contact with the plasterboard or the joists, see Tables 7.1(iii) and 7.1(iv) in Section 7.

For a single cable likely to be totally surrounded by thermally insulating material over a length of more than 0.5 m, the current-carrying capacity should be taken, in the absence of more precise information, as 0.5 times the current-carrying capacity for that cable clipped direct to a surface and open (reference method C).

Where a cable is totally surrounded by thermal insulation for less than 0.5 m the current carrying capacity of the cable should be reduced appropriately depending on the size of cable, the length in insulation and the thermal properties of the insulation. The derating factors in Table F2 are appropriate to conductor sizes up to 10 mm^2 in thermal insulation having a thermal conductivity, A, greater than 0.04 $Wm^{-1}K^{-1}$.

Appendix 4, item 2.6

▼ **Table F2** Cable surrounded by thermal insulation

Length in insulation (mm)	Derating factor (C_i)
50	0.88
100	0.78
200	0.63
400	0.51
≥ 500	0.50

© The Institution of Engineering and Technology

© The Institution of Engineering and Technology

Table F3 Rating factors (Q for one circuit or one multicore cable or for a group of circuits, or a group of multicore cables (to be used with the current-carrying capacities of Tables F4(i), F5(i) and F6)

Table 4C1

Arrangement (cables touching)	Number of circuits or multicore cables										Applicable reference method for current-carrying capacities
	1	2	3	4	5	6	7	8	9	12	
Bunched in air, on a surface, embedded or enclosed	1.0	0.80	0.70	0.65	0.60	0.57	0.54	0.52	0.50	0.45	A to F
Single layer on wall or floor	1.0	0.85	0.79	0.75	0.73	0.72	0.72	0.71	0.70	0.70	C
Single layer multicore on a perforated horizontal or vertical cable tray system	1.0	0.88	0.82	0.77	0.75	0.73	0.73	0.72	0.72	0.72	E
Single layer multicore on a cable ladder system or cleats, etc.	1.0	0.87	0.82	0.80	0.80	0.79	0.79	0.78	0.78	0.78	E

NOTES to Table F3:

1 These factors are applicable to uniform groups of cables, equally loaded.

2 Where horizontal clearances between adjacent cables exceed twice their overall diameter, no rating factor need be applied.

3 The same factors are applied to:
- groups of two or three single-core cables; and
- multicore cables.

4 If a group consists of both two- and three-core cables, the total number of cables is taken as the number of circuits, and the corresponding factor is applied to the tables for two loaded conductors for the two-core cables, and to the tables for three loaded conductors for the three-core cables.

5 If a group consists of *n* single-core cables it may either be considered as n/2 circuits of two loaded conductors (for single-phase circuits) or n/3 circuits of three loaded conductors (for three-phase circuits).

6 The rating factors given have been averaged over the range of conductor sizes and types of installation included in Tables 4D1A to 4J4A of BS 7671 (this includes F4(i), F5(i) and F6 of this Guide) and the overall accuracy of tabulated values is within 5 %.

7 For some installations and for other methods not provided for in the above table, it may be appropriate to use factors calculated for specific cases, see for example Tables 4C4 and 4C5 of BS 7671.

8 Where cables having differing conductor operating temperature are grouped together, the current rating is to be based upon the lowest operating temperature of any cable in the group.

523.5 9 If, due to known operating conditions, a cable is expected to carry not more than 30 % of its grouped rating, it may be ignored for the purpose of obtaining the rating factor for the rest of the group. For example, a group of N loaded cables would normally require a group rating factor of Cg applied to the tabulated I_t. However, if M cables in the group carry loads that are not greater than 0.3 C_g I(amperes the other cables can be sized using the group rating factor corresponding to (N minus M) cables.

▼ **Table F4(i)** Single-core 70 °C thermoplastic (PVC) or thermosetting (NOTE 1) insulated cables, non-armoured, with or without sheath (copper conductors)
Table 4dia

Ambient temperature: 30 °C

Conductor operating temperature: 70 °C

Current-carrying capacity (amperes):

Conductor cross-sectional area	Reference method A (enclosed in conduit in thermally insulating wall, etc.)		Reference method B (enclosed in conduit on a wall or in trunking, etc.)		Reference method C (clipped direct)		Reference method F (in free air or on a perforated cable tray horizontal or vertical)				
	2 cables, single-phase AC or DC	3 or 4 cables, three-phase AC	2 cables, single-phase AC or DC	3 or 4 cables, three-phase AC	2 cables, single-phase AC or DC flat and touching	3 or 4 cables, three-phase AC flat and touching or trefoil	Touching			Spaced by one cable diameter	
							2 cables, single-phase AC or DC flat	3 cables, three-phase AC flat	3 cables three-phase AC trefoil	2 cables single-phase AC or DC or 3 cables three-phase AC flat	
										horizontal	vertical
1	2	3	4	5	6	7	8	9	10	11	12
mm²	A	A	A	A	A	A	A	A	A	A	A
1	11	10.5	13.5	12	15.5	14					
1.5	14.5	13.5	17.5	15.5	20	18					
2.5	20	18	24	21	27	25					
4	26	24	32	28	37	33					
6	34	31	41	36	47	43					

© The Institution of Engineering and Technology

▼ **Table F4(i)** *continued*

Conductor cross-sectional area	Reference method A (enclosed in conduit in thermally insulating wall, etc.)		Reference method B (enclosed in conduit on a wall or in trunking, etc.)		Reference method C (clipped direct)		Reference method F (in free air or on a perforated cable tray horizontal or vertical)				
	2 cables, single-phase AC or DC	3 or 4 cables, three-phase AC	2 cables, single-phase AC or DC	3 or 4 cables, three-phase AC	2 cables, single-phase AC or DC flat and touching	3 or 4 cables, three-phase AC flat and touching or trefoil	Touching			Spaced by one cable diameter	
							2 cables, single-phase AC or DC flat	3 cables, three-phase AC flat	3 cables three-phase AC trefoil	2 cables single-phase AC or DC or 3 cables three-phase AC flat	
										horizontal	vertical
1	2	3	4	5	6	7	8	9	10	11	12
mm²	A	A	A	A	A	A	A	A	A	A	A
10	46	42	57	50	65	59					
16	61	56	76	68	87	79					
25	80	73	101	89	114	104	131	114	110	146	130
35	99	89	125	110	141	129	162	143	137	181	162
50	119	108	151	134	182	167	196	174	167	219	197
70	151	136	192	171	234	214	251	225	216	281	254
95	182	164	232	207	284	261	304	275	264	341	311

NOTES to Table F4(i):

1 The ratings for cables with thermosetting insulation are applicable for cables connected to equipment or accessories designed to operate with cables which run at a temperature not exceeding 70 °C. Where conductor operating temperatures up to 90 °C are acceptable the current rating is increased - see Table 4E1A of BS 7671.

2 Where the conductor is to be protected by a semi-enclosed fuse to BS 3036, see the introduction to this appendix.

3 The current-carrying capacities in columns 2 to 5 are also applicable to flexible cables to BS 6004 Table 1(c) and to 90 °C heat-resisting PVC cables to BS 6231 Tables 8 and 9 where the cables are used in fixed installations.

▼ Table F4(ii) Voltage drop (per ampere per metre) at a conductor operating temperature of 70 °C

Table 4D1B

Conductor cross-sectional area	2 cables DC	2 cables, single-phase AC			3 or 4 cables, three-phase AC			
		Reference methods A & B (enclosed in conduit or trunking)	Reference methods C & F (clipped direct on tray or in free air) touching	Reference methods C & F (clipped direct on tray or in free air) spaced	Reference methods A & B (enclosed in conduit or trunking)	Reference methods C & F (clipped direct, on tray or in free air) Touching, Trefoil	Reference methods C & F (clipped direct, on tray or in free air) Touching, Flat	Reference methods C & F (clipped direct, on tray or in free air) Spaced*, Flat
1	2	3	4	5	6	7	8	9
mm²	mV/A/m	mV/A/m	mV/A/m	mV/A/m	mV/A/m	mV/A/m	mV/A/m	mV/A/m
1	44	44	44	44	38	38	38	38
1.5	29	29	29	29	25	25	25	25
2.5	18	18	18	18	15	15	15	15
4	11	11	11	11	9.5	9.5	9.5	9.5
6	7.3	7.3	7.3	7.3	6.4	6.4	6.4	6.4
10	4.4	4.4	4.4	4.4	3.8	3.8	3.8	3.8
16	2.8	2.8	2.8	2.8	2.4	2.4	2.4	2.4
		z†	z†	z†	z†	z†	z†	z†
25	1.75	1.80	1.75	1.80	1.55	1.50	1.55	1.55
35	1.25	1.30	1.25	1.30	1.10	1.10	1.10	1.15
50	0.93	1.00	0.95	0.97	0.85	0.82	0.84	0.86
70	0.63	0.72	0.66	0.69	0.61	0.57	0.60	0.63
95	0.46	0.56	0.50	0.54	0.48	0.43	0.47	0.51

* Spacings larger than one cable diameter will result in larger voltage drop.

† The impedance values in Table F4(ii) consist of both the resistive and reactive elements of voltage drop, usually provided separately for 25 mm² and above conductor sizes. For more information, see Appendix 4 of BS 7671.

© The Institution of Engineering and Technology

© The Institution of Engineering and Technology

▼ **Table F5(i)** Multicore cables having thermoplastic (PVC) or thermosetting insulation (NOTE 1), non-armoured (copper conductors)

Table 4D2A

Ambient temperature: 30 °C

Conductor operating temperature: 70 °C

Current-carrying capacity (amperes):

Conductor cross-sectional area	Reference method A (enclosed in conduit in a thermally insulating wall, etc.)		Reference method B (enclosed in conduit on a wall or in trunking, etc.)		Reference method C (clipped direct)		Reference method E (in free air or on a perforated cable tray, etc. horizontal or vertical)	
	1 two-core cable*, single-phase AC or DC	1 three-core cable* or 1 four-core cable, three-phase AC	1 two-core cable*, single-phase AC or DC	1 three-core cable* or 1 four-core cable, three-phase AC	1 two-core cable*, single-phase AC or DC	1 three-core cable* or 1 four-core cable, three-phase AC	1 two-core cable*, single-phase AC or DC	1 three-core cable* or 1 four-core cable, three-phase AC
1	2	3	4	5	6	7	8	9
mm^2	A	A	A	A	A	A	A	A
1	11	10	13	11.5	15	13.5	17	14.5
1.5	14	13	16.5	15	19.5	17.5	22	18.5
2.5	18.5	17.5	23	20	27	24	30	25
4	25	23	30	27	36	32	40	34
6	32	29	38	34	46	41	51	43
10	43	39	52	46	63	57	70	60
16	57	52	69	62	85	76	94	80
25	75	68	90	80	112	96	119	101

▼ Table F5(i) *continued*

Conductor cross-sectional area	Reference method A (enclosed in conduit in a thermally insulating wall, etc.)		Reference method B (enclosed in conduit on a wall or in trunking, etc.)		Reference method C (clipped direct)		Reference method E (in free air or on a perforated cable tray, etc. horizontal or vertical)	
	1 two-core cable*, single-phase AC or DC	1 three-core cable* or 1 four-core cable, three-phase AC	1 two-core cable*, single-phase AC or DC	1 three-core cable* or 1 four-core cable, three-phase AC	1 two-core cable*, single-phase AC or DC	1 three-core cable* or 1 four-core cable, three-phase AC	1 two-core cable*, single-phase AC or DC	1 three-core cable* or 1 four-core cable, three-phase AC
1	2	3	4	5	6	7	8	9
mm^2	A	A	A	A	A	A	A	A
35	92	83	111	99	138	119	148	126
50	110	99	133	118	168	144	180	153
70	139	125	168	149	213	184	232	196
95	167	150	201	179	258	223	282	238

NOTES to Table F5(i):

(a) The ratings for cables with thermosetting insulation are applicable for cables connected to equipment or accessories designed to operate with cables which run at a temperature not exceeding 70 °C. Where conductor operating temperatures up to 90 °C are acceptable the current rating is increased - see Table 4E2A of BS 7671.

(b) Where the conductor is to be protected by a semi-enclosed fuse to BS 3036, see the introduction to this appendix.

* With or without protective conductor. Circular conductors are assumed for sizes up to and including 16 mm^2. Values for larger sizes relate to shaped conductors and may safely be applied to circular conductors.

© The Institution of Engineering and Technology

Table 4D2B

▼ **Table F5(ii)** Voltage drop (per ampere per metre) at a conductor operating temperature of 70 °C

Conductor cross-sectional area	Two-core cable, DC	Two-core cable, single-phase AC	Three- or four-core cable, three-phase
1	2	3	4
mm^2	mV/A/m	mV/A/m	mV/A/m
1	44	44	38
1.5	29	29	25
2.5	18	18	15
4	11	11	9.5
6	7.3	7.3	6.4
10	4.4	4.4	3.8
16	2.8	2.8	2.4
		z†	z†
25	1.75	1.75	1.50
35	1.25	1.25	1.10
50	0.93	0.94	0.81
70	0.63	0.65	0.57
95	0.46	0.50	0.43

† The impedance values in Table F5(ii) consist of both the resistive and reactive elements of voltage drop, usually provided separately for 25 mm^2 and above conductor sizes. For more information, see Appendix 4 of BS 7671.

© The Institution of Engineering and Technology

▼ Table F6 70 °C thermoplastic (PVC) insulated and sheathed flat cable with protective conductor (copper conductors)

Table 4D5

Ambient temperature: 30 °C
Conductor operating temperature: 70 °C

Current-carrying capacity (amperes) and voltage drop (per ampere per metre):

Conductor cross-sectional area	Reference method 100*	Reference method 101*	Reference method 102*	Reference method 103	Reference method C	Reference method A	Voltage drop
	(above a plasterboard ceiling covered by thermal insulation not exceeding 100 mm in thickness)	(above a plasterboard ceiling covered by thermal insulation exceeding 100 mm in thickness)	(in a stud wall with thermal insulation with cable touching the inner wall surface)	(in a stud wall with thermal insulation with cable not touching the inner wall surface)	(clipped direct)	(enclosed in conduit in an insulated wall)	
1	2	3	4	5	6	7	8
mm^2	A	A	A	A	A	A	mV/A/m
1	13	10.5	13	8	16	11.5	44
1.5	16	13	16	10	20	14.5	29
2.5	21	17	21	13.5	27	20	18
4	27	22	27	17.5	37	26	11
6	34	27	35	23.5	47	32	7.3
10	45	36	47	32	64	44	4.4
16	57	46	63	42.5	85	57	2.8

NOTES:

* Reference methods 100, 101 and 102 require the cable to be in contact with the plasterboard ceiling, wall or joist, see Tables 7.1(iii) and 7.1(iv) in Section 7.

(a) Wherever practicable, a cable is to be fixed in a position such that it will not be covered with thermal insulation.

(b) Regulation 523.9, BS 5803-5: Appendix C: Avoidance of overheating of electric cables, Building Regulations Approved Document B and Thermal insulation: avoiding risks, BR 262, BRE, 2001 refer.

© The Institution of Engineering and Technology

NOTE

© The Institution of Engineering and Technology

Appendix G
Certification and reporting

The certificates and forms are used with the kind permission of BSI.

G1 Introduction

Fundamentally, two types of form are recognized by BS 7671, certificates and reports:

1 certificates are issued for new installation work
2 condition reports are issued for inspections of existing installations.

C2 Certification

Two types of certificate for new work are recognized by BS 7671:

1 the Electrical Installation Certificate (EIC); and
2 the Minor Electrical Installation Works Certificate (MEIWC).

G2.1 Electrical Installation Certificate

An EIC is intended to be issued where more significant installation work is undertaken; examples are:

(a) a complete installation for a new property;
(b) rewire of an existing installation;
(c) replacement of a consumer unit; or
(d) addition of a new circuit from a distribution board or consumer unit.

G2.2 Minor Electrical Installation Works Certificate

The Minor Electrical Installation Works Certificate (MEIWC) is intended to be issued for an addition or alteration to an existing circuit; such as:

(a) adding lights to a lighting circuit;
(b) adding socket-outlets to a ring final circuit;
(c) rerouting an existing circuit;
(d) replacing an existing shower with a larger power rating of unit; or
(e) replacing circuit-breakers with RCBOs where there is a difference of overcurrent type, e.g. replacing Type C for Type B.

© The Institution of Engineering and Technology

In each case, the **characteristics** of the circuit are likely to have been altered, whether this is the addition of extra load or through changes to the original earth fault loop impedance.

G2.3 Accountability

Certificates call for those responsible for the electrical installation or construction work to certify that the requirements of the Regulations have been met. Under no circumstances should a third party issue a certificate for installation work they have not undertaken.

It is common with larger installations for the design to be carried out by one company, the installation or construction by someone else and the inspection and testing by another body, such as a testing organisation working on behalf of the installer. This is perfectly acceptable, but it is the company carrying out the installation that must issue the EIC.

G3 Reporting

G3.1 Electrical Installation Condition Report

An Electrical Installation Condition Report (EICR) is intended to be issued when a periodic inspection of an electrical installation has been carried out. The EICR does not certify anything and, hence, must not be issued to certify new electrical installation work. The purpose of the EICR is to report on the condition of an existing electrical installation and, ultimately, to present one of two outcomes:

(a) SATISFACTORY - the installation is deemed safe for continued use; or
(b) UNSATISFACTORY - one or more issues of safety have been identified.

Where an unsatisfactory result has been recorded, C1 and/or C2 observations will have been included identifying the reason(s) for the result. FI (Further Investigation) may also be recorded where the inspection has revealed an apparent deficiency which could not, owing to the extent or limitations of the inspection, be fully identified and where further investigation may reveal a code C1 or C2 observation. Once the report has been issued by the inspector, the onus is placed on the client to act in response to the observations recorded.

G3.2 Observations

Observations to be recorded fall into four categories:

- 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.

© The Institution of Engineering and Technology

Examples of C1

The following are examples of C1, where danger currently exists and an immediate issue of safety is apparent:

(a) uninsulated live conductors exposed on broken wiring accessory;
(b) incorrect polarity at socket-outlets, for example live/cpc reversal; and
(c) item of metalwork that has become live due to a fault.

Examples of C2

The following are examples of C2, where the situation is not immediately dangerous but where a dangerous condition could occur due to a fault:

(a) protective equipotential bonding not installed to extraneous-conductive-parts;
(b) residual current device (RCD) (30 mA for additional protection) fails to operate in the required time;
(c) double-pole fusing (line and neutral);
(d) no connection to means of earthing at origin;
(e) no cpc for a lighting circuit having Class I fittings/accessories with exposed-conductive-parts; and
(f) no RCD (30 mA for additional protection) where socket-outlets are likely to supply equipment used outdoors.

Examples of C3

The following examples of C3 are installations complying with older versions of BS 7671 :

(a) no RCD (30 mA for additional protection) for socket-outlets used within the building;
(b) earth leakage circuit-breaker installed at the origin of a TT installation; and
(c) no cpc for lighting circuit where only Class 11fittings/accessories are installed.

Examples of FI

The following are examples of FI, where further investigation may reveal a code C1 or C2:

(a) a consumer unit is fitted with devices and components of different manufacture and may not meet the requirements of BS EN 61439-3; and
(b) where it is suspected that devices within a consumer unit are subject to a product recall.

G3.3 Dangerous situations

Where an inspector discovers an extremely dangerous situation, such as persons or livestock at immediate risk of electric shock or where an imminent fire hazard is evident, urgent action is advised to remove the danger. As an expert, the inspector has been employed to identify electrical problems and, therefore, should make safe such dangerous issues while on the premises.

The inspector is advised to exercise judgement to secure the area and to inform the client immediately, with this followed up in writing. Once permission has been obtained, the danger should be removed.

© The Institution of Engineering and Technology

G3.4 Remedial work

Often the client will ask how much time they have before any necessary remedial work should be carried out once alerted of the unsatisfactory result of the inspection. There is no standard answer that can be given as all installations and situations are different from each other. It is worth informing the client, however, that the installation has been given an unsatisfactory result as there are issues of electrical safety and a duty of care exists in law to ensure that employees or members of the public are not placed in a position of unacceptable risk.

When remedial work has been completed in response to the findings of a periodic inspection, the work may need to be certified as described in G2.

G3.5 Periodic inspection and consumer units in dwellings

Inspectors of electrical installations in dwellings will encounter older consumer units, i.e. those not complying with Regulation 421.1.201, for many years to come. To safeguard the ongoing use of such enclosures and assemblies, the inspector must ensure the following:

- confirmation that **all** conductor connections are correctly located in terminals and are tight and secure; this may involve seeking the advice of the manufacturer of the equipment to establish the correct torque settings for screwdrivers when checking terminals. This applies to **all** terminals conductor/busbar connections within the consumer unit, and where alterations and additions are involved not just those relating to the addition or alteration.
- there are no signs of overheating.
- all covers, shields and barriers supplied when originally installed are present and in a good, serviceable condition.

The following must be verified for all conductor/busbar connections:

- not clamping on insulation;
- conductor not damaged, e.g. through cuts or nicks on a solid conductor during insulation removal, or strands removed;
- conductors are correctly placed, for example, on the correct side of a moving plate in a cage-clamp terminal;
- permitted number of conductors per terminal is not exceeded; and
- no undue strain on the electrical connection, particularly incoming tails.

So far as is reasonably practicable, confirm that incorporated components such as a main switch, circuit-breakers, RCBOs, RCCBs, etc., are not subject of a product recall. This could be achieved by direct question to the manufacturer.

It must not be overlooked that a ferrous enclosure still has the same internal parts and connections as a non-ferrous enclosure. Therefore, a consumer unit with ferrous enclosure should still be inspected and tested at regular intervals.

© The Institution of Engineering and Technology

It is worth bearing in mind the Note by the HSE in BS 7671, which states:

"Existing installations may have been designed and installed to conform to the standards set by earlier editions of BS 7671 or the IEE Wiring Regulations. This does not mean that they will fail to achieve conformity with the relevant parts of the Electricity at Work Regulations 1989."

G4 Introduction to Model Forms from BS 7671

For convenience, the forms are numbered as below:

Form 1	Electrical Installation Certificate
Form 3	Generic Schedule of Circuit Details
Form 4	Generic Schedule of Test Results
Form 5	Minor Electrical Installation Works Certificate
Form 6	Electrical Installation Condition Report
Form 7	Condition Report Inspection Schedule

Appx 6 The introduction to Appendix 6 'Model forms for certification and reporting' of BS 7671 is reproduced below.

(i) The Electrical Installation Certificate required by Part 6 should be made out and signed or otherwise authenticated by a skilled person or persons in respect of the design, construction, inspection and testing of the work.

(ii) The Minor Electrical Installation Works Certificate required by Part 6 should be made out and signed or otherwise authenticated by a skilled person or persons in respect of the design, construction, inspection and testing of the minor work.

(iii) The Electrical Installation Condition Report required by Part 6 should be made out and signed or otherwise authenticated by a skilled person in respect of the inspection and testing of an installation.

(iv) Skilled persons will, as appropriate to their function under (i), (ii) and (iii) above, have a sound knowledge and experience relevant to the nature of the work undertaken and to the technical standards set down in these Regulations, be fully versed in the inspection and testing procedures contained in these Regulations and employ adequate testing equipment.

(v) Electrical Installation Certificates will indicate the responsibility for design, construction, inspection and testing, whether in relation to new work or further work on an existing installation.

© The Institution of Engineering and Technology

FOR DESIGN, CONSTRUCTION, INSPECTION & TESTING

I being the person responsible for the Design, Construction, 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 Design, Construction, Inspection & Testing, hereby CERTIFY that the said work for which I have been responsible is to the best of my knowledge and belief in accordance with BS 7671:2018, amended to .....(date) except for the departures, if any, detailed as follows.

(vi) A Minor Electrical Installation Works Certificate will indicate the responsibility for design, construction, inspection and testing of the work described on the certificate.

(vii) An Electrical Installation Condition Report will indicate the responsibility for the inspection and testing of an existing installation within the extent and limitations specified on the report.

(viii) Schedule(s) of Circuit Details and Schedule(s) of Test Results as required by Part 6 should be issued with the associated Electrical Installation Certificate or Electrical Installation Condition Report.

(ix) Schedule(s) of Inspection as required by Part 6 should be issued with the Electrical Installation Condition Report.

(x) When making out and signing a form on behalf of a company or other business entity, individuals should state for whom they are acting.

(xi) Additional forms may be required as clarification, if needed by ordinary persons, or in expansion, for larger or more complex installations.

G4.1 Electrical Installation Certificate (EIC)

Figures G4.1(i)- (iv) show a typical completed Electrical Installation Certificate comprising Pages 1, 2, 3 and 4. It is assumed that the diagrams and documentation required by Regulation 514.9 are available. The installation is for a music shop, which has SELV lighting and both fire alarm and burglar alarm circuits. Regarding Page 4 (the Schedule of Test Results), the continuity test has been carried out using $(R_1 + R_2)$ and hence R_2 testing is Not Applicable. Different test instruments will show different displays indicating 'out of range', e.g. +299 or >199.

© The Institution of Engineering and Technology

▼ **Figure G4.1 (i)** Electrical Installation Certificate - page 1

ELECTRICAL INSTALLATION CERTIFICATE
(REQUIREMENTS FOR ELECTRICAL INSTALLATIONS - BS 7671)

Certificate No.: SVT-1

DETAILS OF THE CLIENT
Beagle-Meyer Music, Hugo Building, Stotz Road, Little Tripping, AF1 1DD

INSTALLATION ADDRESS
Beagle-Meyer Music, Hugo Building, Stotz Road, Little Tripping, AF1 1DD

DESCRIPTION AND EXTENT OF THE INSTALLATION
Description of installation:

New installation ☑

Extent of installation covered by this Certificate:
Complete installation

Addition to an existing installation ☐

Alteration to an existing installation ☐

(Use continuation sheet if necessary) See continuation sheet No: N/A

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, 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 2022 (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: J Wilson Date: 14/09/2022 Name (IN BLOCK LETTERS): J WILSON Designer No 1

Signature: ..... 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 2022 (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: J Wilson Date: 14/09/2022 Name (IN BLOCK LETTERS): J WILSON 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 2022 (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: J Wilson Date: 14/09/2022 Name (IN BLOCK LETTERS): J 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~~.

© The Institution of Engineering and Technology

▼ **Figure G4.1 (ii)** Electrical Installation Certificate - page 2

Certificate No.: SVT-1

PARTICULARS OF SIGNATORIES TO THE ELECTRICAL INSTALLATION CERTIFICATE

Designer (No 1) Name: J Wilson Company: Wilson Installations
Address: 1 Vanlefton Street, Gearfilched,
Postcode: BRO OKE Tel No: 06431 666666

Designer (No 2) (if applicable) Name: N/A Company:
Address:
Postcode: Tel No:

Constructor Name: As Designer Company:
Address:
Postcode: Tel No:

Inspector Name: As Designer Company:
Address:
Postcode: Tel No:

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) 230 V	BS (EN) 1361
TN-S ☑	1-phase, 2-wire ☑	2-wire ☐	Nominal frequency, f (1) 50 Hz	Type II
TN-C-S ☐	2-phase, 3-wire ☐	3-wire ☐	Prospective fault current, I_{pf} (2) 1.6 kA	Rated current 80 A
TT ☐	3-phase, 3-wire ☐	Other ☐	External earth fault loop impedance, Z_e (2) 0.14 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) ☐ N/A

PARTICULARS OF INSTALLATION REFERRED TO IN THE CERTIFICATE

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

Maximum Demand
Maximum demand (load) 60 ~~kVA /~~ Amps (Delete as appropriate)

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

Main Protective Conductors

Earthing conductor	Material Cu	csa 16 mm²	Connection / continuity verified ☑	
Main protective bonding conductors	Material Cu	csa 10 mm²	Connection / continuity verified ☑	
To water installation pipes ☑	To gas installation pipes ☑	To oil installation pipes ☐ N/A	To structural steel ☐ N/A	
To lightning protection ☐ N/A	To other ☐ Specify N/A			

Main switch ~~/ Switch fuse / Circuit-breaker / RCD~~

Location Small store room	Current rating 100 A	**If RCD main switch**
	Fuse / device rating or setting N/A A	RCD Type N/A
BS(EN) 60947-3	Voltage rating 230 V	Rated residual operating current ($I_{\Delta n}$) mA
No of poles 2		Rated time delay ms
		Measured operating time ms

Schedule of Inspections

Item No.	Description	Outcome ✓ / N/A	Item No.	Description	Outcome ✓ / N/A
1.0	Condition of consumer's intake equipment (Visual inspection only)	✓	8.0	Circuits (Distribution and Final)	✓
			9.0	Isolation and switching	✓
2.0	Parallel or switched alternative sources of supply	N/A	10.0	Current-us equipment (permanently connected)	✓
3.0	Protecti measure: Automatic Disconnection of Supply (ADS)	✓	11.0	Identification and notices	✓
4.0	Bas protection	✓	12.0	Location(s) containing a bath or shower	N/A
5.0	Protective measures other than ADS	✓	13.0	Other special installations or locations	N/A
6.0	Addition protection	✓	14.0	Prosumer's low voltage electrical installation(s)	N/A
7.0	Distributi equipment	✓			

COMMENTS ON EXISTING INSTALLATION (in the case of an addition or alteration see Regulation 644.1.2):
None

SCHEDULES
This Certificate is valid only when 2 Schedules of Circuit Details and Test Results are attached.
(Enter quantities of schedules attached).

© The Institution of Engineering and Technology

▼ **Figure G4.1 (in)** Generic Schedule of Circuit Details - Electrical Installation Certificate - page 3

GENERIC SCHEDULE OF CIRCUIT DETAILS

Certificate/Report number: SVT-1

Distribution board details

DB reference: CU 1 Location: Small store room Supplied from: Meter

Distribution circuit OCPD: BS (EN): 1361 Type: II Rating/Setting: 80 A

SPD Details: Type(s)*: T1 ☐ T2 ☑ T3† ☐ N/A ☐

SPD main switch fitted upstream of CU

CIRCUIT DETAILS

		Conductor details					Overcurrent protective device					RCD			
					Number & size										
1 Circuit number	2 Circuit description	3 Type of wiring	4 Reference method‡	5 Number of points served	6 Live (mm²)	7 cpc (mm²)	8 BS (EN)	9 Type	10 Rating (A)	11 Breaking capacity (kA)	12 Maximum permitted Z_s (Ω)§	13 BS (EN)	14 Type	15 $I_{\Delta n}$ (mA)	16 Rating (A)
1	Ring final, shop socket-outlets	B	B	14	2.5	1.5	61009	B	32	6	1.37	61009	A	30	32
2	Radial, water heater	B	B	1	2.5	1.5	61009	B	16	6	2.37	61009	AC	30	16
3	Radial, burglar alarm	B	B	1	1.5	1.5	60898	B	16	6	2.73	N/A	N/A	N/A	N/A
4	Radial, sockets for counter & office	B	B	12	2.5	1.5	61009	B	20	6	2.19	61009	A	30	20
5	Radial, fire alarm	B	B	1	1.5	1.5	60898	B	16	6	2.37	N/A	N/A	N/A	N/A
6	Lights, internal & external signs	B	100#	22	1.5	1.0	60898	B	6	6	7.28	N/A	N/A	N/A	N/A
7	Spare														
8	Spare														

CODES FOR TYPES OF WIRING

A	B	C	D	E	F	G	H	O
Thermoplastic insulated/ sheathed cables	Thermoplastic cables in metallic conduit	Thermoplastic cables in non-metallic conduit	Thermoplastic cables in metallic trunking	Thermoplastic cables in non-metallic trunking	Thermoplastic SWA cables	Thermosetting SWA cables	Mineral insulated cables	Other - please state

* SPD Type. Where a combined T1 + T2 or T2 + T3 device is installed, indicate by ticking both Type boxes.
† Where a T3 SPD is installed to protect sensitive equipment, enter details in 'Remarks', column 31, of the Schedule of Test Results. (See Section 534 of BS 7671:2018+A2:2022)
‡ See Table 4A2 of Appendix 4 of BS 7671:2018+A2:2022.
§ Where the maximum permitted earth fault loop impedance value stated in column 12 is taken from a source other than the tabulated values given in Chapter 41 of BS 7671:2018+A2:2022, state the source of the data in the appropriate cell for the circuit in the 'Remarks', column 31, of the Schedule of Test Results.

© The Institution of Engineering and Technology

© The Institution of Engineering and Technology

▼ **Figure G4.1(iv)** Generic Schedule of Test Results - Electrical Installation Certificate - page 4

GENERIC SCHEDULE OF TEST RESULTS

Certificate/Report number: SVT-1

Distribution board details

DB reference: CU 1 Z_{db} 0.14 Ω I_{pf} 1.6 kA

Confirmed: Correct polarity ☑ Phase sequence ☐ N/A

SPD: Operational status confirmed¶ ☑ N/A ☐

Details of test instruments used (serial and/or asset numbers)

Multifunction: 3040102-1
Continuity: N/A
Insulation resistance: N/A
Earth fault loop impedance: N/A
RCD: N/A
Earth electrode resistance: N/A

TEST RESULT DETAILS

17 Circuit number	Continuity (Ω) Ring final circuit 18 r_1 (line)	19 r_n (neutral)	20 r_2 (cpc)	(R1 + R2) or R2 21 (R1 + R2)	22 R2	Insulation resistance 23 Test voltage (V)	24 Live - Live (MΩ)	25 Live - Earth (MΩ)	26 Polarity#	Z_s (Ω) 27 Maximum measured	RCD 28 Disconnection time (ms)**	29 Test button operation	AFDD 30 Manual test button operation††	31 Remarks
1	0.6	0.6	0.97	0.38	-	500	>999	>999	✓	0.57	25	✓	N/A	
2	N/A	N/A	N/A	0.20	-	500	>999	>999	✓	0.40	18	✓	N/A	
3	N/A	N/A	N/A	0.29	-	500	>999	>999	✓	0.49	N/A	N/A	N/A	
4	N/A	N/A	N/A	0.78	-	500	>999	>999	✓	0.92	26	✓	N/A	
5	N/A	N/A	N/A	0.39	-	500	>999	>999	✓	0.53	N/A	N/A	N/A	
6	N/A	N/A	N/A	0.51	-	500	N/A	>999	✓	0.71	N/A	N/A	N/A	Insulation (L+N)-E due to electronic transformers
7														Spare
8														Spare

Include details of circuits and/or installed equipment vulnerable to damage when testing

(continue on a separate sheet if necessary)

Tested by name (Capitals): J WILSON

Signature: J Wilson Date: 14 September 2022

¶ Not all SPDs have visible functionality indication.
# Where this schedule is issued with an Electrical Installation Condition Report, and incorrect polarity is identified, an 'X' should be entered.
** RCD effectiveness is verified using an alternating current test at rated residual operating current ($I_{\Delta n}$).
†† Not all AFDDs have a test button

NOTE: One Schedule of Circuit Details and one Schedule of Test Results will be issued for every consumer unit or distribution board

G4.2 Electrical Installation Certificate - Completion

Notes for the person producing the Certificate:

1 The Electrical Installation Certificate is to be used for:

- 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
- the replacement of a consumer unit/distribution board, or
- certifying for where there are multiple additions, or alterations or remedial works to the existing installation which do not extend to new circuits as an alternative to the issue of multiple Minor Electrical Installation Works Certificates.

It is not to be used for a periodic inspection and testing, for which an Electrical Installation Condition Report 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 issued to the person ordering the work (Regulation 644.4). A duplicate should be retained by the person issuing the certificate.

2 This Certificate is only valid if the Schedule of Inspections has been completed to confirm that all relevant inspections have been carried out and where accompanied by Schedule® of Circuit Details and 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. (Where a single signature electrical installation certificate is used, the person authorized for executing the work of design, construction, inspection and testing shall sign the certificate.)

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 the Schedule® of Circuit Details and Test Results should be indicated, together with the total number of pages associated with the certification provided.

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.

© The Institution of Engineering and Technology

G4.3 Electrical Installation Certificate - 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 BS 7671. You should have received an 'original' Certificate and the person that issued the Certificate 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 schedule®, 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 2015 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 documentation.

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 and testing of an existing electrical installation. An 'Electrical Installation Condition Report' should be issued for such an inspection.

This Certificate is only valid if the Schedule of Inspections has been completed to confirm that all relevant inspections have been carried out and where accompanied by Schedule® of Circuit Details and Test Results.

Where the installation includes a residual current device (RCD) it should be tested six-monthly by pressing the button marked T or 'Test'. The device should switch off the supply and should then be switched on to restore the supply. If the device does not switch off the supply when the button is pressed, seek expert advice. For safety reasons it is important that this instruction is followed.

Where the installation includes an arc fault detection device (AFDD) having a manual test facility it should be tested six-monthly by pressing the test button. Where an AFDD has both a test button and automatic test function, manufacturer's instructions shall be followed with respect to test button operation.

Where the installation includes a surge protection device (SPD) the status indicator should be checked to confirm it is in operational condition in accordance with manufacturer's information. If the indication shows that the device is not operational, seek expert advice.

© The Institution of Engineering and Technology

For safety reasons it is important that this instruction is followed.

Where the installation includes alternative or additional sources of supply, warning notices should be found at the origin or meter position, or if remote from the origin, at the consumer unit or distribution board and at all points of isolation of all sources of supply.

G4.4 Schedule of Circuit Details

The schedule of circuit details contains the information relevant to the circuits supplied from the distribution board or consumer unit. These include:

- Details of the distribution board. Its reference number, location, where it is supplied from, the overcurrent protective device BS (EN) number, type and rating/setting and details of the surge protection device where installed; and
- Circuit details including the circuit number and description.

For each circuit is recorded the:

- Conductor details : type of wiring, reference method, number of points served number and size of Live and cpc conductors.
- Overcurrent protective device details: BS (EN) number, Type, Rating (A), Breaking Capacity (kA), and maximum permitted Zs (Ω).
- RCD details: BS (EN) number, Type, $I_{\triangle n}$ (mA), Rating (A).

Once completed this may also be copied and used as the circuit chart for the distribution board as it contains all the relevant information for operation and maintenance.

G4.5 Schedule of Test Results

Notes to the tests and observations required when completing the Schedule of Test Results:

- Measurement of Z_{db} at this distribution board to be recorded
- Measurement of $I_p f$ at this distribution board to be recorded
- Confirm correct polarity of supply to this distribution board by the use of approved test instrument
- Confirmation of phase sequence for multi-phase installations
- SPD operational status confirmation
- Details of the test instruments used to carry out the tests (serial or asset numbers)
- The remarks column (column 31) should include details of circuits and/or installed equipment vulnerable to damage when testing, e.g. SELV transformers, dimming equipment.

© The Institution of Engineering and Technology

The following tests, where relevant, must be carried out in the given sequence (see also 10.2):

A - Installation isolated from the supply

1 Continuity

Radial conductors

Continuity of protective conductors, including main and supplementary bonding

Every protective conductor, including main and supplementary bonding conductors, should be tested to verify that it is continuous and correctly connected.

Test method 1

Where test method 1 is used, enter the measured resistance of the line conductor plus the circuit protective conductor (R1 + R2). See 10.3.1. During the continuity testing (test method 1) the following polarity checks should be carried out:

- **(a)** overcurrent devices and single-pole controls are in the line conductor;
- **(b)** except for E14 and E27 lampholders to BSEN 60238, centre contact screw lampholders have the outer threaded contact connected to the neutral; and
- **(c)** socket-outlet polarities are correct.

Compliance for each circuit is indicated by a tick in polarity column 26.

(R1 + R2) need not be recorded if R_2 is recorded in column 22.

Test method 2

Where test method 2 is used, the maximum value of R_2 is recorded in column 22.

Ring final circuit continuity

Each conductor of the ring final circuit must be tested for continuity, including spurs. An exception is permitted where the cpc is formed by, e.g. metallic conduit or trunking and is not in the form of a ring. N/A can be recorded here but continuity of the cpc will be confirmed in either column 21 or 22.

2 Insulation resistance

The test voltage applied for the test is recorded in column 23.

All voltage sensitive devices to be disconnected or test between live conductors (line and neutral) connected together and earth.

The insulation resistance between live conductors (line-to-line and line-to-neutral for three-phase installations and line-to-neutral for single-phase installations) is inserted in column 24 and between live conductors and earth in column 25.

© The Institution of Engineering and Technology

The minimum insulation resistance values are given in Table 10.3.3 of this Guide.

3 Polarity - by continuity method

A satisfactory polarity test may be indicated by a tick in column 26. Only in a Schedule of Test Results associated with an Electrical Installation Condition Report is it acceptable to record incorrect polarity.

B - Installation energised

4 Polarity of supply

The polarity of the supply at the distribution board should be confirmed and indicated by ticking the box on the Electrical Installation Certificate and Schedule of Test Results.

5 Earth fault loop impedance Z_{db}

Where the distribution board or consumer unit is located at the origin of the installation this will also be the Z_e for the installation. This may be determined by direct measurement at the main incoming terminals of the Distribution Board. Where the distribution board is remote from the installation origin the Z b may be determined by direct measurement at the incoming terminals of the DB or by adding the R1 + R2 for the distribution circuit to the installation Z_e

$(Z_{db} = Z_e + \text{distribution circuit } (R_1 + R_2)$

6 Earth fault loop impedance Z_s

This may be determined either by direct measurement at the furthest point of a live circuit or by adding $(R_1 + R_2)$ of column 21 to Z_e. Z_e is determined by measurement at the origin of the installation.

$Z_s = Z_e + (R_1 + R_2)$

Z_s should not exceed the values given in Appendix B.

7 Functional testing

The operation of RCDs (including RCBOs) is tested by simulating a fault condition, independent of any test facility in the device; see Section 11.

RCDs are tested and compliance is confirmed when testing at I_{An} and disconnection is achieved within 300 ms. The actual operating time is recorded in column 28.

Effectiveness of the test button must be confirmed and the result recorded in column 29.

AFDDs and SPDs which are provided with a test button this must be operated to confirm its function. Where only a status indicator is provided this must be checked to determine the device is in a healthy condition. The result is recorded in column 30.

© The Institution of Engineering and Technology

8 Switchgear

All switchgear and controlgear assemblies, controls, etc. must be operated to ensure that they are properly mounted, adjusted and installed.

9 Earth electrode resistance

The resistance of earth electrodes must be measured. For reliability in service the resistance of any earth electrode should be below 200 Ω. Record the value on Form 1, 2 or 6, as appropriate.

G4.6 Minor Electrical Installation Works Certificate

Figure G4.6 shows an example of a completed Minor Electrical Installation Works Certificate and Table G4.9 gives some notes on how to complete it.

© The Institution of Engineering and Technology

Figure G4.6 Minor Electrical Installation Works Certificate - page 1 of 1

MINOR ELECTRICAL INSTALLATION WORKS CERTIFICATE Certificate No.: SMT-2
(REQUIREMENTS FOR ELECTRICAL INSTALLATIONS - BS 7671)
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 ... Andrews Heating and Ventilation ... Date minor works completed ... 14/09/2022
2. Installation location/address ... 12 Bold St, Newington, Cambs WW1 OWW
3. Description of the minor works ... Addition of 8 no. lighting points to existing lighting circuit
4. Details of any departures from BS 7671:2018 as amended to 2022 (date) for the circuit altered or extended (Regulation 120.3, 133.1.3 and 133.5).
   Details of permitted exceptions (Regulation 411.3.3). Where applicable, a suitable risk assessment(s) must be attached to this Certificate. Risk assessment attached ☐
   None
5. **Comments on (including any defects observed in) the existing installation (Regulation 644.1.2):**
   Visible signs of wear, PVC trunking lid missing in storeroom No overvoltage protection provided

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 ... 0.37 ... Ω
3. Presence of adequate main protective conductors:
   Earthing conductor ☑
   Main protective bonding conductor(s) to: Water ☑ Gas ☑ Oil ☐ Structural steel ☐ Other (Specify)..... ☐

PART 3: Circuit details

DB Reference No.: ... CU1 ... DB Location and type: ... Store room, 8-way consumer unit
Circuit No.: ... 2 ... Circuit description: ... Lighting circuit ... Installation reference method ... B and C
Number & size of conductors: Live ... 1.5 ... mm² cpc ... 1.0 ... mm²
Circuit overcurrent protective device: BS (EN) ... 61009 ... Type ... B ... Rating ... 10 ... A
RCD: BS (EN) ... 61009 ... Type ... AC ... Rating ... 10 ... A Rated residual operating current ($I_{\Delta n}$) ... 30 ... mA
AFDD: BS (EN) ... N/A ... Rating ... A
SPD: BS (EN) ... N/A ... Type ...

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

Protective conductor continuity: ($R_1 + R_2$) ... 0.48 ... Ω or R_2 ... N/A ... Ω
Continuity of ring final circuit conductors: L/L ... N/A ... Ω N/N ... N/A ... Ω cpc/cpc ... N/A ... Ω
Insulation resistance: Test voltage ... 500 ... V Live - Live ... >999 ... MΩ Live - Earth ... >999 ... MΩ
Polarity satisfactory: ☑ Maximum measured earth fault loop impedance: Z_s ... 2.04 ... Ω
RCD disconnection time at rated residual operating current ($I_{\Delta n}$) ... 35 ... ms Satisfactory test button operation: ☑
AFDD satisfactory test button operation: ☐ NOTE: Not all AFDDs have a test button N/A
SPD functionality confirmed: ☐ NOTE: Not all SPDs have visible functionality indication N/A

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 amended to ... 2022 ... (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: ... J Wilson
For and on behalf of: ... Wilson Installation
Address: ... 1, Vanlefton Street
Gearfilched
BRO OKE

Signature: ... J Wilson
Position: ... Proprietor
Date: ... 14 September 2022

© The Institution of Engineering and Technology

C4.7 Minor Electrical Installation Works Certificate - Scope of application

Notes for the person producing the certificate: The Minor Electrical Installation Works Certificate is intended to be used for additions and alterations 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.

G4.8 Minor Electrical Installation Works Certificate - 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 BS 7671.

You should have received an 'original' Certificate and the person that issued the Certificate 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 person that issued the Certificate 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 BS 7671 at the time the Certificate was issued.

For safety reasons, the electrical installation will need to be inspected at appropriate intervals by a skilled person or persons, competent in such work.

Where the installation includes an RCD it should be tested six-monthly by pressing the button marked T or 'Test'. The device should switch off the supply and should then be switched on to restore the supply. If the device does not switch off the supply when the button is pressed, seek expert advice. For safety reasons it is important that this instruction is followed.

Where the installation includes an arc fault detection device (AFDD) having a manual test facility it should be tested six-monthly by pressing the test button. Where an AFDD has both a test button and automatic test function, manufacturer's instructions shall be followed with respect to test button operation.

© The Institution of Engineering and Technology

Where the installation includes a surge protection device (SPD) the status indicator should be checked to confirm it is in operational condition in accordance with manufacturer's information. If the indication shows that the device is not operational, seek expert advice. For safety reasons it is important that this instruction is followed.

Where the installation includes alternative or additional sources of supply, warning notices should be found at the origin or meter position, or if remote from the origin, at the consumer unit or distribution board and at all points of isolation of all sources of supply.

G4.9 Notes on completion of the Minor Electrical Installation Works Certificate

▼ **Table G4.9** Description of the required information

Part 1: Description of minor works	Information to record
1	The person ordering the work to whom the certificate is issued. The date of issue must be included.
2	The address of the installation.
3	The work to which the certificate applies must be described so that the work can be readily identified.
4	No departures are to be expected except in most unusual circumstances. See Regulations 120.3, 133.1.3 and 133.5. Any risk assessment associated with Regulation 411.3.3 must be attached to the certificate and indicated.
5	Comments on existing installationThe installer responsible for the new work should record on the Minor Electrical Installation Works Certificate any defects found, so far as is reasonably practicable, in the existing installation. The defects recorded should not affect the safety of the installation work to which the certificate applies.
	In non-domestic installations where a risk assessment has been carried out and the findings show that additional protection by RCD is not necessary, the assessment(s) must be attached to this Certificate.
Part 2 - Installation details	
1	System earthing arrangement.
2	Earth fault loop impedance at the distribution board (Zjb) supplying the final circuit being worked on.
3	Declaration of adequacy of earthing and bonding conductors.
Part 3 - Circuit details	Record information.
Part 4 - Test results for the circuit altered or extended	Record test results.
Part 5 - Declaration	The Certificate must be made out and signed by a skilled person in respect of the design, construction, inspection and testing of the work.

© The Institution of Engineering and Technology

G4.10 Electrical Installation Condition Report (EICR)

Installations may be divided into two types:

1. Domestic and similar installations with up to 100 A single- or three-phase supply; and
2. Installations with a supply greater than 100 A.

However, this Guide will only consider the Electrical Installation Condition Report for Domestic and similar installations with up to 100 A supply. For installations with a supply greater than 100 A, see IET Guidance Note 3.

For domestic and similar installations with up to 100 A supply, the inspector will be required to complete a minimum of six pages of information for an EICR.

An Electrical Installation Condition Report is to be issued for all inspected installations.

Figures G4.10(i)-(v) show a typical completed Electrical Installation Condition Report comprising Pages 1 to 6. The installation is some 20 years old and has no RCD fitted.

© The Institution of Engineering and Technology

Figure G4.10(i) Electrical Installation Condition Report - page 1

ELECTRICAL INSTALLATION CONDITION REPORT

Report No.: 42345

SECTION A. DETAILS OF THE PERSON ORDERING THE REPORT
Name W Lilly.
Address 14 Waning Crescent, Newton NY2 4PP

SECTION B. REASON FOR PRODUCING THIS REPORT Requested by client due to burning smell. Known rodent infestation, suspected cable damage.
Date(s) on which inspection and testing was carried out 2 September 2022

SECTION C. DETAILS OF THE INSTALLATION WHICH IS THE SUBJECT OF THIS REPORT
Occupier W Lilly.
Address 14 Waning Crescent, Newton NY2 4PP

Description of premises
Residential ☑ Commercial ☐ Industrial ☐ Other (include brief description) ☐
Estimated age of wiring system 20 years
Evidence of additions / alterations? Yes ☑ No ☐ Not apparent ☐ If yes, estimate age 5 years
Installation records available? (Regulation 651.1) Yes ☐ No ☑ Date of last inspection Unknown (date)

SECTION D. EXTENT AND LIMITATIONS OF INSPECTION AND TESTING
Extent of the electrical installation covered by this report Visual inspection of distributor's equipment and meter. Inspection and testing of consumer unit and final circuits.
Agreed limitations including the reasons (see Regulation 653.2) No dismantling or removal of fitted kitchen units or appliances.
Agreed with: Person ordering the work
Operational limitations including the reasons (see page no. N/A) None

The inspection and testing detailed in this report and accompanying schedules have been carried out in accordance with BS 7671:2018 as amended to 2022

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) Cable damage evident in loft, otherwise the condition of the installation is good, with some signs of wear and tear.

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 02/09/2032 (date) for the following reasons.... Standard dwelling, the installation condition supports such a period

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) G. STOKES	Name (Capitals) G. STOKES
Signature Geoff Stokes	Signature Geoff Stokes
For/on behalf of Stokes Electrical Limited	For/on behalf of Stokes Electrical Limited
Position Director	Position Director
Address Unit 4, Coates Business Park, Newtown WA4 5XX	Address Unit 4, Coates Business Park, Newtown WA4 5XX
Date 02/09/2022	Date 02/09/2022

SECTION H. SCHEDULE(S)
1 Inspection Schedule(s) and 1 Schedule(s) of Circuit Details and 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.

© The Institution of Engineering and Technology

▼ **Figure G4.10(ii)** Electrical Installation Condition Report - page 2

Report No.: 42345

SECTION I. SUPPLY CHARACTERISTICS AND EARTHING ARRANGEMENTS

Earthing arrangements	Number and Type of Live Conductors	Nature of Supply Parameters	Supply Protective Device
TN-C ☐ TN-S ☐ TN-C-S ☑ TT ☐ IT ☐	AC ☑ DC ☐ 1-phase, 2-wire ☑ 2-wire ☐ 2-phase, 3-wire ☐ 3-wire ☐ 3-phase, 3-wire ☐ Other ☐ 3-phase, 4-wire ☐ Confirmation of supply polarity ☑	Nominal voltage, U / U_0(1) 230 V Nominal frequency, f(1) 50 Hz Prospective fault current, I_{pf}(2) 1.6 kA External earth fault loop impedance, Z_e(2) 0.16 Ω (Note: (1) by enquiry (2) by enquiry or by measurement)	BS (EN) 1361 Type II Rated current 80 A

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

SECTION J. PARTICULARS OF INSTALLATION REFERRED TO IN THE REPORT

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

Details of Installation Earth Electrode (where applicable)
Type N/A
Location
Resistance to Earth Ω

Main Protective Conductors

Earthing conductor	Material Cu csa 16 mm²	Connection / continuity verified ☑
Main protective bonding conductors	Material Cu csa 10 mm²	Connection / continuity verified ☑

To water installation pipes ☑	To gas installation pipes ☑	To oil installation pipes N/A	To structural steel ☐ N/A
To lightning protection N/A	To other ☐ Specify N/A		

Main switch / Switch-fuse / Circuit-breaker / RCD

Location Garage	Current rating 100 A	**If RCD main switch**
	Fuse / device rating or setting N/A A	RCD Type N/A
BS(EN) 5486	Voltage rating 250 V	Rated residual operating current ($I_{\Delta n}$) N/A mA
No of poles 2		Rated time delay N/A ms
		Measured operating time N/A ms

SECTION K. OBSERVATIONS

Referring to the attached inspection schedule(s) and schedule(s) of circuit details 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 cable for Circuit 7 (shower) in loft. Conductors visible, evidence of arcing	C1
2 Damage to cable for Circuit 6 (lighting) in loft, conductors visible	C1
3 No additional protection by RCD for socket-outlets	C3
4 No additional protection by RCD for lighting circuits	C3

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

© The Institution of Engineering and Technology

Figure C4.1 0(iii) Electrical Installation Condition Report Inspection Schedule - page 3

Certificate/Report Number 42345

CONDITION REPORT INSPECTION SCHEDULE FOR RESIDENTIAL AND SIMILAR PREMISES WITH UP TO 100 A SUPPLY

Note: This form is suitable for many types of smaller installation, not exclusively residential.

The persons responsible for the periodic inspection of the installation should include the relevant items in relation to the electrical installation, the inspection schedule can be reduced or expanded depending on the requirements for the installation.

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	**SUPPLY INTAKE EQUIPMENT (visual inspection only)**	
1.1	Distributor/supplier intake equipment • Service cable • Service head • Earthing arrangement • Meter tails • Metering equipment • Isolator (where present) Where inadequacies in the intake equipment are encountered, which may result in a dangerous or potentially dangerous situation, the person ordering the work and/or duty holder must be informed. It is strongly recommended that the person ordering the work informs the appropriate authority.	Where inadequacies are found a cross should be put against the appropriate item and a comment made in section K. An outcome against an item in section 1.0, other than access to live parts, should not be used to determine the overall outcome.
	Person ordering word / Duty holder notified (Delete as appropriate)	~~Y~~ / N/A (Delete as appropriate)
1.2	Consumer's isolator (where present)	N/A
1.3	Consumer's meter tails	✓
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 (543.3.2)	✓
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, where required (514.12.2)	✓
4.11	Presence of alternative supply warning notice at or near consumer unit/distribution board (514.15)	N/A
4.12	Presence of other required labelling (please specify) (Section 514)	N/A
4.13	Compatibility of protective device and base and other components; correct type and rating. (No signs of unacceptable thermal damage, arcing or overheating) (536.4.203)	✓
4.14	Single-pole switching or protective devices in line conductors only (132.14.1; 530.3.2)	✓
4.15	Protection against mechanical damage where cables enter consumer unit/distribution board (132.14.1; 522.8.1; 522.8.5; 522.8.11; 530.3.2)	✓
4.16	Protection against electromagnetic effects where cables enter consumer unit/distribution board/enclosures (521.5.1)	✓
4.17	RCD(s) provided for fault protection – includes RCBOs (411.4.9; 411.5.2; 531.2)	N/A
4.18	RCD(s) provided for additional protection - includes RCBOs (411.3.3; 415.1)	C3
4.19	Confirmation of indication that SPD is functional (651.4)	N/A

© The Institution of Engineering and Technology

▼ **Figure G4.10(iv)** Electrical Installation Condition Report Inspection Schedule - page 4

Certificate/Report Number 42345

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)
4.20	Confirmation that ALL conductor connections, including connections to busbars, are correctly located in terminals and are tight and secure (526.1)	✓
4.21	Adequate arrangements where a generating set operates as a switched alternative to the public supply (551.6)	N/A
4.22	Adequate arrangements where a generating set operates in parallel with the public supply (551.7)	N/A
5.0	**FINAL CIRCUITS**	
5.1	Identification of conductors (514.3.1)	✓
5.2	Cables correctly supported throughout their run (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; 543.2.1)	✓
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 32 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
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)	✓
	• 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)	✓
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; 530.3.2)	✓
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 supply units 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 7671:2008 (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
8.0	**CHAPTER 82 PROSUMER'S LOW VOLTAGE ELECTRICAL INSTALLATION(S)**	
8.1	Where the installation includes additional requirements and recommendations relating to Chapter 82, additional inspection items should be added to the checklist.	N/A

Inspected by:
Name (Capitals) G. STOKES **Signature** Geoff Stokes **Date** 02/09/2022

© The Institution of Engineering and Technology

▼ **Figure G4.10(v)** Generic Schedule of Circuit Details - Electrical Installation Condition Report - page 5

GENERIC SCHEDULE OF CIRCUIT DETAILS

Certificate/Report number: 42345

Distribution board details

DB reference: CU1 Location: Kitchen cupboard near boiler Supplied from: Meter

Distribution circuit OCPD: BS (EN): 1361 Type: II Rating/Setting: 80 A

SPD Details: Type(s)*: T1 ☐ T2 ☐ T3† ☐ N/A ☑

CIRCUIT DETAILS

		Conductor details					Overcurrent protective device					RCD			
					Number & size										
1 Circuit number	2 Circuit description	3 Type of wiring	4 Reference method‡	5 Number of points served	6 Live (mm^2)	7 cpc (mm^2)	8 BS (EN)	9 Type	10 Rating (A)	11 Breaking capacity (kA)	12 Maximum permitted Z_s (Ω)§	13 BS (EN)	14 Type	15 $I_{\Delta n}$ (mA)	16 Rating (A)
1	Ring final (downstairs socket-outlets)	A	C	10	2.5	1.5	60898	B	32	6	1.37	N/A	N/A	N/A	N/A
2	Ring final (upstairs socket-outlets)	A	C	9	2.5	1.5	60898	B	32	6	1.37	N/A	N/A	N/A	N/A
3	Ring final (kitchen/utility socket-outlets)	A	C	10	2.5	1.5	60898	B	32	6	1.37	N/A	N/A	N/A	N/A
4	Lights (upstairs)	A	C	7	1.0	1.0	60898	B	6	6	7.28	N/A	N/A	N/A	N/A
5	Lights (downstairs and utility)	A	C	11	1.0	1.0	60898	B	6	6	7.28	N/A	N/A	N/A	N/A
6	Lights (garage)	A	C	3	1.0	1.0	60898	B	6	6	7.28	N/A	N/A	N/A	N/A
7	Shower	A	C	1	6.0	2.5	60898	B	40	6	1.09	N/A	N/A	N/A	N/A
8	Spare														

CODES FOR TYPES OF WIRING

A	B	C	D	E	F	G	H	O
Thermoplastic insulated/ sheathed cables	Thermoplastic cables in metallic conduit	Thermoplastic cables in non-metallic conduit	Thermoplastic cables in metallic trunking	Thermoplastic cables in non-metallic trunking	Thermoplastic SWA cables	Thermosetting SWA cables	Mineral insulated cables	Other - please state

* SPD Type. Where a combined T1 + T2 or T2 + T3 device is installed, indicate by ticking both Type boxes.
† Where a T3 SPD is installed to protect sensitive equipment, enter details in 'Remarks', column 31, of the Schedule of Test Results. (See Section 534 of BS 7671:2018+A2:2022.)
‡ See Table 4A2 of Appendix 4 of BS 7671:2018+A2:2022.
§ Where the maximum permitted earth fault loop impedance value stated in column 12 is taken from a source other than the tabulated values given in Chapter 41 of BS 7671:2018+A2:2022, state the source of the data in the appropriate cell for the circuit in the 'Remarks', column 31, of the Schedule of Test Results.

© The Institution of Engineering and Technology

© The Institution of Engineering and Technology

▼ **Figure C4.10(vi)** Generic Schedule of Test Results - Electrical Installation Condition Report - page 6

GENERIC SCHEDULE OF TEST RESULTS

Certificate/Report number: 42345

Distribution board details

DB reference: CU1 Z_{db} 0.16 Ω I_{pf} 1.6 kA

Confirmed: Correct polarity ☑ Phase sequence ☐ N/A

SPD: Operational status confirmed¶ ☐ N/A ☑

Details of test instruments used (serial and/or asset numbers)

Multifunction: Serial 4010399
Continuity: N/A
Insulation resistance: N/A
Earth fault loop impedance: N/A
RCD: N/A
Earth electrode resistance: N/A

TEST RESULT DETAILS

17 Circuit number	Continuity (Ω)					Insulation resistance			26 Polarity#	Z_s (Ω)	RCD		AFDD	31 Remarks
	Ring final circuit			$(R_1 + R_2)$ or R_2										
	18 r_1 (line) (Ω)	19 r_n (neutral)	20 r_2 (cpc)	21 $(R_1 + R_2)$	22 R_2	23 Test voltage (V)	24 Live - Live (MΩ)	25 Live - Earth (MΩ)		27 Maximum measured	28 Disconnection time (ms)**	29 Test button operation	30 Manual test button operation††	Include details of circuits and/or installed equipment vulnerable to damage when testing (continue on a separate sheet if necessary)
1	0.48	0.48	0.79	0.31	N/A	500	>999	>999	✓	0.48	N/A	N/A	N/A	
2	0.33	0.33	0.54	0.22	N/A	500	>999	>999	✓	0.38	N/A	N/A	N/A	
3	0.70	0.70	1.15	0.46	N/A	500	>999	>999	✓	0.62	N/A	N/A	N/A	
4	N/A	N/A	N/A	3.07	N/A	500	>999	>999	✓	3.24	N/A	N/A	N/A	
5	N/A	N/A	N/A	3.80	N/A	500	>999	>999	✓	3.96	N/A	N/A	N/A	
6	N/A	N/A	N/A	0.36	N/A	500	>999	>999	✓	0.52	N/A	N/A	N/A	
7	N/A	N/A	N/A	0.15	N/A	500	>999	>999	✓	0.31	N/A	N/A	N/A	
8														Spare

Tested by name (Capitals): G STOKES

Signature: Geoff Stokes Date: 2 September 2022

¶ Not all SPDs have visible functionality indication.
# Where this schedule is issued with an Electrical Installation Condition Report, and incorrect polarity is identified, an 'X' should be entered.
** RCD effectiveness is verified using an alternating current test at rated residual operating current ($I_{\Delta n}$).
†† Not all AFDDs have a test button

NOTE: One Schedule of Circuit Details and one Schedule of Test Results will be issued for every consumer unit or distribution board

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 replacement of a consumer unit/distribut ion 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 ($I_p f$) 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 requirements of Regulation 652.1 and the overall condition of the installation.

© The Institution of Engineering and Technology

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 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. This Report is only valid if accompanied by the Schedule® of Inspections and the Schedule® of Circuit Details and Test Results.
3. The person ordering the Report should have received the 'original' Report and the inspector should have retained a duplicate.
4. 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.
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).

© The Institution of Engineering and Technology

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'.

11 Where the installation includes a residual current device (RCD) it should be tested six-monthly by pressing the button marked T or 'Test'. The device should switch off the supply and should then be switched on to restore the supply. If the device does not switch off the supply when the button is pressed, seek expert advice. For safety reasons it is important that this instruction is followed.

12 Where the installation includes an arc fault detection device (AFDD) having a manual test facility it should be tested six-monthly by pressing the test button. Where an AFDD has both a test button and automatic test function, manufacturer's instructions shall be followed with respect to test button operation.

13 Where the installation includes a surge protection device (SPD) the status indicator should be checked to confirm it is in operational condition in accordance with manufacturer's information. If the indication shows that the device is not operational, seek expert advice. For safety reasons it is important that this instruction is followed.

14 Where the installation includes alternative or additional sources of supply, warning notices should be found at the origin or meter position, or if remote from the origin, at the consumer unit or distribution board and at all points of isolation of all sources of supply.

© The Institution of Engineering and Technology

NOTE

© The Institution of Engineering and Technology

Appendix H
Standard circuit arrangements for household and similar installations

H1 Introduction

This appendix gives advice on standard circuit arrangements for household and similar premises. The circuits provide guidance on the requirements of Chapter 43 for overload protection and Section 537 of BS 7671 for isolation and switching. Reference must also be made to Section 7 and Table 7.1(ii) for cable cross-sectional area (csa), length and installation reference method.

It is the responsibility of the designer and installer when adopting these circuit arrangements to take the appropriate measures to comply with the requirements of other relevant chapters or sections, such as Chapter 41 'Protection against electric shock', Chapter 54 'Earthing arrangements and protective conductors' and Chapter 52 'Selection and erection of wiring systems'.

Circuit arrangements other than those detailed in this appendix are not precluded when specified by a competent person, in accordance with the general requirements of Regulation 314.3.

H2 Final circuits using socket-outlets complying with BS 1363-2 and fused connection units complying with BS 1363-4

H2.1 General

In this arrangement, a ring or radial circuit, with spurs if any, feeds permanently connected equipment and a number of socket-outlets and fused connection units.

The floor area served by the circuit is determined by the known or estimated load and should not exceed the value given in Table H2.1.

433.1.204 A single 30 A or 32 A ring circuit may serve a floor area of up to 100 m^2. Socket-outlets for washing machines, tumble dryers and dishwashers should be located so as to provide reasonable sharing of the load in each leg of the ring, or consideration should be given to separate circuits.

© The Institution of Engineering and Technology

553.1.7 The number of socket-outlets provided should be such that all equipment can be supplied from an adjacent accessible socket-outlet, taking account of the length of flex normally fitted to portable appliances and luminaires. See H7.

Diversity between socket-outlets and permanently connected equipment has already been taken into account in Table H2.1 and no further diversity should be applied, see Appendix A of this Guide.

▼ **Table H2.1** Final circuits using BS 1363 socket-outlets and connection units

Type of circuit		Overcurrent protective device rating (A)	Minimum live conductor cross-sectional area* (mm^2)		
			Copper conductor thermoplastic or thermosetting insulated cables	Copper conductor mineral insulated cables	Maximum floor area served (m^2)
1	2	3	4	5	6
A1	Ring	30 or 32	2.5	1.5	100
A2	Radial	30 or 32	4	2.5	75
A3	Radial	20	2.5	1.5	50

* See Section 7 and Table 7.1(ii) for the minimum csa for particular installation reference methods. It is permitted to reduce the values of conductor cross-sectional area for fused spurs.

Where two or more ring final circuits are installed, the socket-outlets and permanently connected equipment to be served should be reasonably distributed among the circuits.

H2.2 Circuit protection

Table H2.1 is applicable for circuits protected by:

- ► fuses to BS 3036, BS 1361 and BS 88, and
- ► circuit-breakers:
  - Types B and C to BS EN 60898 or BS EN 61009-1
  - BS EN 60947-2
  - Types 1, 2 and 3 to BS 3871.

© The Institution of Engineering and Technology

H2.3 Conductor size

The minimum size of conductor cross-sectional area in the circuit and in non-fused spurs is given in Table H2.1. However, the actual size of cable is determined by the current carrying capacity for the particular method of installation, after applying the appropriate rating factors from Appendix F (see Table 7.1(ii)). The as-installed current-carrying capacity (Ij so calculated must be not less than:

(a) 20 A for ring circuit Al;
(b) 30 A or 32 A for radial circuit A2 (i.e. the rating of the overcurrent protective device); and
(c) 20 A for radial circuit A3 (i.e. the rating of the overcurrent protective device).

The conductor size for a fused spur is determined from the total current demand served by that spur, which is limited to a maximum of 13 A.

Where a fused spur serves socket-outlets the minimum conductor size is:

(a) 1.5 mm^2 for cables with thermosetting or thermoplastic (PVC) insulated cables, copper conductors; and
(b) 1 mm^2 for mineral insulated cables, copper conductors.

The conductor size for circuits protected by BS 3036 fuses is determined by applying the 0.725 factor of Regulation 433.1.202, that is the current-carrying capacity must be at least 27 A for circuits Al and A3, 41 A for circuit A2.

H2.4 Spurs

The total number of fused spurs is unlimited but the number of non-fused spurs should not exceed the total number of socket-outlets and items of stationary equipment connected directly in the circuit.

In an Al ring final circuit and an A2 radial circuit of Table H2.1 a non-fused spur should feed only one single or one twin or multiple socket-outlet or one item of permanently connected equipment. Such a spur should be connected to the circuit at the terminals of a socket-outlet or junction box, or at the origin of the circuit in the distribution board.

A fused spur should be connected to the circuit through a fused connection unit, with the rating of the fuse in the unit not exceeding that of the cable forming the spur and, in any event, not exceeding 13 A.

H2.5 Permanently connected equipment

Permanently connected equipment should be locally protected by a fuse complying with BS 1362 of rating not exceeding 13 A or by a circuit-breaker of rating not exceeding 16 A and should be controlled by a switch, where needed (see Appendix J). A circuit-breaker may be used for infrequent switching of a load for isolation and maintenance. For more frequent switching operations an additional functional switch is required.

© The Institution of Engineering and Technology

H3 Radial final circuits using 16 A socket-outlets complying with BS EN 60309-2 (BS 4343)

H3.1 General

Where a radial circuit feeds equipment the maximum demand of which, having allowed for diversity, is known or estimated not to exceed the rating of the overcurrent protective device and in any event does not exceed 20 A, the number of socket-outlets is unlimited.

H3.2 Circuit protection

The overcurrent protective device should have a rating not exceeding 20 A.

H3.3 Conductor size

The minimum size of conductor in the circuit is given in Tables H2.1 and 7.1(ii). Where cables are grouped together the limitations of 7.2.1 and Appendix F apply.

H3.4 Types of socket-outlet

Socket-outlets should have a rated current of 16 A and be of a type appropriate to the number of phases, circuit voltage and earthing arrangements. Socket-outlets incorporating pilot contacts are not included.

H4 Cooker circuits in household and similar premises

The circuit supplies a control switch or a cooker unit complying with BS 4177, which may incorporate a socket-outlet.

The rating of the circuit is determined by the assessment of the current demand of the cooking appliance®, and the cooker control unit socket-outlet if any, in accordance with Table Al of Appendix A. A 30 A or 32 A circuit is usually appropriate for household or similar cookers of rating up to 15 kW.

A circuit of rating exceeding 15 A but not exceeding 50 A may supply two or more cooking appliances where these are installed in one room. The control switch or cooker control unit should be placed within 2 m of the appliance, but not directly above it. Where two stationary cooking appliances are installed in one room, one switch may be used to control both appliances provided that neither appliance is more than 2 m from the switch. Attention is drawn to the need to provide selective (discriminative) operation of protective devices as stated in Regulation 536.3.

© The Institution of Engineering and Technology

H5 Water and space heating

Water heaters fitted to storage vessels in excess of 15 litres capacity, or permanently connected heating appliances forming part of a comprehensive space heating installation, should be supplied by their own separate circuit.

Immersion heaters should be supplied through a switched cord-outlet connection unit complying with BS 1363-4.

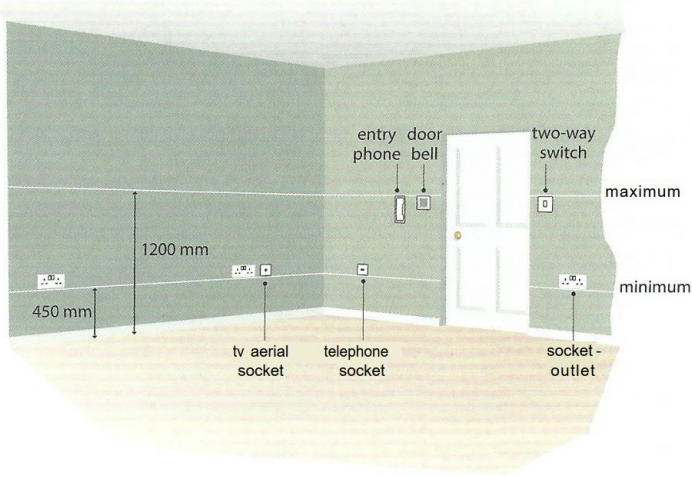
H6 Height of switches, socket-outlets and controls

553.1.6 The Building Regulations of England and Wales and Scotland require switches and socket-outlets in new dwellings to be installed so that all persons including those whose reach is limited can easily use them. A way of satisfying this requirement is to install switches, socket-outlets and controls throughout the dwelling in accessible positions at a height of between 450 mm and 1200 mm from the finished floor level (see Figure H6). Because of the sensitivity of circuit-breakers, RCCBs and RCBOs fitted in consumer units, consumer units should be readily accessible.

NOTE: The requirements applicable to dwellings for known wheelchair users will vary.

(In areas subject to flooding, meters, cut-outs and consumer units should preferably be fixed above flood water level.)

▼ **Figure H6** Height of switches, socket-outlets, etc. for visible and accessible adaptable buildings



© The Institution of Engineering and Technology

H7 Number of socket-outlets

553.1.7 Sufficient socket-outlets are required to be installed so that all equipment likely to be used can be supplied from a reasonably accessible socket-outlet, taking account of the length of flexible cable normally fitted to portable appliances and luminaires. Table H7 provides guidance on the number of socket-outlets that are likely to meet this requirement.

In Scotland, Mandatory Standard 4.6 requires that every building must be designed and constructed in such a way that electric lighting points and socket-outlets are provided to ensure the health, safety and convenience of occupants and visitors. The Building Standards Division of the Scottish Government make recommendations for the number of socket-outlets that should be installed in a domestic premises in Section 4.6.4 of the domestic technical handbook as follows:

- kitchen - 6 (at least 3 above worktop height)
- other habitable rooms - 4
- plus at least 4 more throughout the property including at least one per circulation area per storey.

The socket-outlets may be either single or double.

▼ **Table H7** Minimum number of twin socket-outlets to be provided in homes (Source: Electrical Safety First and the Electrical Installation Forum.)

Room type	Smaller rooms (up to 12 m^2)	Medium rooms (12-25 m^2)	Larger rooms (more than 25 m^2)
Main living room	4	6	8
Dining room	3	4	5
Single bedroom	2	3	4
Double bedroom	3	4	5
Bedsitting room	4	5	6
Study	4	5	6
Utility room	3	4	5
Kitchen	6	8	10
Garages	2	3	4
Conservatory	3	4	5
Hallways and landings	1	2	3
Loft	1	2	3
Location containing a bath or shower	see NOTE 3		
Electric vehicle charging	see NOTE 4		

NOTE: With certain exceptions, all socket-outlets are required to be protected by a 30mA RCD in accordance with BS 7671 (IET Wiring Regulations).

© The Institution of Engineering and Technology

NOTES to Table H7:

1 KITCHEN - If a socket-outlet is provided in the cooker control unit, this should not be included in the 6 recommended in the table above. Appliances built into kitchen furniture (integrated appliances) should be connected to a socket-outlet or switch fused connection unit that is accessible when the appliance is in place and in normal use. Alternatively, where an appliance is supplied from a socket-outlet or a connection unit, these should be controlled by an accessible double-pole switch or switched fused connection unit. It is recommended that wall mounted socket-outlets above a work surface are spaced at not more than 1 metre intervals along the surface.

2 HOME ENTERTAINMENT - In addition to the number of socket-outlets shown in the table it is recommended that at least two further double socket-outlets are installed in home entertainment areas.

3 LOCATIONS CONTAINING A BATH OR SHOWER - Socket-outlets other than SELV socket-outlets and shaver supply units complying with BS EN 61558-2-5 are prohibited within a distance of 2.5 m horizontally from the boundary of zone 1. For example, 250 V socket-outlets in a bathroom must be installed a minimum 2.5 m from the edge of the bath, BS 7671 refers.

4 ELECTRIC VEHICLE CHARGING - Electric vehicle charging should be from a single socket-outlet via a dedicated circuit provided for the connection to electric vehicles. This dedicated circuit must conform to the relevant requirements in Section 722 of BS 7671 'Electric Vehicle Charging Installations', which includes the specification of socket-outlets and connectors for the charging point. See also the IET *Code of Practice for Electric Vehicle Charging Equipment Installation.*

H8 LED lighting

Installers will quite correctly select and install energy efficient lighting to comply with Part L of the Building Regulations, to improve the efficiency of the installation and to minimize energy costs to the client.

Incandescent lighting was commonly replaced by compact fluorescent lamps (CFLs) and these in turn are being replaced by light emitting diode (LED) lamps. The advantage of LED lamps over CFL lamps is they do not require a warm-up period to enable full brightness and they are generally more efficient in terms of lumens per watt. In addition, to their improved efficiency, LED lamps are available in various colour temperatures for different applications and client preference.

Manufacturers of LED lamps will claim a product life of up to 25,000 hours depending on the manufacturer and model range. Generally, the cost of the lamp will dictate performance and life expectancy. LED lamps are produced for every type of lampholder and application and are available for both mains voltages and extra-low voltage (ELV). Lamps for use on mains voltages will have a small power supply built into the individual lamp base while ELV lamps will be supplied from a separate lamp driver power supply. When selecting lamps and drivers where dimming is required, it is important to select types that are specified as dimmable by the manufacturer.

Although manufacturers and suppliers are claiming very long life for their LEDs and drivers, contractors are reporting very early failures and much shorter product life. Installers should carefully read the manufacturer's product sheet to ensure they are installed in accordance with the manufacturer's specification. Designers and installers are required to comply with Regulation 134.1.1 of BS 7671 which states, "The installation of electrical equipment shall take account of manufacturers' instructions".

© The Institution of Engineering and Technology

One reason for early failure is when drivers and recessed downlighters are installed in ceilings and are covered with, or touching, thermal or acoustic insulation. This may cause the driver or lamp to overheat, which leads to early failure. Insulation should be kept clear of drivers and lamps and installers should consider using proprietary displacement boxes to achieve this separation.

Another reason for early failure of drivers and LED lamps is that they are not suitable for the supply voltage prevailing on the installation. Many manufacturers will specify a maximum operating voltage of 230 V or 240 V but Appendix 2 of BS 7671 shows nominal voltage of 230 V with permitted tolerances of +10 % / —6 °/o, meaning that the supply voltage at the incoming terminals of an electrical supply provided in accordance with the Electricity Safety, Quality and Continuity Regulations (ESQCR) can be between the limits of 216.2 - 253.0 V.

© The Institution of Engineering and Technology

Appendix I
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 $S^2 = I^2.t/k^2$, 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 $I = U_0/Z_s$

where:

Uo	is the nominal voltage to earth
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 circuit concerned
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 BS 7671 limiting values of earth fault loop impedance given in Tables 41.2 to 41.4, it is necessary to establish the relevant impedances of the circuit conductors concerned at their operating temperature.

Table 11gives values of $(R_1 + R_2)$ per metre for various combinations of conductors up to and including 35 mm^2 cross-sectional area. It also gives values of resistance in milliohms per metre $(m\Omega/m)$ for each size of conductor. These values are at 20 °C.

© The Institution of Engineering and Technology

Appendix

▼ Table 11 Values of resistance/metre or ($R_1 + R_2$)/metre for copper and aluminium conductors at 20 °C

Cross-sectional area (mm^2)		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
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

© The Institution of Engineering and Technology

▼ **Table 12** Ambient temperature multipliers to Table 11

Expected ambient temperature (°C)	Correction factor*
5	0.94
10	0.96
15	0.98
20	1.00
25	1.02

* 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.

Verification

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 11. The rating factors in Table 12 may be applied to the values to take account of the ambient temperature (for test purposes only).

Multipliers for conductor operating temperature

Table 41.2
Table 41.3

Table 13 gives the multipliers to be applied to the values given in Table 11 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, as applicable, the earth fault loop impedance of Table 41.2, Table 41.3 or Table 41.4 of BS 7671.

Table 41.4

Where it is known that the actual operating temperature under normal load is less than the maximum permissible value for the type of cable insulation concerned (as given in the tables of current-carrying capacity) the multipliers given in Table 13 may be reduced accordingly.

© The Institution of Engineering and Technology

▼ Table 13 Multipliers to be applied to Table 11to calculate conductor resistance at maximum operating temperature (NOTE 3) for standard devices (NOTE 4)

Conductor installation	Conductor insulation		
	70 °C Thermoplastic (PVC)	90 °C Thermoplastic (PVC)	90 °C Thermosetting
Not incorporated in a cable and not bunched (NOTE 1)	1.04	1.04	1.04
Incorporated in a cable or bunched (NOTE 2)	1.20	1.28	1.28

NOTES:

Table 54.2 Table 54.3

1 See Table 54.2 of BS 7671, which applies where the protective conductor is not incorporated or bunched with cables, or for bare protective conductors in contact with cable covering.

2 See Table 54.3 of BS 7671, which applies where the protective conductor is a core in a cable or is bunched with cables.

3 The multipliers given in Table 13 for both copper and aluminium conductors are based on a simplification of the formula given in BS EN 60228, namely that the resistance-temperature coefficient is 0.004 per °C at 20 °C.

4 Standard devices are those described in Appendix 3 of BS 7671 (fuses to BS 1361, BS 88, and BS 3036, and circuit-breakers to BS EN 60898 types B, C, and D) and BS 3871-1.

© The Institution of Engineering and Technology

Appendix J
Selection of devices for isolation and switching

Table 537.4

Table J1 Guidance on the selection of protective, isolation and switching devices, reproduced from BS 7671

Device	Standard	Isolation[4]	Emergency switching off[2]	Functional switching[5]
Switching device	BS EN 50428	No	No	Yes
	BS EN 60669-1	No	No	Yes
	BS EN 60669-2-1	No	No	Yes
	BS EN 60669-2-2	No	No	Yes
	BS EN 60669-2-3	No	No	Yes
	BS EN 60669-2-4	Yes[3]	Yes	Yes
	BS EN 60947-3	Yes[1,3]	Yes	Yes
	BS EN 60947-5-1	No	No	Yes
Contactor	BS EN 60947-4-1	Yes[1]	Yes	Yes
	BS EN 61095	No	No	Yes
Starters	BS EN 60947-4-1	Yes[1]	Yes	Yes
	BS EN 60947-4-2	No	No	Yes
	BS EN 60947-4-3	No	No	Yes
Circuit-breaker	BS EN 60898	Yes[3]	Yes	Yes
	BS EN 60947-2	Yes[1]	Yes	Yes
	BS EN 61009-1	Yes[3]	Yes	Yes
RCD	BS EN 60947-2	Yes[1]	Yes	Yes
	BS EN 61008 series	Yes[3]	Yes	Yes
	BS EN 61009 series	Yes[3]	Yes	Yes
	BS 7288	Yes[3]	No	Yes
Arc fault detection devices	BS EN 62606	Yes[3]	Yes	Yes

© The Institution of Engineering and Technology

▼ **Table JI** *continued*

Device	Standard	Isolation[4]	Emergency switching off[2]	Functional switching[5]
Isolating switch	BS EN 60669-2-4	Yes[3]	Yes	Yes
	BS EN 60947-3	Yes[1,3]	Yes	Yes
Plug and socket-outlet (≤ 20 A)	BS EN 60309	Yes[3]	No	Yes
Plug and socket-outlet (> 32 A)	BS EN 60309	Yes[3]	No	No
Device for the connection of luminaire	BS EN 61995-1	Yes[3]	No	No
Control and protective switching device for equipment (CPS)	BS EN 60947-6-1	Yes[1,3]	Yes	Yes
	BS EN 60947-6-2	Yes[1,3]	Yes	Yes
Fuse (removal of fuse link)	BS 88 series	Yes	No	No
	BS 3036	Yes	No	No
Device with semiconductors	BS EN 50428	No	No	Yes
	BS EN 60669-2-1	No	No	Yes
Luminaire Supporting Coupler	BS 6972	Yes[3]	No	No
Plug and unswitched socket-outlet	BS 1363-1	Yes[3]	No	Yes
	BS 1363-2	Yes[3]	No	Yes
Plug and switched socket-outlet[6]	BS 1363-1	Yes[3]	No	Yes
	BS 1363-2	Yes[3]	No	Yes
Plug and unswitched socket-outlet	BS 546	Yes[3]	No	Yes
Plug and switched socket-outlet[6]	BS 546	Yes[3]	No	Yes
Plug and socket-outlet	BS 5733	Yes[3]	No	Yes
Switched fused connection unit	BS 1363-4	Yes[3]	Yes	Yes
Unswitched fused connection unit	BS 1363-4	Yes[3] (Removal of fuse link)	No	No
Cooker Control Unit switch	BS 4177	Yes[3]	Yes	Yes

© The Institution of Engineering and Technology

Yes = Function provided, No = Function not provided

537.3.3.6 (1) Function provided if the device is suitable and marked with the symbol for isolation (see IEC 60617 identity number S00288) 

537.3.3.6 (2) See Regulation 537.3.3.

(3) Device is suitable for on-load isolation, i.e. disconnection whilst carrying load current.

462.2 (4) In an installation forming part of a TT or IT system, isolation requires disconnection of all the live conductors. See Regulation 462.2.

(5) Circuit-breakers, AFDDs and RCDs are primarily circuit protective devices and, as such, they are not intended for frequent load switching. Infrequent switching of circuit-breakers on-load is admissible for the purposes of isolation or emergency switching. For a more frequent duty, the number of operations and load characteristics according to the manufacturer's instructions should be taken into account or an alternative device from those listed as suitable for functional switching in Table 537.4 should be employed.

(6) The switch of a socket-outlet is not required to be suitable for isolation, as isolation is achieved by withdrawal of the plug. See Regulation 537.1.3.

NOTES to Table J1

462.2

NOTE 1: An entry of (1,3) means that the device is suitable for on-load isolation only if it is marked with the symbol for **on-load** isolation 

NOTE 2: In the above table, the functions provided by the devices for isolation and switching are summarized, together with an indication of the relevant product standards.

© The Institution of Engineering and Technology

NOTE

© The Institution of Engineering and Technology

Appendix K
Identification of conductors

K1 Introduction

The requirements of BS 7671 were harmonized with the technical intent of CENELEC Standard HD 384.5.514: *Identification,* including 514.3: *Identification of conductors* (now withdrawn).

Amendment No 2:2004 (AMD 14905) to BS 7671:2001 implemented the harmonized cable core colours and the alphanumeric marking of the following standards:

- HD 308 52:2001 *Identification of cores in cables and flexible cords*
- BS EN 60445:201 7 *Basic and safety principles for man-machine interface, marking and identification of equipment and terminals and of terminations*

This appendix provides guidance on marking at the interface between old and harmonized colours, and general guidance on the colours to be used for conductors.

British Standards for fixed and flexible cables have been harmonized (see Table KI). BS 7671 has been modified to align with these cables but also allows other suitable methods of marking connections by colours, e.g. tapes, sleeves or discs, or by alphanumerics, i.e. letters and/or numbers. Methods may be mixed within an installation.

© The Institution of Engineering and Technology

Table si 514.3.1

▼ Table KI Identification of conductors (Harmonized)

Function	Alphanumeric	Colour
Protective conductor	PE	Green-and-Yellow (CNYE)
Protective bonding conductors	PB	Green-and-Yellow (GNYE)
Functional earthing conductor	FE	Pink (PK)
AC power circuit[1]		
Line of single-phase circuit	L	Brown (BN)
Neutral of single- or three-phase circuit	N	Blue (BU)
Line 1 of three-phase AC circuit	L1	Brown (BN)
Line 2 of three-phase AC circuit	L2	Black (BK)
Line 3 of three-phase AC circuit	L3	Grey (GY)
Two-wire unearthed DC power circuit		
Positive of two-wire circuit	L+	Red (RD)
Negative of two-wire circuit	L—	White (WH)
Two-wire earthed DC power circuit		
Positive (of negative earthed) circuit	L+	Red (RD)
Negative (of negative earthed) circuit [2]	M	Blue (BU)
Positive (of positive earthed) circuit [2]	M	Blue (BU)
Negative (of positive earthed) circuit	L—	White (WH)
Three-wire DC power circuit		
Outer positive of two-wire circuit derived from three-wire system	L+	Red (RD)
Outer negative of two-wire circuit derived from three-wire system	L-	White (WH)
Positive of three-wire circuit	L+	Red (RD)
Mid-wire of three-wire circuit [2,3]	M	Blue (BU)
Negative of three-wire circuit	L—	White (WH)
Control circuits, ELV and other applications		
Line conductor	L	Black (BK), Brown (BN), Red (RD), Orange (OG), Yellow (YE), Green (GN), Violet (VT), Grey (GY), White (WH), Pink (PK) or Turquoise (TQ)
Neutral or mid-wire' [1]	N or M	Blue (BU)

NOTES:

1 Power circuits include lighting circuits.

2 M identifies either the mid-wire of a three-wire DC circuit, or the earthed conductor of a two-wire earthed DC circuit.

3 Only the middle wire of three-wire circuits may be earthed.

4 An earthed PELV conductor is blue.

© The Institution of Engineering and Technology

K2 Addition or alteration to an existing installation

K2.1 Single-phase

An addition or alteration made to a single-phase installation need not be marked at the interface provided that:

(a) the old cables are correctly identified by the colours red for line and black for neutral; and

(b) the new cables are correctly identified by the colours brown for line and blue for neutral.

K2.2 Two- or three-phase installation

Where an addition or alteration is made to a two- or a three-phase installation wired in the old core colours with cable to the new core colours, unambiguous identification is required at the interface. Cores shall be marked as follows:

Neutral conductors

Old and new conductors: N

Line conductors

Old and new conductors: L1, L2, L3

▼ **Table K2** Example of conductor marking at the interface for additions and alterations to an AC installation identified with the old cable colours

Function	Old conductor		New conductor	
	Colour	Marking	Marking	Colour
Line 1 of AC	Red	L1	L1	Brown*
Line 2 of AC	Yellow	L2	L2	Black*
Line 3 of AC	Blue	L3	L3	Grey*
Neutral of AC	Black	N	N	Blue
Protective conductor	Green-and-Yellow			Green-and-Yellow

* Three single-core cables with insulation of the same colour may be used if identified at the terminations.

© The Institution of Engineering and Technology

K3 Switch wires in a new installation or an addition or alteration to an existing installation

Where a two-core cable with cores coloured brown and blue is used as a switch wire, both conductors being line conductors, the blue conductor should be marked brown or L at its terminations.

K4 Intermediate and two-way switch wires in a new installation or an addition or alteration to an existing installation

Where a three-core cable with cores coloured brown, black and grey is used as a switch wire, all three conductors being line conductors, the black and grey conductors should be marked brown or L at their terminations.

K5 Line conductors in a new installation or an addition or alteration to an existing installation

Power circuit line conductors should be coloured as in Table K1. Other line conductors may be brown, black, red, orange, yellow, violet, grey, white, pink or turquoise.

In a two- or three-phase power circuit, the line conductors may all be of one of the permitted colours, either identified L1, L2, L3 or marked brown, black, grey at their terminations.

K6 Changes to cable core colour identification

▼ Table K6(i) Cable to BS 6004 (flat cable with bare cpc)

Cable type	Old core colours	New core colours
Single-core + bare cpc	Red or Black	Brown or Blue
Two-core + bare cpc	Red, Black	Brown, Blue
Alt. two-core + bare cpc	Red, Red	Brown, Brown
Three-core + bare cpc	Red, Yellow, Blue	Brown, Black, Grey

© The Institution of Engineering and Technology

▼ **Table K6(ii)** Standard 600/1000 V armoured cable to BS 6346, BS 5467 or BS 6724

Cable type	Old core colours	New core colours
Single-core	Red or Black	Brown or Blue
Two-core	Red, Black	Brown, Blue
Three-core	Red, Yellow, Blue	Brown, Black, Grey
Four-core	Red, Yellow, Blue, Black	Brown, Black, Grey, Blue
Five-core	Red, Yellow, Blue, Black, Green-and-Yellow	Brown, Black, Grey, Blue, Green-and-Yellow

▼ **Table K6(iii)** Flexible cable to BS 6500

Cable type	Old core colours	New core colours
Two-core	Brown, Blue	No change
Three-core	Brown, Blue, Green-and-Yellow	No change
Four-core	Black, Blue, Brown, Green-and-Yellow	Brown, Black, Grey, Green-and-Yellow
Five-core	Black, Blue, Brown, Black, Green-and-Yellow	Brown, Black, Grey, Blue, Green-and-Yellow

K7 Addition or alteration to a DC installation

Where an addition or alteration is made to a DC installation wired in the old core colours with cable to the new core colours, unambiguous identification is required at the interface. Cores should be marked as follows:

Neutral and midpoint conductors

Old and new conductors: M

Line conductors

Old and new conductors: Red or White, or L+ or L-

© The Institution of Engineering and Technology

▼ **Table K7** Example of conductor marking at the interface for additions and alterations to a DC installation identified with the old cable colours

Function	Old conductor			New conductor	
	Colour (to 2004)	Colour (2004-2021)	Marking	Marking	Colour
Two-wire unearthed DC power circuit					
Positive of two-wire circuit	Red	Brown	L+	L+	Red
Negative of two-wire circuit	Black	Grey	L-	L-	White
Two-wire earthed DC power circuit					
Positive (of negative earthed) circuit	Red	Brown	L+	L+	Red
Negative (of negative earthed) circuit	Black	Blue	M	M	Blue
Positive (of positive earthed) circuit	Black	Blue	M	M	Blue
Negative (of positive earthed) circuit	Blue	Grey	L—	L—	White
Three-wire DC power circuit					
Outer positive of two-wire circuit derived from three-wire system	Red	Brown	L+	L+	Red
Outer negative of two-wire circuit derived from three-wire system	Red	Grey	L—	L—	White
Positive of three-wire circuit	Red	Brown	L+	L+	Red
Mid-wire of three-wire circuit	Black	Blue	M	M	Blue
Negative of three-wire circuit	Blue	Grey	L—	L—	White

© The Institution of Engineering and Technology

K8 Colour codes for diagrams and specifications

Colour code conventions for wiring colours in operation and maintenance documentation, schedules and diagrams should follow the harmonized standard BS 7645 (IEC 60757), implementing CENELEC HD 457 SI, as outlined in Table K8 Bi-colour identification should be documented as 'AABB' where AA is the predominant colour and BB is the secondary colour, e.g. GNYE for green-and-yellow.

▼ **Table K8** BS 7645 colour code convention for conductor identification in documentation, schedules and drawings

Code	Colour
BK	Black
BN	Brown
BU	Blue
GN	Green
GY	Grey
OG	Orange
PK	Pink
RD	Red
TQ	Turquoise
VT	Violet
WH	White

© The Institution of Engineering and Technology

NOTE

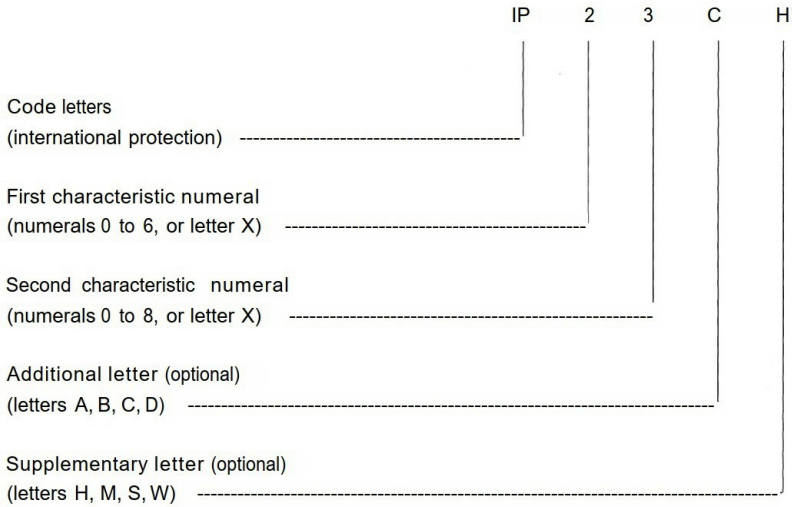
© The Institution of Engineering and Technology

Appendix L
Degrees of protection provided by enclosures (IP code)

The requirements of the IP code are given in BS EN 60529:1 992+A2:201 3. For more information see IET Guidance Note 1.

The degree of protection provided by an enclosure is indicated by two numerals followed by an optional additional letter and/or optional supplementary letter(s) as shown in Figure LI.

▼ **Figure LI** IP code format



For the purposes of this Guide, IP codes cited are defined as follows:

IP2X	Penetration by a solid foreign object ≥ 12.5 mm in diameter shall not be possible.
IPXXB	Access of a finger shall not be possible.
IP2XC	Penetration by a solid foreign object ≥12.5 mm in diameter shall not be possible. Additionally, an inserted 2.5 mm ^{2} probe of 100 mm in length shall have adequate clearance from live parts.

© The Institution of Engineering and Technology

IP4X Penetration by a solid foreign object ≥ 1.0 mm in diameter shall not be possible.

IPXXD Access by a 100 mm length of wire with csa of 1.0 mm^2 shall not be possible.

IPX4 Water splashed against the enclosure from any direction will not affect the equipment.

IPX5 Waterjets directed against the enclosure from any direction will not affect the equipment.

IPX7 Temporarily immersed enclosure, ingress of water shall not cause harmful effects to the equipment.

© The Institution of Engineering and Technology

Index

© The Institution of Engineering and Technology

© the Institution of Engineering and Technology

© The Institution of Engineering and Technology

© The Institution of Engineering and Technology

J

L

M

N

O

P

© The Institution of Engineering and Technology

© The Institution of Engineering and Technology

© The Institution of Engineering and Technology

V

W

Z

© The Institution of Engineering and Technology


Emergency lighting luminaire (or special circuit)


Self-contained emergency lighting luminaire


Push-button with indicator lamp


Clock


Acoustic signalling device, general symbol (e.g. bell)


Buzzer


Telephone handset


Microphone


Loudspeaker


Antenna


Machine
* Function
M = Motor
G = Generator


Static generator


Voltmeter


Ammeter


Operating device (coil)


Make contact, normally open


Break contact, normally closed


Manually operated switch


Three-phase winding, delta


Three-phase winding, star


Converter
Changer not used in IEC standards


Rectifier


Inverter


Battery of primary or secondary cells


Transformer, general symbol with two windings

10^{9}	giga	G
10^{6}	mega	M
10^{3}	kilo	k
10^{-3}	milli	m
10^{-6}	micro	μ

The only guide to BS7671 written by the Wiring Regulations experts at the IET, the On-Site Guide contains clear, concise guidance to the technical information contained in the Regulations.

It enables the competent electrical installer to deal with installations up to 100 A, three-phase, providing essential information in a convenient easy-to-use form.

The Institution of Engineering and Technology
Michael Faraday House
Six Hills Way
Stevenage
Herts
SG1 2AY

www.theiet.org
ISBN 978-1-83953-227-6