ENGINEERING DESIGN STANDARD

EDS 06-0017

CUSTOMER LV INSTALLATION EARTHING DESIGN

Network(s): EPN, LPN, SPN

Summary: This standard provides guidance on the earthing of customer LV installations.

Author: Stephen Tucker   Date: 05/09/2018

Approver: Paul Williams   Date: 10/09/2018

This document forms part of the Company's Integrated Business System and its requirements are mandatory throughout UK Power Networks. Departure from these requirements may only be taken with the written approval of the Director of Asset Management. If you have any queries about this document please contact the author or owner of the current version.

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**Revision Record**

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<th>10/09/2023</th>
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<td>Author</td>
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**Reason for update:** Internal and external feedback including the IET.

**What has changed:**
- References to BS 7671:2018 added throughout.
- Clarification on the provision of TT earthing (Section 4.2).
- Clarification on the provision of an earth terminal from existing networks (Section 4.2).
- Supply neutral conductor sizes added (Section 4.4).
- Railway supplies revised (section 5.1).
- Temporary supplies to existing buildings added (Section 5.2.3).
- Motor homes corrected to mobile homes (Section 5.9).
- Electric vehicle charging points aligned with other documents (Section 5.16).
- Street furniture requirements including diagram clarified (Section 5.17).
- Installation requirements section introduced with examples of earth provision for metered and unmetered supplies, end-of-main electrode requirements and warning labels (Section 6).
- Railway supply forms revised EDS 06-0017D and EDS 06-0017E revised.

Document and associated documents reviewed and review date extended.

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**Reason for update:** Cut-out earthing labels revised.

**What has changed:** New earthing labels introduced for PME, PNB, TN-S and TT supplies (Section 6.2).

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**Reason for update:** Revised to align with the published version of ENA EREC G12/4 and incorporate business feedback.

**What has changed:**
- Supplies to railway installations clarified (Section 5.1).
- Railway application and assessment forms EDS 06-0017D and EDS 06-0017E revised.
- Supplies to temporary installations (Section 5.3), caravans and motor caravans (Section 5.6), caravan sites, campsites and sports pavilions (Section 5.7), boats, marinas and similar locations (Section 5.8), mobile homes (Section 5.9), fuel filling stations (Section 5.11) and oil refineries and oil distribution centres (Section 5.12) added to Section 5.
- Additional street furniture loads and associated electrode resistances added to Table 7.2 (5.17.2).
- HV supplies removed (old Section 8) and replaced with references to other standards in the scope (Section 2).
- Document title amended.

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Minor updates to ensure consistency with other standards and new PME label (130) added to Section 6.2. Document reviewed for publishing on G81 website.

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Street furniture, railway installations and multiple occupancy building sections updated.

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Reclassification of document from Earthing Design Manual Section 7.

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Completely rewritten to provide a more consistent and practical approach and separated from LV network design.

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Original

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Customer LV Installation Earthing Design

Document Number: EDS 06-0017
Version: 6.0
Date: 05/09/2018

1 Introduction

This standard provides guidance on earthing of customer low voltage (LV) installations. It brings together a common approach to system design and operation and has been written to provide guidance to designers, meter operators, developers and contractors. This standard supersedes all previous EPN, LPN and SPN specific guidance on customer installation earthing including:

- LPN – E14-26 – A guide to the connection of customers’ electrical installations to protective multiple earthed networks.
- SPN – PME Guide – A guide to the application of Protective Multiple Earthing to customers’ electrical installations.
- LV Earthing Design Manual version 1 and 2.
- Earthing Design Manual – Section 6B – Construction Site Earthing Requirements.
- Earthing Design Manual – Section 7 – Customer Installation Earthing Design.

This document is based on the latest version of ENA EREC G12/4 and also reflects the requirements of BS 7671:2018 (IET Wiring Regulations 18th Edition).

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It is the Installer's responsibility to ensure that the earthing system is safe and complies with the relevant regulations.

For further information on any aspect of a project please contact the nominated UK Power Networks' Connections Project Designer for the project.

2 Scope

This standard applies to the earthing used in customer LV installations.

Refer to EDS 06-0016 for LV network earthing design.

Refer to EDS 06-0019 for guidance on earthing associated with customer EHV and HV supplies and generation.

Refer to EDS 06-0014 for secondary substation earthing design.
# 3 Glossary and Abbreviations

<table>
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<th>Term</th>
<th>Definition</th>
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<tr>
<td>Caravan**</td>
<td>A trailer leisure accommodation vehicle, used for touring, designed to meet the requirements for the construction and use of road vehicles (also see Motor Caravan)</td>
</tr>
<tr>
<td>Class I Equipment**</td>
<td>Equipment in which protection against electric shock does not rely on basic insulation only, but which includes means for the connection of exposed-conductive-parts to a protective conductor in the fixed wiring of the installation (refer to BS EN 61 140)</td>
</tr>
<tr>
<td>Class II Equipment**</td>
<td>Equipment in which protection against electric shock does not rely on basic insulation only, but in which additional safety precautions such as supplementary insulation are provided, there being no provision for the connection of exposed metalwork of the equipment to a protective conductor, and no reliance upon precautions to be taken in the fixed wiring of the installation (refer to BS EN 61140)</td>
</tr>
<tr>
<td>CNE</td>
<td>Combined Neutral and Earth. A cable where the neutral and protective functions are combined in a single conductor</td>
</tr>
<tr>
<td>Customer/Consumer</td>
<td>Any person who has responsibility for premises connected by agreement to distribution networks owned by UK Power Networks</td>
</tr>
<tr>
<td>Customer's Installation</td>
<td>The electrical apparatus under the control of the customer on the customer's premises together with the wiring connecting this apparatus to the supply terminals. A cut-out and meter shall not form part of the customer’s installation (unless additional metering is supplied by the customer, e.g. landlord’s supplies)</td>
</tr>
<tr>
<td>Customer's Premises</td>
<td>Any area or building occupied by the customer</td>
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<td>Distributing Main (or Main)</td>
<td>A low voltage electric line which connects a source of voltage to one or more service lines or directly to a single customer’s installation</td>
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<td>Distributor*</td>
<td>A person who owns or operates a network, except for a network situated entirely offshore or where that person is an operator of a network within the meaning of Part I of the Railways Act 1993</td>
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<tr>
<td>DNO</td>
<td>Distribution Network Operator. See distributor</td>
</tr>
<tr>
<td>Earth Electrode</td>
<td>A metal rod, plate or strip conductor buried in the earth for the purpose of providing a connection with the general mass of earth</td>
</tr>
<tr>
<td>Earth Loop Impedance (ELI)</td>
<td>See Earth Fault Loop Impedance</td>
</tr>
<tr>
<td>Earth Fault Loop Impedance (EFLI)**</td>
<td>The impedance of the earth fault current loop starting and ending at the point of earth fault. This impedance is denoted by the symbol Zs. The part of the earth fault loop impedance which is external to the customer installation is denoted by the symbol Ze.</td>
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<tr>
<td>Earthing Systems</td>
<td>See separate definitions and Appendix B for further details</td>
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<td>Earthing Terminal</td>
<td>The main earth terminal for an installation is usually located close to the incoming service. If provided by UK Power Networks as part of a PME supply (TN-C-S) this will be directly connected to the supply neutral conductor at the supply terminals</td>
</tr>
<tr>
<td>EHV</td>
<td>Extra High Voltage. Refers to voltages at 132 kV, 66kV and 33kV</td>
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1 *Definitions taken from the Electricity Safety, Quality and Continuity Regulations 2002.

**Definitions taken from BS 7671.
<table>
<thead>
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<tr>
<td>Term</td>
<td>Definition</td>
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<tr>
<td>EMC</td>
<td>Electromagnetic Compatibility</td>
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<td>EPR</td>
<td>Earth Potential Rise (EPR) or Rise of Earth Potential (ROEP). EPR or ROEP is the potential (or voltage) rise that occurs on any metalwork due to the current that flows through the ground when an earth fault occurs on the HV network. <strong>Note:</strong> Some current will flow through the cable sheath back to the source and some will flow through the ground, it is only the current that flows through the ground that causes the earth potential rise</td>
</tr>
<tr>
<td>Electric Line*</td>
<td>Any line which is used or intended to be used for carrying electricity for any purpose and includes, unless the context otherwise requires: a) any equipment connected to any such line for the purpose of carrying electricity. b) any wire, cable, tube, pipe, insulator or other similar thing (including its casing or coating) which surrounds or supports, or is associated with, any such line</td>
</tr>
<tr>
<td>Equipotential Bonding</td>
<td>An electrical connection maintaining various exposed conductive parts and extraneous conductive parts at substantially the same potential (voltage)</td>
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<td>Exhibition**</td>
<td>Event intended for the purpose of displaying and/or selling products etc., which can take place in any suitable location, either a room, building or temporary structure</td>
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<tr>
<td>Exposed Conductive Part</td>
<td>A conductive part (metalwork) of equipment which can be touched and which is not normally live but which can become live when the basic insulation fails</td>
</tr>
<tr>
<td>Extraneous Conductive Part</td>
<td>A conductive part (metalwork) liable to introduce a potential (voltage), generally earth potential, into the site but not forming part of the electrical installation, e.g. pipework, scaffolding etc.</td>
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<td>High-voltage (HV)</td>
<td>HV refers to any voltage above 1000V. The HV network typically refers to the 22kV, 20kV, 11kV or 6.6kV secondary distribution system</td>
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<tr>
<td>HOT Site</td>
<td>A HOT site is a grid, primary or secondary substation where the earth potential rise (EPR) is greater than 430V (or 650V for high reliability circuits)</td>
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<tr>
<td>IDNO</td>
<td>Independent Distribution Network Operator</td>
</tr>
<tr>
<td>Inset Network</td>
<td>Privately owned electricity supply network, owned and operated by a licensed Independent Distribution Network Operator (IDNO), supplied at a boundary point or points from the DNO network</td>
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<tr>
<td>Low-voltage (LV)</td>
<td>LV refers to any voltage less than 1000V. The LV network refers to the 400V distribution system</td>
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<tr>
<td>Marina**</td>
<td>Facility for mooring and servicing of pleasure craft with fixed wharves, jetties, piers or pontoon arrangements capable of berthing more than one pleasure craft</td>
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<tr>
<td>Mobile/Transportable Unit**</td>
<td>A vehicle and/or mobile or transportable structure in which all or part of an electrical installation is contained, which is provided with a temporary supply by means of, for example, a plug and socket-outlet</td>
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<td>Motor Caravan**</td>
<td>Self-propelled leisure accommodation vehicle, used for touring, that meets the requirements for the construction and use of road vehicles (also see Caravan)</td>
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<tr>
<td>Multi-service</td>
<td>Any electric line through which energy may be supplied to two, three or four adjacent customers from any distributing main or substation</td>
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<td>Term</td>
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<td>-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
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<td>PME (TN-C-S)</td>
<td>Protective Multiple Earthing. PME is the most common form of earthing provided at new installations. A single conductor for neutral and earthing functions is utilised and an earth terminal is provided at the customer’s installation. The customer’s earthing may be connected to this terminal providing the relevant requirements in BS 7671 are satisfied. In some cases it is not appropriate to provide a PME earth terminal, either due to the nature of the distribution system or due to the type of installation itself</td>
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<td>Residual Current Device (RCD)</td>
<td>An RCD is a current operated device which measures the imbalance between phase and neutral currents, and if this leakage current exceeds a pre-set level will operate to interrupt the current flow. Typical domestic RCDs have a 30mA operating threshold</td>
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<tr>
<td>ROEP</td>
<td>Rise of earth potential. See EPR</td>
</tr>
<tr>
<td>Secondary (Distribution) Substation</td>
<td>An HV/LV substation typically transforming 22kV, 20kV, 11kV or 6.6kV to 400V</td>
</tr>
<tr>
<td>Second Fix</td>
<td>All the work after the plastering required to complete a building, i.e. electrical fixtures connected to the cables, sinks/baths connected to the pipes and doors fitted into doorframes</td>
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<tr>
<td>SNE</td>
<td>Separate Neutral and Earth. A cable where the neutral and protective functions are provided by separate conductors. The neutral conductor is usually a fourth core and the earth conductor forms a protective sheath</td>
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<td>Service Line*</td>
<td>Any electric line which either connects a street electrical fixture, or no more than four customers’ installations in adjacent buildings, to a distributing main</td>
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<tr>
<td>Service</td>
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<tr>
<td>Service Termination</td>
<td>The cut-out where the service cable terminates</td>
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<tr>
<td>Show**</td>
<td>Display or presentation in any suitable location, either a room, building or temporary structure</td>
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<tr>
<td>Stand**</td>
<td>Area or temporary structure used for display, marketing or sales</td>
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<td>Street Electrical Fixture*</td>
<td>A permanent fixture which is or is intended to be connected to a supply of electricity and which is in, on, or is associated with a highway</td>
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<tr>
<td>Supplier*</td>
<td>A person who contracts to supply electricity to consumers</td>
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<tr>
<td>TN-C-S</td>
<td>Terre Neutral Combined Separated. See PME</td>
</tr>
<tr>
<td>TN-S</td>
<td>Terre Neutral Separated. See Cable Sheath Earth/Separate Continuous Earth Wire</td>
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<tr>
<td>TT</td>
<td>Terre Terre. Independent local or TT earthing is common in older installations and is also used where PME cannot be provided. An earth terminal is not provided and the customer is responsible for providing the earth electrode system (typically buried earth rods and/or conductor). Where local earthing is employed the installation normally has to be protected by a residual current device (RCD) in order to comply with BS 7671</td>
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<tr>
<td>UK Power Networks (Operations) Ltd</td>
<td>UK Power Networks (Operations) Ltd consists of three electricity distribution networks as follows:</td>
</tr>
<tr>
<td></td>
<td>- Eastern Power Networks plc (EPN)</td>
</tr>
<tr>
<td></td>
<td>- London Power Network plc (LPN)</td>
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<td>- South Eastern Power Network plc (SPN)</td>
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4 Customer LV Installations

4.1 General Requirements

The Electricity Safety, Quality and Continuity Regulations 2002 Regulation 24(4) (Appendix A) state that a distributor shall make an earthing terminal available when installing a new low voltage connection or replacing an existing connection unless it is inappropriate for reasons of safety.

An earth terminal can usually be provided if the following criteria are satisfied:

- The installation complies with the industry guidance in ENA EREC G12.
- The installation complies with the earthing and bonding requirements of BS 7671.
- All services to a building with a steel-frame or shared metallic services originate from a single point on the combined neutral/earth network to eliminate neutral current diversion (Section 4.2).
- The installation type and situation is considered (Sections 4.2 and 4.3).
- The neutral conductor is appropriately sized (Section 4.4).
- The earth fault loop impedance is within the specified limits (Section 4.5).
- An end-of-main earth electrode is provided where required (Section 6.2).
- The earth terminal is labelled (Section 6.3).

4.2 Earth Terminal

UK Power Networks' will provide an earth terminal wherever it is appropriate and safe. The earth terminal will be from a PME system or, for customer supplies direct from a substation a TN-S earthing terminal will be provided.

There are some situations (as detailed in Section 4.3) where it may not be appropriate to provide an earth terminal from a PME system and one of the following should be used:

- TT earthing system (no earth terminal provided).
- TN-S earthing system (where permitted in this document).

Examples of earth terminal provision are shown in Section 6.1.

For further information on LV network design and supplies refer to EDS 08-2000, EDS 08-2100, EDS 08-2101, EDS 08-2102 and EDS 08-1103.

Note 1: The construction of the LV distribution network to PME requirements and the provision of an earth terminal from a PME system at the cut-out does not automatically imply that it is appropriate or safe to release the earth terminal for use by the customer. This decision is the responsibility of the meter operator appointed by the electricity supplier based on the specific design provided by UK Power Networks.

Note 2: All LV distribution networks should assumed to be PME when providing new supplies, even if they were originally constructed using SNE cables; therefore all new installations shall meet the full PME requirements for equipotential bonding specified in BS 7671.

Note 3: Generally only one service and earth terminal shall be provided to a customer or a building. Multiple services to a single customer or building are not recommended as multiple services can cause neutral current diversion (refer to Section 5.13.1) and uncertainty when isolating the supplies. However in the exceptional circumstances where more than one service is required, the earthing requirements of Section 5.13.4 shall be satisfied.
4.3 Special Situations

Table 4-1 provides a summary of where a PME earth terminal is not permitted. Unless specified otherwise in this document these installations shall use a TT earthing system which shall consist of an independent earth electrode and RCD protection. The TT earthing system shall be segregated by a minimum of 2m from any PME earthing system. The earthing system and protection for this type of installation is the responsibility of the customer.

**Note:** In these situations it is not acceptable to provide an SNE service from a PME main as the earth conductor will still experience a rise in voltage in the event of a broken neutral on the main.

Refer to Section 5 for more detailed information on all special situations.

Table 4-1 – Special Situations – Use of PME Earth Terminal

<table>
<thead>
<tr>
<th>Situation</th>
<th>PME Earth Terminal</th>
<th>Refer to the document listed for the PME criteria or alternative earthing system(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exhibitions, shows and stands</td>
<td>No</td>
<td>Refer to Section 5.3.1</td>
</tr>
<tr>
<td>Fairgrounds, amusement parks and circuses</td>
<td>No</td>
<td>Refer to Section 5.3.2</td>
</tr>
<tr>
<td>Mobile and transportable vehicles and units that contain an electrical installation for outside broadcast, medical services, advertising, catering services etc.</td>
<td>No</td>
<td>Refer to Section 5.3.3</td>
</tr>
<tr>
<td>Caravans and motor caravans</td>
<td>No</td>
<td>Refer to Section 5.6</td>
</tr>
<tr>
<td>Boats, marinas and similar locations</td>
<td>No</td>
<td>Refer to Section 5.8</td>
</tr>
<tr>
<td>Petrol Fuel filling stations</td>
<td>No</td>
<td>Refer to Section 5.11</td>
</tr>
<tr>
<td>Permanent buildings associated with the above installations e.g. living accommodation, office, restaurant, shop etc.</td>
<td>Yes</td>
<td>Provided the building is electrically separated and its electrical installation complies with the bonding requirements of BS 7671.</td>
</tr>
<tr>
<td>Oil refineries, oil distribution centres and other explosive/flammable environments</td>
<td>No</td>
<td>Refer to Section 5.12</td>
</tr>
<tr>
<td>Construction and demolition sites</td>
<td>No</td>
<td>Use either TN-S or TT – refer to Section 5.2</td>
</tr>
<tr>
<td>Mines and quarries</td>
<td>No</td>
<td>Use either TN-S or TT – refer to Section 5.10</td>
</tr>
<tr>
<td>Railway installations</td>
<td>Yes</td>
<td>Refer to Section 5.1</td>
</tr>
<tr>
<td>Farms, agricultural and horticultural premises</td>
<td>Yes</td>
<td>Refer to Section 5.4</td>
</tr>
<tr>
<td>Sports pavilions and Swimming pools</td>
<td>Yes</td>
<td>Refer to Section 5.5</td>
</tr>
<tr>
<td>Caravan Sites, Campsites and Sports Pavilions</td>
<td>Yes</td>
<td>Refer to Section 5.7</td>
</tr>
<tr>
<td>Mobile homes</td>
<td>Yes</td>
<td>Refer to Section 5.9</td>
</tr>
<tr>
<td>EV charging points in the highway</td>
<td>No</td>
<td>Refer to Section 5.16</td>
</tr>
<tr>
<td>EV charging points in premises</td>
<td>Yes</td>
<td>Refer to Section 5.16</td>
</tr>
<tr>
<td>Street lighting</td>
<td>Yes</td>
<td>Refer to Section 5.17.1</td>
</tr>
<tr>
<td>Street furniture</td>
<td>Yes</td>
<td>Refer to Section 5.17.2</td>
</tr>
<tr>
<td>Situation</td>
<td>PME Earth Terminal</td>
<td>Refer to the document listed for the PME criteria or alternative earthing system(s)</td>
</tr>
<tr>
<td>------------------------------------------------</td>
<td>--------------------</td>
<td>-----------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Multiple occupancy buildings</td>
<td>Yes</td>
<td>Refer to Section 5.13</td>
</tr>
<tr>
<td>Metal-clad buildings</td>
<td>Yes</td>
<td>Refer to Section 5.14</td>
</tr>
<tr>
<td>Cathodic protection installations</td>
<td>Yes</td>
<td>Refer to Section 5.20</td>
</tr>
<tr>
<td>Communication stations</td>
<td>Yes</td>
<td>Refer to Section 5.21</td>
</tr>
<tr>
<td>Mobile Phone Base Stations and Masts associated with Substations</td>
<td>Yes</td>
<td>Refer to Sections 5.22, 5.23 and 5.24</td>
</tr>
</tbody>
</table>

### 4.4 Supply Neutral Conductor Size

The supply neutral conductor in any three-phase four-wire, or single-phase three-wire (split phase) distributing main or service shall not be less than half the equivalent cross-sectional area of the phase conductors.

The supply neutral conductor in any single-phase two-wire or two-phase three-wire distributing main or service shall be not less than the equivalent cross-sectional area of the phase conductor, with recommended minimum values of 10 mm² for copper conductors and 16 mm² for aluminium conductors.

### 4.5 Earth Fault Loop Impedance

For guidance on earth fault loop impedance refer to EDS 08-2000 (new supplies) or EDS 06-0004 (existing supplies).
5 Special Situations

This section describes a number of special situations where an alternative earthing system may be required and also includes arrangements for some other special situations. This section is generally based on the guidance given in ENA EREC G12/4 Section 6.2. The following situations are included:

- Railway installations.
- Construction and demolition sites.
- Supplies to temporary installations.
- Farms, agricultural and horticultural premises.
- Swimming pools.
- Caravans and motor caravans.
- Caravan sites, campsites and sports pavilions
- Boats, marinas and similar locations.
- Mobile homes.
- Mines and quarries.
- Fuel filling stations.
- Oil refineries and oil distribution centres.
- Multiple occupancy buildings.
- Metal-clad buildings.
- Conversion of older properties into flats.
- LV generators.
- Street lighting and road signs.
- Street furniture.
- Electric vehicle charging points.
- Freestanding metallic pillars.
- Lightning protection systems.
- Cathodic protection installations.
- Communication stations.
- Mobile phone masts and base stations.
- HOT sites.
- Inset networks.
5.1 Railway Installations

This section details the requirements for providing PME earth terminals to operators of railway systems and is based on the requirements of ENA EREC G12/4. If the various criteria cannot be satisfied a TT earthing system shall be used or alternatively dedicated TN-S supplies provided directly from a substation.

5.1.1 General

The following criteria apply to all supplies to railway installations with a PME earth terminal:

1. To avoid neutral current diversion\(^2\) only one PME earth terminal shall be provided unless:
   - The existing PME earth terminal is to be removed or
   - There is no likelihood of common metallic coupling between the two earth terminals e.g. supply to trackside cubicle without further interconnection to railway earth.
2. All installations shall comply with the requirements of BS 7671, including equipotential bonding for PME conditions.
3. The housing at the intake position shall not expose a member of the general public to dangerous touch voltages.
4. Metallic enclosures containing LV equipment are not permitted at the intake position or where they may expose a member of the general public to dangerous touch voltages.

   **Note:** Network Rail has been given a temporary dispensation by the ENA to enable them to use metallic enclosures provided the earthing requirements of Section 5.18 are adopted.

The above measures do not necessarily provide full protection against touch voltages for railway personnel and it is the responsibility of the railway operator to assess and control such risks.

5.1.2 LV Supplies at Traction Supply Points

A PME earth terminal shall not be provided at traction supply points associated with AC traction systems. The requirements for LV auxiliary supplies at these locations are detailed in ENA EREC P24.

5.1.3 LV Supplies Associated with AC Traction Systems at Locations other than Traction Supply Points

A PME earth terminal may be provided to premises and trackside cubicles associated with railway lines using an AC traction system subject to the railway operator confirming that the following criteria are satisfied:

1. If there is DC traction in the vicinity refer to Section 5.1.5.
2. The equipment being supplied and all other equipment to which it is bonded shall not have any risk of coming into contact with the traction supply or (where equipment is at risk of contact with the traction supply) a bonding conductor shall be provided between the PME earth terminal and the traction return circuit, which shall be of an adequate size to carry foreseeable traction fault current. If this current exceeds the LV service cable rating then no such bond shall be made and adequate segregation ensured.

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\(^2\) If multiple PME supplies are provided and there is common metallic infrastructure between supply points the neutral current may return to source via the rail infrastructure under both normal load and especially broken neutral conditions which could cause damage at the intake or to the railway infrastructure.
3. The earth potential rise during fault conditions shall be less than:
   - 430V for faults with a duration greater than 0.2s but less than 3s.
   - 650V for faults with a duration less than or equal to 0.2s.

4. The rise of voltage on the traction rail due to traction return current shall not exceed 25V under frequent traction peak starting or running current conditions.

The railway operator shall provide a drawing of the proposed installation in order to demonstrate that a suitable path exists for traction fault current. These requirements seek to minimise the touch voltages that may appear on the LV network due to the railway design standards which allow higher values. Specific information about the compliance of individual railway operators is detailed in Appendix C.

5.1.4 LV Supplies Associated with DC Traction Systems

Refer to Appendix C for information on the construction of DC traction systems.

A PME earth terminal may be provided to premises and trackside cubicles associated with railway lines using DC traction systems provided the following criteria are satisfied:

1. If there is an AC traction system in the vicinity refer to Section 5.1.5.

2. The traction supply (3rd rail or overhead) and return (running rails and/or 4th rail) rails are insulated from earth in accordance with the requirements of BS EN 50122-2.

3. Neither pole of the traction supply shall be directly connected to earth and any connection to earth is solely for the purpose of the detection of earth fault conditions.

4. The LV supply, including the protective earthing conductor, and all earthed metal associated with it shall be segregated from all DC conductors by the maximum practicable distance, subject to a minimum distance of 1m in soil in accordance with BS EN 50122-2.

5. There shall be no evidence of corrosion on railway equipment which may be due to stray DC current. In the event that the railway operator detects corrosion due to stray DC current on any of their equipment following the provision of an LV supply they shall advise UK Power Networks.

6. The voltage between the running rails and earth shall satisfy the requirements of BS EN 50122-1 i.e. less than 5V.

7. The conductance between the running rails and earth shall satisfy the requirements of BS EN 50122-2 i.e. less than 0.55S/km per track.

These requirements seek to minimise the risk of electrolytic corrosion of earthing systems due to stray DC currents. They are based on a recognition that, if stray currents exist, there will be paths electrically closer to the traction system which will take larger stray currents than will flow through an LV earthing system. In this case corrosion of cable sheaths, structures and earthing systems, which are subject to regular inspections, will quickly become apparent to the railway operator. These measures will also ensure that for PME systems no external voltage is impressed on the neutral/earth conductor. If in doubt a DC stray voltage study/measurement should be requested from the rail operator.

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3 If UK Power Networks are advised by Network Rail that corrosion has been detected the supply shall be reassessed using the assessment process in Section 5.1.7 and if appropriate the earth terminal shall be withdrawn and Network Rail advised to use a TT earthing system.
5.1.5  LV Supplies for Sites with both AC and DC Traction Systems

A PME earth terminal shall **not** be provided to sites that have both AC and DC traction systems unless it can be demonstrated that:

- There is no transfer track\(^4\) between the AC and DC systems.
- The DC system is not and will not be connected to earth.
- The DC supply is segregated by at least 1m from the PME earth through soil.
- Simultaneous contact between LV earths and rail/other earths cannot occur (2m separation above ground).
- The requirements for LV supplies to AC traction systems (Section 5.1.3) and DC traction systems (Section 5.1.4) are satisfied.

5.1.6  Other Electrified Systems

Refer to ETR 123 for supplies to Light Rapid Transit Systems.

Requirements for the provision of earthing terminals to premises and equipment at the trackside of operators of other traction systems should be referred to the earthing specialist.

5.1.7  Assessment Process

To enable the request for a PME supply associated with a railway installation to be correctly assessed, the railway operator shall be requested to complete the application form in Appendix D. The form and flow chart shown in Appendix E can then be used to assess the application.

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\(^4\) A transfer track is a section of track that connects a section of track with an AC supply to a section of track with a DC supply.
5.2 Construction and Demolition Sites

This section details the types of earthing systems that can be used for temporary supplies to construction and demolition sites. The transition from a temporary to a permanent supply should be taken into account and both supplies considered during the design and planning stages. UK Power Networks and the customer should work together to ensure that the customer's expectations can be satisfied.

The distribution of electricity on construction and building sites is covered in BS 7375.

5.2.1 Background

Construction and demolition sites have particular earthing issues due to the amount of exposed conductive parts (e.g. scaffolding, cranes etc.) which are in contact with the ground and, in effect, providing an earthed surface. The very process of construction and demolition means that bonding is not always in place. If another earth from an electricity supply is introduced into the site, voltage differences may occur between the two earthing systems and simultaneous contact with the two earthing systems is likely to cause an electric shock. The situation is exacerbated by the presence of earthed conducting surfaces and a higher risk of both installation fault and broken supply neutral conditions due to the nature of the installation.

5.2.2 Temporary Supplies

A PME earth terminal shall not be provided to construction or demolition sites because it is not possible to verify that the installation continuously complies with the bonding requirements of BS 7671. The following alternatives are available:

- TT earthing system.
- TN-S (SNE) earthing system from a dedicated transformer.
- TN-S (SNE) earthing system via an isolating transformer.

The protection requirements for each of these are covered in BS 7671.

5.2.2.1 TT Earthing System with RCD Protection

The preferred option is a TT earthing system as shown in Figure 5-1.

The supply shall be protected in accordance with BS 7671 and shall include a residual current device (RCD) on the customer's side of the cut-out. There should be no extraneous conductive parts before and/or enclosing the RCD.

The earth electrode shall be a minimum of 2m away from any PME earth electrode or exposed LV metallic cable sheath and a minimum of 8m away from any substation with separate HV and LV earths and associated cables to limit the effect of transfer voltage between earthing systems.

The developer/contractor is responsible for maintaining the RCD and the site earth. It is also the developers/contractors responsibility to ensure that RCD settings comply with BS 7671.
5.2.2.2 TN-S from a Dedicated Transformer

If the site has a dedicated UK Power Networks secondary substation that only supplies the customer it will usually be possible to provide a TN-S earth terminal directly from the transformer neutral – see Figure 5-2. This arrangement will also enable easier transition to a permanent supply when it is required.

**Note:** If the transformer supplies other customers or interconnects with other parts of the LV network, this arrangement is not permitted. Before connecting the construction supply it is necessary to first permanently disconnect:

- The other customers or LV network.
- All relevant cables.
- All earth connections apart from the substation LV earth.

If there is any doubt one of the other options shall be used.
5.2.2.3 TN-S Earthing via an Isolating Transformer

If the site doesn't have a dedicated transformer, i.e. the transformer supplies other customers or other parts of the LV network, it is still possible to provide a TN-S supply by using a 1:1 isolating transformer as shown in Figure 5-3. The neutral of the isolating transformer can be used to provide a TN-S earthing system within the boundary of the site.

The isolating transformer should be Δ-Y and comply with BS EN 61558-2-4.

The transformer enclosure and core shall be connected to the site earth. The transformer shall be protected against primary winding faults with a residual current device (RCD) on the customer’s side of the cut-out. The setting of the RCD shall ensure that the voltage rise on the site earth is less than 50V.

Note: Additional RCDs may be required on the secondary side of the isolating transformer for the sub-circuit protection to satisfy the requirements of BS 7671.

The customer’s earth electrode shall be a minimum of 2m away from any PME earth electrode or exposed LV metallic cable sheath and a minimum of 8m away from any HOT substation and associated cables to limit the effect of transfer voltage between earthing systems.

The developer/contractor is responsible for maintaining the RCD, the isolating transformer, the LV supply and the site earth. It is also the developer’s/contractor’s responsibility to ensure that RCD settings comply with BS 7671.

![Figure 5-3 – TN-S Earth from an Isolating Transformer](image-url)
5.2.3 Existing Buildings

A temporary building supply is often required for an existing building which already has a supply (e.g. PME) that is undergoing construction works with scaffolding in place. The risks are similar to those outlined previously and the following criteria shall be satisfied before the temporary supply is provided:

- It is not possible for a person to make simultaneous contact between any conductive parts bonded to the building earthing system and conductive parts outside the building. (Provided that they cannot be touched at the same time the conductive parts outside the building will not be classified as extraneous conductive parts, as defined by BS 7671.) For a building other than a metal-clad building, it will usually be possible to satisfy this requirement even if scaffolding is still in place on the outside of the building provided the scaffolding is not bonded to the TT earth.
- Any TT earth including equipment bonded to it shall be a minimum of 2m from the permanent supply earth including equipment bonded to it.
- The site shall be in a reasonable condition and satisfy the meter operator's requirements.

5.2.4 Transition to a Permanent Supply

Although it is preferable, it is not always practical to remove the temporary building supply before the permanent supply is required. Therefore a permanent supply may be provided to a building if the following criteria are satisfied:

- The building second fix installation shall be complete or, alternatively, a phased handover agreed with the customer and meter operator.
- The building installation shall satisfy the requirements of BS 7671.
- It is not possible for a person to make simultaneous contact between any conductive parts bonded to the PME earth and conductive parts outside the building (provided that they cannot be touched at the same time the conductive parts outside the building will not be classified as extraneous conductive parts, as defined by BS 7671). For a building other than a metal-clad building, it will usually be possible to satisfy this requirement even if scaffolding is still in place on the outside of the building provided the scaffolding is not bonded to the TT earth.
- Any isolating transformer used to provide a temporary supply shall be removed from the site.
- Any TT earth including equipment bonded to it shall be a minimum of 2m from the permanent supply earth including equipment bonded to it.
- The site shall be in a reasonable condition and satisfy the meter operator's requirements.

Note: These requirements also apply to an existing building that is undergoing construction works with scaffolding in place.

5.3 Supplies to Temporary Installations

5.3.1 Exhibitions, Shows and Stands

A PME earth terminal shall not be provided to temporary exhibitions, shows and stands. Refer to BS 7671:2018 Section 711 for the earthing and bonding requirements.

5.3.2 Fairgrounds, Amusement Parks and Circuses

A PME earth terminal shall not be provided to fairgrounds, amusement parks and circuses. Refer to BS 7671:2018 Section 740 for the earthing and bonding requirements.
5.3.3 Mobile and Transportable Vehicles and Units

A PME earth terminal shall not be provided to mobile and transportable vehicles and units that contain an electrical installation for outside broadcast\(^5\), medical services, advertising, catering services etc. Refer to BS 7909 and BS 7671:2018 Section 717 for the earthing and bonding requirements.

5.3.4 Other Temporary Buildings

A PME earth terminal may be provided to other temporary buildings (e.g. temporary classrooms) if the following criteria are satisfied:

- The installation is constructed such that a person in contact with the general mass of earth cannot touch any metalwork of the temporary installation
- The installation complies with the earthing and bonding requirements of BS 7671.

A PME terminal shall not be provided to a temporary building which is not constructed as above (e.g. metalclad buildings), refer to Section 5.14 for further details on metal-clad buildings.

5.4 Farms, Agricultural and Horticultural Premises

A PME earthing terminal may be provided for use in farms, agricultural and horticultural premises provided that:

- There is no extraneous metalwork.
- The building electrical installation complies with the earthing and bonding requirements of BS 7671.
- The building is not occupied by animals or, if it is occupied by animals, a bonded earth grid is installed in the floor.

If these conditions cannot be satisfied a TT earthing system shall be used and shall consist of an independent earth electrode and RCD protection. The TT earthing system shall be segregated by a minimum of 2m from any PME earthing system or any building with a PME earthing installation. Furthermore earthing systems shall not be mixed within a building. The supply and installation of earthing system and protection is the responsibility of the customer.

**Note:** It is the responsibility of the customer to ensure that the installation conforms to the requirements of BS 7671. BS 7671:2018 Section 705 requires all final circuits to incorporate RCD protection regardless of type of earthing system used.

5.5 Swimming Pools

A PME earthing terminal may be provided for use in swimming pools provided that the electrical installation complies with the bonding requirements of BS 7671. Electrical supplies to swimming pools and other basins are covered in Section 702 of BS 7671:2018. Alternatively a TT earthing system may be used for the entire installation.

**Note:** It is the responsibility of the customer to ensure that the installation conforms to the requirements of BS 7671.

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\(^5\) The blanket approval previously given for outside broadcast vehicles (such as those owned by the BBC or IBA companies) to use a PME earthing system has been withdrawn.
5.6 Caravans and Motor Caravans

The Electricity, Continuity, Quality and Continuity Regulations 2002 preclude the provision of a PME earth terminal to caravans and motor caravans. A TT earthing system shall be used. Refer to BS 7671:2018 Section 708 for the earthing and bonding requirements. The supply and installation of earthing system and protection is the responsibility of the customer.

A PME earth terminal may be provided to permanent buildings (e.g. living accommodation, office, restaurant, shops etc.) provided the building is electrically separated and its electrical installation complies with the earthing and bonding requirements of BS 7671.

5.7 Caravan Sites, Campsites and Sports Pavilions

The provision of PME earthing for use in caravan sites, campsites, sports pavilions and similar locations is not recommended due to the probability of persons being barefooted.

However a PME earthing terminal may be provided on condition that the electrical installation complies with the earthing and bonding requirements of BS 7671 and either:

- No shower area exists or is likely to exist, or
- A bonded earth grid is installed in the floor of the shower area.

If these conditions cannot be satisfied a TT earthing system shall be used and shall consist of an independent earth electrode and RCD protection. The TT earthing system shall be segregated by a minimum of 2m from any PME earthing system. The supply and installation of earthing system and protection is the responsibility of the customer.

Note: It is the responsibility of the customer to ensure that the installation conforms to the requirements of BS 7671.

5.8 Boats, Marinas and Similar Locations

The Electricity, Continuity, Quality and Continuity Regulations 2002 preclude the provision of a PME earth terminal to boats, marinas and similar locations. A TT earthing system shall be used. Refer to BS 7671:2018 Section 709 for the earthing and bonding requirements.

A PME earth terminal may be provided to permanent buildings (e.g. living accommodation, office, restaurant, shops etc.) provided the building is electrically separated and its electrical installation complies with the earthing and bonding requirements of BS 7671.

5.9 Mobile Homes

A PME earthing terminal may be provided to mobile homes if the following criteria are satisfied:

- The mobile home is permanently sited.
- The mobile home is permanently connected to water and sewerage services.
- The installation is constructed such that a person in contact with the general mass of earth cannot touch any metalwork connected to the earth terminal.
- The installation complies with the earthing and bonding requirements of BS 7671.

If these conditions cannot be satisfied the mobile home shall be treated as a caravan in accordance with Section 5.6.

Refer to BS 7671:2018 Section 721 for the earthing and bonding requirements.
5.10 Mines and Quarries

A PME earthing terminal may be provided for use in mine/quarry permanent buildings (e.g. permanent offices and canteens) provided that the electrical installation complies with the bonding requirements of BS 7671. A PME earthing terminal may **not** be provided to amenity shower blocks unless an earth grid is installed.

Supplies to underground shafts, the production side of quarries or associated amenity shower blocks shall use a TT earthing system and shall consist of an independent earth electrode and RCD protection. The TT earthing system shall be segregated by a minimum of 2m from any PME earthing system. The supply and installation of earthing system and protection is the responsibility of the customer.

If the site has a dedicated secondary substation that only supplies the customer an alternative is to provide a TN-S earth terminal directly from the transformer neutral.

Also refer to HSE internet publication 'Electrical Safety in Quarries’ at [http://www.hse.gov.uk/quarries/electricity.htm](http://www.hse.gov.uk/quarries/electricity.htm)

**Note:** It is the responsibility of the customer to ensure that the installation conforms to the requirements of BS 7671.

5.11 Fuel Filling Stations

A PME earth terminal shall not be provided to fuel filling stations.

Refer to ‘Guidance for the Design, Construction, Modification and Maintenance of Petrol Filling Stations’ published jointly by the Association for Petroleum and Explosives Administration and the Institute of Petroleum for further information for the earthing requirements.

5.12 Oil Refineries and Distribution Centres

A PME earth terminal shall not be provided to oil refineries and oil distribution centres. Supplies shall use a TT or TN-S earthing system.

The TT earthing system shall consist of an independent earth electrode and RCD protection and shall be segregated by a minimum of 2m from any PME earthing system. The supply and installation of earthing system and protection is the responsibility of the customer.

Alternatively an earth terminal from a TN-S system (directly from the transformer neutral) may be used providing:

- The earth terminal is derived from dedicated secondary substation that only supplies the refinery or distribution centre.

The refinery or distribution centre has a common earthing system with a low overall earth resistance and complies with the required industry standards such as Shell’s design and engineering practice (DEP) documents (e.g. Electrical Engineering Guidelines DEP 33.64.10.10-Gen).

The above criteria shall also be applied to similar explosive or flammable environments e.g. hydrogen filling stations.
5.13 Multiple Occupancy Buildings

5.13.1 Overview

This section is based on the requirements of ENA EREC G87 and provides a summary of the earthing options that may be used to supply a multiple occupancy building. A multiple occupancy building is defined in ENA EREC G87 as a building occupied by more than one customer – some typical examples are flats and industrial units (Figure 5-4).

![Diagram showing high-rise and low-rise examples of multiple occupancy buildings]

Figure 5-4 – Multiple Occupancy Building Examples

It has been common practice for many years to provide connections to individual premises from a PME system and for individual premises to be given a PME earth terminal. However this is no longer acceptable due to the issues outlined below:

- The provision of a suitable end-of-main electrode which may be impractical, particularly in multi-storey buildings.
- The problems caused by the flow of neutral current (refer to Appendix F) through the building steelwork.
- The need to apply continuous ratings to steel wire armour on cables used for the building network to cater for diverted neutral current.
- The need for equipotential bonding between the intake positions.

The following sections apply to multiple occupancy buildings that have a steel-frame or shared metallic services. Where these criteria do not apply all services may be provided with a PME earth terminal, subject to the relevant planning standards.

This section should be read in conjunction with EDS 08-1103 and EDS 08-2100 which detail the only permissible supply options for multiple occupancy buildings.
5.13.2 New Building Design – Single Service to a Single Intake Position

Supplies to new multiple occupancy buildings shall be designed with a single intake position and be provided with an earth terminal as shown in Figure 5-5. The appropriate main equipotential bonding connections to structural steelwork and to metallic services shall be made at this point of connection.

All cables on the customer side of the ownership boundary shall be SNE.

At an individual customer’s installation the main equipotential bonding between metallic services, extraneous metalwork and the earth terminal shall be carried out in accordance with BS 7671. This will ensure that no harmful voltages appear between earthed and extraneous metalwork within the customer’s premises. For bonding purposes, the customer’s installation shall be considered to be TN-C-S if a PME earth terminal is provided at the intake position.

A single intake position with a single service avoids the problems outlined previously However if it is not possible to design on the basis of a single-intake/service position, two separate intakes may be provided in accordance with Section 5.13.3 or multiple services to a single intake in accordance with 5.13.4.

![Diagram of single intake supply arrangements](image)

Figure 5-5 – Single Intake Supply Arrangements
5.13.3 New Building Design – Services to Multiple Intakes

It may be not possible to design using a single intake position for a horizontal run of steel-framed residential, industrial or commercial units (EDS 08-1103 refers to this as buildings with no BNO and a common metallic framework). Individual PME connections shall not be used in these situations due to the risks associated with significant neutral current flow through structural steelwork and fixings under fault or other conditions and the difficulty associated with providing a bond between intake positions.

Therefore one of the following options shall be used:

- Freestanding pillar – provide a PME connection to a freestanding distribution pillar/cabinet and use a SNE cable to supply each unit (refer to Figure 5-6a). The neutral and earth conductors of the SNE cables shall not be bonded together at any point other than the pillar as this would result in a path for neutral current to be diverted into the building structure.
- Secondary substation – use a SNE cable to supply each unit directly from a local secondary substation (refer to Figure 5-6b).
- Individual service – alternatively an individual service may be provided to each unit using a TT earthing system. Although this will eliminate the problems it has other disadvantages that may be unacceptable to the customer.

![Diagram of Multiple Intake Supply Arrangements](image)

Figure 5-6 – Multiple Intake Supply Arrangements
5.13.4 Multiple Services to a Single Intake Position

Multiple CNE services to a single customer or building are **not** recommended due to the problems associated with neutral current diversion (refer to Appendix F) and with the isolation of the supplies. If there is no alternative to providing an additional service or an additional service has already been provided the following requirements (shown in Figure 5-7) shall be satisfied for PME earthing:

- The services shall be from the same secondary substation and ideally from the same main.
- The services shall be positioned no more than 5m apart at the same intake position and have the same size neutral conductors.
- The earth terminals of each service shall be bonded together using a copper conductor covered in green/yellow PVC with a blue marker at each end (to indicate that it’s carrying current). The size of the bonding conductor shall be not less than that of the associated service neutral conductor. The bonding conductor shall have a warning label (BS 951) fitted to each end as detailed in Table 6-1.
- A warning label (EDS 07-0009.119) shall be installed next to each cut-out as detailed in Table 6-1.
- Each service to the building shall be treated as a separate supply within the customer’s installation and the equipotential bonding to other services (gas, water etc.) installed accordingly. This ensures that equipotential bonding is maintained if one of the services is removed in the future.

---

6 The neutral/earth bonding conductor prevents excessive current flowing through the customer’s bonding in the event of a broken neutral conductor.
5.13.5 Existing Buildings

Wherever possible, i.e. when alterations or upgrades are requested, the requirements for new buildings detailed in Section 5.13.2 or 5.13.3 should be applied to existing buildings. If these cannot be satisfied the options should be based on the multiple services requirements detailed in Section 5.13.4.

However as a last resort the existing arrangements may be retained and extended following consultation with Asset Management.

5.13.6 End-of-main Earth Electrode

Where a PME service is provided to a multi-occupancy building an end-of-main earth electrode with a maximum resistance of 100Ω shall be installed adjacent to the point of entry to the building of the incoming service cable. The associated earthing conductor may be run into the building alongside the service cable and connected to the neutral at the intake position (refer to EDS 06-0016 for the electrode details).

5.14 Metal-clad Buildings

Where metal-clad buildings incorporate a steel-frame, the steel-frame will provide a good connection with earth and will effectively limit the earth potential rise.

A PME service may be provided to a metal-clad building if the following criteria are satisfied:

- The metal cladding is bonded to the steel-frame.
- The supply is either three-phase with less than 40% unbalance or the supply is single-phase and the frame to earth impedance is less than 20Ω.

Note: For multiple occupancy buildings the criteria detailed in Section 5.13 shall also be satisfied.

5.15 LV Generators

For LV generator connections refer to ENA EREC G83, G84 and G59.
5.16 Electric Vehicle Charging Points

In accordance with ENA EREC G12 a PME earth terminal shall not be provided for a supply direct to electric vehicle charging points installed in the highway. A TT earthing system shall be used for all electric vehicle charging points installed in the highway. The supply and installation of earthing system and protection is the responsibility of the customer’s electrical designer/installer.

A PME earth terminal may be provided to a premise with an electric vehicle charging point that is not street electrical furniture (e.g. domestic installation) subject to the general requirements of BS 7671:2018 Regulation 722.411.4.1 (limitation of earth potential rise to 70V). The customer’s electrical designer/installer is responsible for ensuring that any PME earth terminal is used appropriately and conforms to the requirements of BS 7671.

Any TT earth electrode shall be segregated by a minimum of 2m from any PME earthing system; this can usually be achieved by ensuring there is 2m separation above ground between earthed metalwork. Where reasonably practicable consideration should be given to the presence of underground earth electrodes.

Some examples of acceptable and unacceptable arrangements are given in Table 5-1.

It is not permissible to consider metallic lamp columns to be earth electrodes.

Refer to BS 7671:2018 Section 772 for specific guidance on electric vehicle changing points.

Table 5-1 – PME and TT Earthing System Separation

<table>
<thead>
<tr>
<th>Existing Asset Earthing System</th>
<th>Separation</th>
<th>New Asset Earthing System</th>
<th>Acceptable</th>
</tr>
</thead>
<tbody>
<tr>
<td>PME</td>
<td>&lt; 2m</td>
<td>PME</td>
<td>✓</td>
</tr>
<tr>
<td>TT</td>
<td>&gt;= 2m</td>
<td>PME</td>
<td>✓</td>
</tr>
<tr>
<td>PME</td>
<td>&gt;= 2m</td>
<td>TT</td>
<td>✓</td>
</tr>
<tr>
<td>TT</td>
<td>&lt;= 2m</td>
<td>TT</td>
<td>✓</td>
</tr>
<tr>
<td>PME</td>
<td>&lt; 2m</td>
<td>TT</td>
<td>✗</td>
</tr>
<tr>
<td>TT</td>
<td>&lt; 2m</td>
<td>PME</td>
<td>✗</td>
</tr>
</tbody>
</table>
5.17 Street Lighting and Street Furniture

5.17.1 Street Lighting and Road Signs up to 500W

A PME earthing terminal may be provided to supply street lighting and road signs with a load of 500W or less owned by Network Operators and Street Lighting Authorities with a combined neutral and earth; however private street lighting installations are not permitted to combine the neutral and earth function therefore SNE cables shall be used throughout their installation. The supply to street lighting authority and private installations is usually via a pillar. The following earthing requirements shall be applied to all street lighting installations:

- An earth electrode shall be installed at the supply point, e.g. feeder pillar, feeder column or at the end of the service, supplying a Street Lighting Authority or private street lighting network as shown in Figure 5-8.
- An earth electrode shall be installed at the last lamp column position. However the earth electrode may be omitted for single lamp columns provided the distributor neutral conductor is earthed either at or beyond the service joint position (refer to Figure 5-8). It is not permissible to consider metallic lamp columns to be earth electrodes.
- An earth electrode shall be installed at every lamp column that is installed in an insulated sleeve.
- The minimum size of bonding conductor shall be 6mm$^2$ for a standard street lighting cut-outs (up to 25A) and 16mm$^2$ for other cut-outs up to 100A.
- Small isolated metal parts (e.g. doors in concrete lamp columns) which are unlikely to come into contact with earthed metalwork do not need to be bonded.
- Segregated from any substation with separate HV and LV earths by 2m.
- The earth terminal and any external metalwork of street lighting fittings mounted on buildings or wooden poles shall be connected to the PME earth terminal unless the fitting is Class II insulated.

![Diagram of Street Lighting Earth Electrode Positions](image_url)

Figure 5-8 – Examples of Street Lighting Earth Electrode Positions

For further details on all other aspects of street lighting refer to EDS 08-2102.

Electrical supplies to outdoor lighting installations, highway power supplies and street furniture are covered in BS 7671:2018 Section 714.
5.17.2 Street Furniture and Other Housings/Enclosures Accessible to the Public up to 7kW

This section covers all other electrical street furniture, housings and enclosures accessible to the public including communication and cable television electrical distribution cabinets, street lighting/traffic lights with a load up to 7kW.

Note: Supplies to electric vehicle charging points in the highway are covered by Section 5.16.

The practice of installing equipment in metallic enclosures is discouraged due to the risk of any earthed metalwork becoming live in the event of a broken neutral and the difficulty in managing the step and touch voltages around the enclosure. Therefore unless specified otherwise in this document all metallic street furniture with an unmetered or metered supply shall use a TT earthing system.

A PME earth terminal may be provided to any street furniture that is either Class II (double-insulated) construction (as defined in BS 7671) or housed in a Class II enclosure, e.g. public telephones, ticket machines, bollards etc.

A PME earth terminal may also be provided to street furniture or enclosure of Class I construction (as defined in BS 7671) provided the electrical installation satisfies the following criteria:

- It complies with the earthing and bonding requirements of BS 7671.
- It complies with the earth electrode and labelling requirements detailed in Table 5-2.
- It is segregated from any other below ground earth electrodes (e.g. substation) or above ground earthed metalwork (e.g. substation fence) by 2m.

Alternatively, or if these requirements cannot be satisfied, a TT earthing system shall be provided in accordance with BS 7671 and will usually consist of an independent earth electrode and RCD protection. The TT earth electrode shall be segregated by a minimum of 2m from any PME earthing system; this can usually be achieved by ensuring there is 2m separation above ground between earthed metalwork. Where reasonably practicable consideration should be given to the presence of underground earth electrodes.

Table 5-2 – PME Maximum Load and Earth Electrode Resistance Values for Class I Street Furniture

<table>
<thead>
<tr>
<th>Connection</th>
<th>Maximum Single-phase Load or Three-phase Overall Load Unbalance</th>
<th>Customer Earth Electrode Requirements$^8$</th>
<th>Labelling Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Balanced three-phase</td>
<td>No load unbalance</td>
<td>Not required</td>
<td>n/a</td>
</tr>
<tr>
<td>Unbalanced three-phase or single-phase</td>
<td>500W</td>
<td>100Ω</td>
<td>Refer to Table 6-1</td>
</tr>
<tr>
<td></td>
<td>1kW</td>
<td>50Ω</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2kW</td>
<td>20Ω</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3kW</td>
<td>18Ω</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4kW</td>
<td>14Ω</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5kW</td>
<td>11Ω</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6kW</td>
<td>9Ω</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7kW</td>
<td>7Ω</td>
<td></td>
</tr>
</tbody>
</table>

$^8$ These values are based on ENA EREC G12/4 and have been selected to limit the touch voltage to 100V.
5.18 Metallic Enclosures

The use of metallic enclosures is discouraged however it is recognised there are some applications e.g. metering cubicles supplying IDNOs and Network Rail etc. In these circumstances the requirements detailed below and illustrated in Figure 5-9 shall be applied:

- The feeder pillar shall be surrounded by a 70mm$^2$ bare copper conductor grading electrode buried at a depth of approx. 500mm and located approx. 500mm away from all sides of the pillar.
- The pillar and the grading electrode shall be connected to the earth terminal.
- The pillar shall be at least 2m clear of other earthed metalwork not connected to the same earth to avoid touch voltage risks arising from inadvertent contact between the pillar and the other earthed metalwork.
- Where the pillar is located within 2m of a secondary substation the pillar grading electrode shall be connected to the secondary substation earthing via duplicate connections.

Network Rail has an approved earthing design for their metallic cabinets as shown in Figure 5-10 and it shall be adopted at all of their sites.
5.19 Lightning Protection

Lightning protection is covered by BS EN 62305 (protection against lightning). BS EN 62305-3 specifies that the resistance of the lightning protection system (LPS) should not exceed 10Ω and that it is preferable to have a single integrated earthing system. Therefore provided the customer’s lightning system does not exceed 10Ω it should be connected to the UK Power Networks LV earthing system. The connection point shall be clearly labelled, and bolted to facilitate disconnection under controlled conditions should this be necessary.

If the installation has an associated onsite secondary substation, refer to the lightning protection section in EDS 06-0014 for additional requirements.

If the systems are connected, a removable link shall be provided to separate the two systems for maintenance and testing purposes and a warning label installed.

Note:
- There will be an electric shock risk between the two earthing systems if the connection between them is broken.
- If the two earthing systems are not bonded then care is required to ensure that metalwork connected to the two earthing systems cannot be touched simultaneously.
- If the two earthing systems are not bonded then during lightning strike conditions a flashover may occur between the lightning conductors and any pipework or conductor (including cables within the customer’s installation) connected to the earth terminal.

5.20 Cathodic Protection Installations

The usual source of power for cathodic protection installations is a mains supply via a transformer rectifier unit. The preferred arrangement for cathodic protection installations is a TT earthing system which shall consist of an independent earth electrode and RCD protection. The TT earthing system shall be segregated by a minimum of 2m from any PME earthing system. The supply and installation of earthing system and protection is the responsibility of the customer.

Cathodic protection is covered by BS 7361.
5.21 Small Radio Stations (requiring a functional earth)

Some communication stations require an independent earth electrode for functional/lightning purposes. Where such an earth is installed its earth resistance may be comparable or less than that of the DNO earthing system. On a PME network, in the event of an open circuit neutral the customer earth electrode may carry most of the diverted neutral current. However the size of the customer earthing and bonding connections may be insufficient for this current, particularly where the service size is small.

If this is the case a TT earthing system and RCD protection shall be used for either the whole of the installation or the part of the installation supplying the radio/communication equipment and any associated metalwork to prevent the possible neutral current diversion described above. In the latter case the TT installation earthing shall be segregated by a minimum of 2m from any PME earthing system and any earthing/bonding in the remainder of the customer installation. The supply and installation of earthing system and protection is the responsibility of the customer.

Where disruption due to possible RCD nuisance tripping would be unacceptable, an alternative to the TT earthing system is to size the earthing and bonding accordingly (i.e. the customer earthing and bonding shall not be less than the cross-sectional area of the service neutral).

5.22 Mobile Phone Masts

A PME earthing terminal may be provided for a mobile phone mast supply provided the rules for street furniture detailed in Section 5.17.2 are satisfied.

However if a functional earth is also required the installation shall be treated as a radio transmitter and a TT earthing system consisting of an independent earth electrode and RCD protection shall be used. The TT earthing system shall be segregated by a minimum of 2m from any PME earthing system. The supply and installation of earthing system and protection is the responsibility of the customer.

5.23 Mobile Phone Base Stations and Masts Associated with Substations

Positioning a mobile phone base station (MPBS), mast or other communication tower adjacent to or within a substation has touch, step and transfer voltage implications as there are two separate earthing systems in close proximity to each other. Furthermore, the ground in and around the substation will rise in voltage under earth fault conditions and it is necessary to ensure that the MPBS and/or mast is not situated within the 430V contours, since this voltage could be collected by the mast’s earthing system and impressed on the supply neutral.

Therefore there is a need to limit touch and step voltages, and to prevent transfer voltages onto the LV network. The rules in the following sections may be applied to MPBS and masts associated with secondary distribution substations and pole-mounted sites to satisfy this.

However, if these rules, and in particular the specified segregation, cannot be satisfied a detailed earthing study shall be carried out to calculate the earth potential rise, the extent of the voltage contours and the interaction with any metalwork. A specialised design is required to ensure that touch and step voltages are managed and that dangerous voltages are not transferred into the LV network.

For MPBS and masts associated with grid and primary substations refer to EDS 06-0013.
5.23.1 MPBS and Masts Adjacent to a COLD Secondary Substation

A PME earthing terminal may be provided from a COLD site (combined HV/LV earth), as the earth potential rise is within safe limits and transfer voltage is not an issue, unless a functional earth is required then it shall be TT as detailed in Section 5.22. However, the MPBS or mast cannot be assumed to be bonded to the PME earth terminal and at times may exist at a different voltage to the metalwork at the substation. Therefore the mast and any metalwork connected to it shall be positioned at least 2m away from any metalwork connected to or associated with the substation (refer to Figure 5-11).

Figure 5-11 – COLD Substation with Adjacent MPBS or Mast

5.23.2 MPBS and Masts Adjacent to a HOT Secondary Substation/Pole-mounted Site

A PME earthing terminal may be provided from a HOT site (segregated HV/LV earth), unless a functional earth is required then it shall be TT as detailed in Section 5.22, however additional precautions are needed to prevent danger resulting from the high voltages appearing on the metalwork and the rise in earth potential under earth fault conditions. Therefore the MPBS, mast and any associated metalwork shall be positioned at least 8m away from the following (refer to Figure 5-12):

- Any metallic sheath cables in contact with the ground.
- Any other HV or LV earth electrodes.
- Any metalwork connected to or associated with the substation.

Note: Metallic fences around the substation shall be assumed to be part of the substation.

Figure 5-12 – HOT Substation with Adjacent MPBS or Mast
5.23.3 MPBS and Masts within a Secondary Substation

The following criteria shall be applied for a MPBS or mast situated within the substation boundary fence (refer to Figure 5-13):

- If the site is COLD (combined HV/LV earth) a PME earthing terminal may be provided.
- If the site is HOT (segregated HV/LV earth) a PME earth terminal is not permitted and a TT earthing system shall be used.
- The MPBS and mast shall be bonded to the substation earth grid.
- The MPBS and mast shall be positioned at least 2m away from other separately earthed metalwork (e.g. fencing with an independent earth).

![Substation with MPBS or Mast within the Boundary Fence](image)

Figure 5-13 – Substation with MPBS or Mast within the Boundary Fence

5.24 Mobile Phone Base Stations and Masts on/in Buildings

Where mobile phone base stations and masts are installed on or within a building an additional supply is likely to be requested. These requests should be treated the same as a supply for a multi-occupied building and the requirements detailed in Section 5.13 shall apply.

5.25 Mobile Phone Base Stations Associated with Transmission Towers

For LV supplies to mobile phone base stations mounted on 132kV, 275kV or 400kV transmission towers refer to EDS 08-2109.

5.26 HOT Sites and National Grid Sites

For supplies to HOT sites and National Grid sites refer to EDS 08-2108.

5.27 Inset Networks

Refer to EDS 06-0016 for boundary earth electrode requirements.

For further guidance on inset networks refer to EDS 08-1101.
5.28 HV/LV Supplies to Same Customer or Building

Different HV and LV supplies to the same customer or building are a cause of concern due to the possibility of interconnecting different earthing systems. For example, if a new HV/LV supply is introduced into a building that already has a UK Power Networks LV supply, the earthing system of the latter may be exposed to unacceptable fault and circulating current. To address this situation, site specific design considerations are necessary.

If a customer supplied at HV provides LV supplies into the same building that already has LV supplies from the distribution network, the customer shall ensure that an alternative earthing system is not introduced within the building.

Customers are not permitted to use a PME system on their own internal LV network (ESQC Regulation 8 (4)). However a customer may operate a TN-S network with deliberate interconnection with the UK Power Networks’ earthing system provided the following criteria are satisfied:

- The connection between the two systems shall be sized appropriately (minimum 70mm$^2$) to handle diverted fault currents arising from faults on the customer's system.
- The customer shall carry out specific studies to ensure the earth potential rise on any part of the system is maintained at safe levels under all circumstances and that there is no possibility of danger arising to UK Power Network’s existing customers.
- A removable link shall be provided to separate the two systems for maintenance and testing purposes and a warning label installed as detailed in Table 6-1. **Note:** There will be an electric shock risk between the two earthing systems when the link is removed.

If these criteria cannot be satisfied the earthing systems shall be segregated by a minimum of 2m.

Refer to EDS 06-0019 for guidance on earthing associated with customer EHV and HV supplies.

Refer to EDS 08-1103 for further guidance on multiple supplies.
6 Installation Requirements

6.1 Cut-out Earth Terminal Provision

Examples of earth terminal provision at a 100A cut-out are shown in Figure 6-1 (PME), Figure 6-2 (TN-S) and Figure 6-3 (TT) only. Unmetered cut-out examples are shown in Figure 6-4 (PME) and Figure 6-5 (TT).

<table>
<thead>
<tr>
<th>Figure 6-1 – 100A Cut-out PME Earth Terminal</th>
<th>Figure 6-2 – 100A Cut-out TN-S Earth Terminal</th>
<th>Figure 6-3 – 100A Cut-out TT Earth (no earth terminal)</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="PME (TN-C-S) Earth Terminal" /> This cut-out is connected to a PME system</td>
<td><img src="image" alt="TN-S Earth Terminal" /> This cut-out is connected to a system with separate neutral and earth conductors</td>
<td><img src="image" alt="TT Earth" /> This installation is not suitable for connection to a network earth terminal</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Figure 6-4 – Unmetered Cut-out PME Earth Terminal</th>
<th>Figure 6-5 – Unmetered Cut-out TT Earth (no earth terminal)</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="PME (TN-C-S) Earth Terminal" /> This cut-out is connected to a PME system</td>
<td><img src="image" alt="TT Earth" /> This installation is not suitable for connection to a network earth terminal</td>
</tr>
</tbody>
</table>
6.2 End-of-Main Earth Electrode

An end-of-main earth electrode shall be provided at all three-phase cut-outs above 100A for large services and multi-occupancy buildings (Section 5.13.6). The earth electrode shall consist of a single earth rod, usually installed in the cable trench outside the building, connected to the cut-out via 70mm² insulated stranded copper cable.

If an existing supply is being upgraded or converted, the end-of-main earth electrode may be omitted provided the existing service cable is being utilised and there is an end-of main earth electrode beyond the main/service joint.

If the intake is adjacent to the substation and the cable is less than 10 metres in length and not buried the end-of-main earth electrode may also be omitted.

6.3 Warning Labels

The appropriate earthing terminal label from Table 6-1 shall be installed next to the cut-out to advise the type of the earthing that has been provided.

Additional warning labels detailed in Table 6-2 may also be required for PNB, multiple supplies and street furniture.

Table 6-1 – Earth Terminal Warning Labels

<table>
<thead>
<tr>
<th>Situation/Location</th>
<th>Reference⁹ (Material Code¹⁰)</th>
<th>Specification</th>
<th>Label</th>
</tr>
</thead>
<tbody>
<tr>
<td>PME Earth Next to the cut-out</td>
<td>EDS 07-0009.121 (21657Q)</td>
<td>100mm x 25mm adhesive label</td>
<td><img src="image" alt="PME (TN-C-S) Earth Terminal" /></td>
</tr>
<tr>
<td>TN-S Earth Next to the cut-out</td>
<td>EDS 07-0009.178 (21691R)</td>
<td>100mm x 25mm adhesive label</td>
<td><img src="image" alt="TN-S Earth Terminal" /></td>
</tr>
<tr>
<td>TT Earth Next to the cut-out</td>
<td>EDS 07-0009.179 (21692B)</td>
<td>100mm x 25mm adhesive label</td>
<td><img src="image" alt="TT Earth" /></td>
</tr>
<tr>
<td>PNB Earth Next to the cut-out</td>
<td>EDS 07-0009.180 (21693L)</td>
<td>100mm x 25mm adhesive label</td>
<td><img src="image" alt="PNB (TN-C-S) Earth Terminal" /></td>
</tr>
</tbody>
</table>

⁹ Refer to EAS 07-0021 for the availability of labels without a material code.
¹⁰ UK Power Networks material code.
Table 6-2 – Other Warning Labels

<table>
<thead>
<tr>
<th>Situation/Location</th>
<th>Reference9 (Material Code10)</th>
<th>Specification</th>
<th>Label</th>
</tr>
</thead>
<tbody>
<tr>
<td>PNB Earth</td>
<td>EDS 07-0009.9</td>
<td>70mm x 20mm tie on label</td>
<td>![PNB Earth Do not disturb earth connection]</td>
</tr>
<tr>
<td>Multiple Supplies</td>
<td>EDS 07-0009.119</td>
<td>100mm x 50mm adhesive label</td>
<td>![Warning There is more than one electrical supply point in this building]</td>
</tr>
<tr>
<td>Multiple Supplies</td>
<td>BS 951</td>
<td>SAFETY ELECTRICAL CONNECTION – DO NOT REMOVE</td>
<td>![Warning Maximum permitted load is 2kW due to the earthing design. Contact the local network operator if the load increases]</td>
</tr>
<tr>
<td>Street Furniture</td>
<td>EDS 07-0009.127 (21664U)</td>
<td>100mm x 50mm adhesive label</td>
<td>![Warning Maximum permitted load is 600W due to the earthing design. Contact the local network operator if the load increases]</td>
</tr>
<tr>
<td>Street Furniture</td>
<td>EDS 07-0009.127 (21663K)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

6.4 Bonding Requirements

A summary of the main bonding requirements and minimum size of bonding conductors for PME installations are given in Table 6-3.

Table 6-3 – General Bonding Requirements

<table>
<thead>
<tr>
<th>Connection Type</th>
<th>Copper or Copper Equivalent Bonding Conductor</th>
<th>Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>At customer’s premises between service neutral and main earthing terminal</td>
<td>16mm² or half the size of the neutral meter tail whichever is the larger</td>
<td>UK Power Networks</td>
</tr>
<tr>
<td>At customer’s premises between the main earthing terminal and the earth bar of the consumer unit</td>
<td>16mm² or half the size of the neutral meter tail whichever is the larger</td>
<td>Customer</td>
</tr>
<tr>
<td>At customer’s premises between the main earthing terminal and all metal structures, metal pipes and other extraneous conductive parts</td>
<td>Refer to BS 7671:2018 Table 54.8</td>
<td>Customer</td>
</tr>
</tbody>
</table>
7 References

7.1 UK Power Networks’ Standards

EDS 06-0004 Earth Fault Loop Impedance Requirements (internal document only)
EDS 06-0014 Secondary Substation Earthing Design
EDS 06-0015 Pole-mounted Equipment Earthing Design
EDS 06-0016 LV Network Earthing Design
EDS 06-0017D Railway PME Application Form
EDS 06-0017E Railway PME Assessment Form (internal use only)
EDS 07-0009 Signs and Labels for Operational Sites
EAS 07-0021 Signs and Labels for Operational Sites
EDS 06-0019 Customer EHV and HV Connections (including Generation) Earthing Design and Construction Guidelines
EDS 08-1101 Guidance for the Application of ENA Engineering Recommendation G88 and G81 Inset Networks (IDNOs and other licenced DNOs)
EDS 08-1103 Supplies to Multi-occupied Buildings
EDS 08-2000 LV Network Design
EDS 08-2100 LV Customer Supplies
EDS 08-2101 LV Customer Supplies up to 100A
EDS 08-2102 Services to Unmetered Street Furniture
EDS 08-2108 Supplies to HOT Sites and National Grid Sites
EDS 08-2109 LV supplies to Mobile Phone Base Stations Mounted on 132, 275 and 400kV Towers (internal document only)

7.2 National and International Standards

The Distribution Code (http://www.dcode.org.uk/).
The Electricity Safety, Quality and Continuity Regulations (ESQC) 2002 as amended (2006)
BS 7671:2018 Requirements for Electrical Installations (IET Wiring Regulations 18th Edition)
BS 7430 Code of Practice for Earthing
BS 7361 Cathodic Protection
BS 7375:1998 Distribution of Electricity on Construction and Building Sites
BS 7909 Code of Practice for Temporary Electrical Systems for Entertainment and Related Purposes
BS EN 50122-1 Railway Applications – Fixed Installations – Protective Provisions Relating to Electrical Safety and Earthing
BS EN 50122-2 Railway Applications – Fixed Installations – Protective Provisions Against the Effects of Stray Currents caused by DC Traction Systems
BS EN 61140 Protection Against Electric Shock. Common Aspects for Installation and Equipment
BS EN 61851 Electric Vehicle Conductive Charging System. General Requirements
BS EN 61558-2-4 Safety of Power Transformers, Power Supply Units and Similar. Part 2.4: Particular Requirements for Isolating Transformers for General Use
BS EN 62305 Protection Against Lightning
ENA EREC G12/4 Requirements for the Application of Protective Multiple Earthing to Low-voltage Networks
ENA EREC G59 Recommendations for the Connection of Generation Plant to the Distribution Systems of Licenced Distribution Network Operators
ENA EREC G83 Recommendations for the Connection of Type Tested Small-scale Embedded Generators (Up to 16 A per Phase) in Parallel with Low-Voltage Distribution Networks
ENA EREC G84 Recommendations for the Connection of Mobile Generating Sets to Public Distribution Networks
ENA EREC G87 Guidelines for the Provision of Low-voltage Connections to Multiple Occupancy Buildings
ENA EREC P24 AC Traction Supplies to British Rail
ENA ETR 123 Guidelines for Managing the Interfaces between Utility Services and Light Rapid Transit Systems

Electrical safety in quarries [http://www.hse.gov.uk/quarries/electricity.htm](http://www.hse.gov.uk/quarries/electricity.htm)
Guidance for the Design, Construction, Modification and Maintenance of Petrol Filling Stations published jointly by the Association for Petroleum and Explosives Administration and the Institute of Petroleum

### 8 Dependent Documents

- **EDS 06-0001** Earthing Standard
- **EDS 06-0013** Grid and Primary Substation Earthing Design
- **EDS 06-0016** LV Network Earthing Design
- **EDS 06-0019** Customer EHV and HV Connections (including Generation) Earthing Design and Construction Guidelines
- **ECS 06-0023** Secondary Distribution Network Earthing Construction
- **EDS 08-1103** Multi Occupied Building Supplies
- **EDS 08-2100** LV Customer Supplies
- **EDS 08-2101** LV Customer Supplies up to 100A Single Phase
- **EDS 08-2102** LV Customer Unmetered Supplies
- **EDS 08-2108** Supplies to HOT Sites and National Grid Sites
- **EDS 08-2110** Guidance for the Application of ENA Engineering Recommendation G88 and G81 Inset Networks (IDNO's and other licenced DNO's)
- **EDS 08-5050** Electric Vehicle Connections

Overhead Craft Manual
Appendix A – Legislation

The Electricity Safety, Quality and Continuity Regulations 2002 cover customers’ installations and the provision of earthing facilities. Some relevant regulations include:

**General Requirements for Connection with Earth**

8 (4) A consumer shall not combine the neutral and protective functions in a single conductor in his consumer's installation.

**Protective Multiple Earthing**

9 (1) This regulation applies to distributors' low voltage networks in which the neutral and protective functions are combined.

(2) In addition to the neutral with earth connection required under regulation 8(3)(b) a distributor shall ensure that the supply neutral conductor is connected with earth at:

(a) a point no closer to the distributor’s source of voltage (as measured along the distributing main) than the junction between that distributing main and the service line which is most remote from the source; and

(b) such other points as may be necessary to prevent, so far as is reasonably practicable, the risk of danger arising from the supply neutral conductor becoming open circuit.

(3) Paragraph (2)(a) shall only apply where the supply neutral conductor of the service line referred to in paragraph (2)(a) is connected to the protective conductor of a consumer’s installation.

(4) The distributor shall not connect his combined neutral and protective conductor to any metalwork in a caravan or boat.

**Equipment on a Consumer’s Premises**

24 (4) Unless he can reasonably conclude that it is inappropriate for reasons of safety, a distributor shall, when providing a new connection at low voltage, make available his supply neutral conductor or, if appropriate, the protective conductor of his network for connection to the protective conductor of the consumer's installation.

**Connections to Installations or to Other Networks**

25 (2) A distributor shall not give his consent to the making or altering of the connection referred to in paragraph (1), where he has reasonable grounds for believing that:

(a) the consumer's installation, street electrical fixture or other distributor's network fails to comply with British Standard Requirements or these Regulations; or

(b) the connection itself will not be so constructed, installed, protected and used or arranged for use, so as to prevent as far as is reasonably practicable, danger or interruption of supply.
Appendix B – Earthing Systems

B.1 IEC Standard for the Naming of Earthing Systems

Mains electricity systems are categorized in IEC 364 according to how the earthing is implemented. The common ones are TN-C-S, TN-S and TT. In these descriptions, 'system' refers to both the supply and the installation, and 'live parts' includes the neutral conductor. These conventions are used in BS 7671.

First letter (refers to supply networks):

- **T** – The live parts in the system have one or more direct connects to earth (i.e. via the neutral).
- **I** – The live parts in the system have no connection to earth or are connected only through a high impedance.

Second Letter (refers to the customer’s installation):

- **T** – All exposed conductive parts are connected via earth conductors to a local earth connection.
- **N** – All exposed conductive parts are connected to the earth provided by the supply network.

Remaining Letters:

- **C** – Combined neutral and earth functions (same conductor).
- **S** – Separate neutral and protective earth functions (separate conductors).

**Note:** The letters are derived from the French language: **T** – Terre (earth), **N** – Neutre (neutral), **S** – Séparé (separate), **C** – Combiné (combined) and **I** – Isolé (isolated).

B.2 BS 7671 Definitions

**TN (Terre-Neutral)**
A system having one or more points of the source of energy directly earthed, the exposed conductive-parts of the installation being connected to that point by protective conductors. TN systems may be subdivided as described below.

**TN-C (Terre-Neutral-Combined)**
A system in which neutral and protective functions are combined in a single conductor throughout the system.

**TN-S (Terre-Neutral Separated)**
A system having separate neutral and protective conductors throughout the system.

**TN-C-S (Terre-Neutral-Combined-Separated)**
A system in which neutral and protective functions are combined in a single conductor in part of the system.

**TT (Terre-Terre)**
A system having one point of the source of energy directly earthed, the exposed-conductive parts of the installation being connected to earth electrodes electrically independent of the earth electrodes of the source.
B.3 TN-S (Terre-Neutral Separated)

In a TN-S earthing system (refer to Figure B-1), the incoming supply has a single point of connection between the supply neutral and earth at the supply transformer. The supply cables have separate neutral and protective earth conductors (SNE) for the complete system, and there is no bonding between the neutral and earth conductors, except at the supply transformer. The neutral conductor may be a fourth core, or a split concentric cable may be used with part of the concentric conductor insulated and used as the neutral. The sheath or a separate conductor is used to provide the protective earth. The customer is provided with an earth terminal connected to the sheath of the service cable or to the separate earth conductor.

Note:
- TN-S was the default earthing system pre-1978 before PME became commonplace.
- Since all extensions and repairs use CNE cable it shall be assumed that all networks will have the neutral and protective earth conductors combined for at least part of the system will therefore be TN-C-S. The only exceptions will be dedicated supplies to single customers using a separate earth conductor.

![Figure B-1 – TN-S Earthing System](image)

B.4 TN-C-S (Terre-Neutral-Combined-Separated)

The TN-C-S earthing system is a combination of TN-C and TN-S earthing systems. The supply cables have a combined neutral and earth (CNE) metallic outer sheath with a PVC covering (TN-C). The supply neutral conductor also serves as the protective earth and an earth terminal is provided from it. The supply on the customers side is TN-S, i.e. the neutral and earth are separate and only linked at the service termination. Both PME and PNB are examples of the TN-C-S earthing system.

Note: If any part of a network has CNE cable, or has SNE cable with the sheath and neutral bonded at more than one point, the complete system is classified as TN-C-S.
PME (Figure B-2) is a variant of the TN-C-S earthing system but additional earth electrodes are connected to the neutral.

![PME Earthing System](image)

Figure B-2 – PME Earthing System

PNB (Figure B-3) is another variant of the TN-C-S earthing system and is similar to PME. It is generally only used for supplies to a single customer or a small group of customers, e.g. a customer supplied from a pole-mounted transformer. The neutral conductor is only earthed at one point and therefore the transformer and the customer share a common neutral earth. The earth is located closer to the customer than the transformer and often connected at the cut-out.

The customer's electrical installation requirements are exactly the same as for PME.

![PNB Earthing System](image)

Figure B-3 – PNB Earthing System
B.5 TT (Terre-Terre)

In a TT earthing system (Figure B-4), the supply is earthed at one or more points and the supply cable sheaths are connected to it. The customer has an independent earth electrode to which any exposed metalwork of the customer’s installation is connected. The earth loop impedance is relatively high for this arrangement and therefore a residual current device (RCD) is usually required to protect the customer's installation.

![TT Earthing System Diagram](image)

**Figure B-4 – TT Earthing System**

**Note:**
- The resistance of this electrode shall be low enough to ensure that under fault conditions the voltage on exposed metalwork will not exceed 50V.
- BS 7671:2018 411.5.3 (ii) states that \( R_A I_{\Delta n} \leq 50 \, \text{V} \) where \( R_A \) is the customer’s electrode resistance and \( I_{\Delta n} \) is the rated residual operating current of the residual current device (RCD).
- BS 7671 also suggests that \( R_A \) should not exceed 200\( \Omega \) otherwise it may not be stable.
- BS 7671 generally requires the use of an RCD for domestic properties, including installations which utilise a distributor’s earth terminal; these systems are not TT systems.
Appendix C – Railways

C.1 AC Electrified Traction Systems in the UK

AC traction systems are used by Network Rail and, London and Continental Railways.

C.2 DC Electrified Traction Systems in the UK

The following methods of construction are employed in the UK.

C.2.1 Third Rail/Overhead Supply with Return via Insulated Running Rail

The supply is fed via an insulated overhead wire or third running rail mounted on insulators. The running rails are insulated from earth with plastic pads. Neither pole of the supply is earthed.

Where track-circuit signalling is used this relies on effective insulation between the running rails for correct operation.

This system is used on Network Rail third rail systems.

Information on these systems, and the measures to prevent corrosion due to leakage currents, is given in BS 7430.

C.2.2 Third Rail Supply with Return via Insulated Fourth Rail

The supply is fed via a third running rail mounted on insulators, and the return fourth rail is also mounted on insulators. Neither pole of the supply is earthed.

This system is used on London Underground (with connections to third and fourth rails to detect earth faults).

Information on this system, and the measures to detect earth fault currents, is given in BS 7430.

C.2.3 Third Rail Supply with Return via Insulated Fourth Rail and Running Rails

This system is used to enable trains equipped for either third or fourth rail systems to run on the same track. The return fourth rail is mounted on insulators, and the running rails are insulated from earth with plastic pads. The running rails and the fourth rail are bonded together. Neither pole of the supply is earthed.

This system is used on lines shared by Network Rail and London Underground.

C.2.4 Uninsulated Return

Tramways are fed via overhead wires with return via running rails embedded in the ground. Special provisions are required to limit stray DC currents in these systems.

The provision of PME or SNE earth terminals to these systems should be assessed on a case-by-case basis.
Appendix D – Railway PME Application Form

The railway PME application form should be completed by the railway operator when requesting a PME supply associated with a railway as detailed in Section 5.1. The form is attached as a separate document for convenience:

- EDS 06-0017D Railway PME Application Form.

Appendix E – Railway PME Assessment Form and Flowchart

The railway PME assessment form and flowchart can be used to assess an application for a PME supply associated with a railway as detailed in Section 5.1. The form is attached as a separate document for convenience:

- EDS 06-0017E Railway PME Assessment Form (internal use only).
Appendix F – Neutral Current Diversion

Neutral current diversion can occur within the structure of a steel-framed building (or a building with shared metallic services) supplied with multiple services from a combined neutral and earth network due to a broken neutral or unbalanced loads. The natural passage of neutral current through the structural steelwork can cause:

- Magnetic field problems both close to the steelwork and at the source which may cause interference and failure to comply with EMC directive.
- Equipotential bonding conductors to carry neutral current resulting in overheating and consequential fire risk.

F.1 Broken Neutral

When a multiple services from a combined neutral and earth network are provided to a steel-framed building neutral current may flow through the building structure due to a broken neutral on the network. Figure F-1 (a) shows the normal flow of neutral current and Figure F-1 (b) shows the flow of neutral current through the building structure due to a broken neutral.

Neutral diversion and the associated risks can be eliminated if all services are provided from a single point (e.g. intake room, feeder pillar or a secondary substation) on the combined neutral and earth network.

F.2 Unbalanced Loads

Unbalanced three-phase loads and single-phase loads cause current to flow in the neutral conductor. Neutral current diversion occurs when multiple CNE services are provided to the same building and an alternative path exists (e.g. through the structural steelwork of a building and an earth bond) to the other neutral/earth terminal. Neutral current diversion within a building due to unbalanced loads can be virtually eliminated by using separate neutral and earth conductors within the building\(^\text{11}\).

\(^{11}\) Source ENA EREC G87.