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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:** 10/07/2025

Approver: Paul Williams **Date:** 15/07/2025

Applicable To:

UK Power Networks

☒	Asset Management	☐	Information Systems
☐	Capital Programme	☐	Innovation
☒	Connections	☐	Legal
☐	Customer Services	☒	Network Operations
☐	DSO	☐	Procurement
☐	Finance / Income Management	☐	Strategy & Regulation
☐	Health & Safety	☒	Technical Training

External

☒	G81 Website	☐	Contractors
☒	ICPs/IDNOs	☐	Meter Operators

Revision Record

Version	7.1	**Review Date**	26/11/2028
Date	10/07/2025	**Author**	Stephen Tucker

Reason for update: Alignment with other standards.

What has changed:

- Section 4.3 TT earthing guidance revised to ensure consistence approach across all standards.
- Section 5.2 minor revision to railway requirements including removal of traction earth bonding note (5.2.1) and inclusion of 25V voltage rise note (5.2.3).
- Section 5.3.2.1 PME replaced with all other earthing systems.
- Section 5.17 reference to OPDD added.
- Section 5.18.2 reference to OPDD added.

Version	7.0	**Review Date**	26/11/2028
Date	26/11/2023	**Author**	Stephen Tucker

Reason for update: Alignment with ENA EREC G12/5 and other LV earthing standards.

What has changed:

- Section 1 references to legacy requirements and associated standards removed.
- Section 4.3 TT earth section added, and references added throughout document.
- Section 4.3, 5.2.5, 5.3, 5.9, 5.18.2 & 5.19 separation increased from 2 to 2.5 metres to align with BS 7671.
- Section 5.1 special situation list replaced with table previously in Section 4.4.
- Section 5.3.3 & 5.3.4 reference to scaffolding form EDS 06-0017C added.
- Section 5.5 farms, agricultural and horticultural section rewritten.
- Section 5.12 fuel filling station guidance updated.
- Section 5.15 metal-clad building guidance updated.
- Section 5.16 generation references updated to ENA ERC G98/G99.
- Section 5.18 street lighting guidance updated.
- Section 5.19 metallic enclosure earthing guidance updated.
- Section 5.20.3 mobile phone base stations and masts associated substation content removed and reference to EDS 06-0013/EDS 06-0014 added.
- Section 5.23 HOT site guidance replaced with ‘high EPR’ guidance.
- Section 6 cut-out arrangements, warning labels and installation content moved to ECS 06-0026.
- EDS 06-0017C new form for transition to permanent supply with temporary supply/scaffolding still in place.
- EDS 06-0017D and EDS 06-0017E minor amendments to railway forms.
- Mixed HV/LV supplies to the same building section removed.
- Original Appendix C on railways removed.
- Minor amendments throughout.
- Document reviewed.

Version	6.1	**Review Date**	10/09/2023
Date	19/06/2023	**Author**	Stephen Tucker

Reason for update: Alignment with the electric vehicle connection standard.

What has changed:

- Section 5.17 electric vehicle charging point earthing content replaced with a reference to EDS 08-5050.
- Section 7 references updated.
- No other review or changes considered - full review planned for Q3 2023.

Version	6.0	**Review Date**	10/09/2023
Date	05/09/2018	**Author**	Stephen Tucker

Reason for update: Internal and external feedback including the IET.

What has changed:

- Section 4.2 clarification on the provision of TT earthing.
- Section 4.2 clarification on the provision of an earth terminal from existing networks.
- Section 5.2 railway supplies revised.
- Section 5.3.3 temporary supplies to existing buildings added.
- Section 5.10 motor homes corrected to mobile homes.
- Section 5.17 electric vehicle charging points aligned with other documents.
- Section 5.18 street furniture requirements including diagram clarified.
- Section 6 installation requirements section introduced with examples of earth provision for metered and unmetered supplies, end-of-main electrode requirements and warning labels.
- References to BS 7671:2018 added throughout.
- EDS 06-0017D and EDS 06-0017E railway supply forms revised.

Version	5.0	**Review Date**	31/07/2019
Date	05/11/2015	**Author**	Stephen Tucker

Reason for update: Cut-out earthing labels revised.

What has changed: New earthing labels introduced for PME, PNB, TN-S and TT supplies.

Version	4.0	**Review Date**	31/07/2019
Date	31/07/2015	**Author**	Stephen Tucker

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

What has changed:

- Section 5.2 supplies to railway installations clarified.
- EDS 06-0017D & EDS 06-0017E railway application and assessment forms revised.
- Section 5 supplies to temporary installations (5.4), caravans and motor caravans (5.7), caravan sites, campsites and sports pavilions (5.8), boats, marinas and similar locations (5.9), mobile homes (5.10), fuel filling stations (5.12) and oil refineries and oil distribution centres (5.13) added.
- Section 5.18.2 additional street furniture loads and associated electrode resistances added to Table 7.2.
- HV supplies removed and replaced with references to other standards in the scope.
- Document title amended.

Version	3.1	**Review Date**	
Date	22/08/2012	**Author**	Stephen Tucker

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

Version	3.0	**Review Date**	
Date	01/02/2012	**Author**	Stephen Tucker

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

Version	2.1	**Review Date**	
Date	03/08/2011	**Author**	Stephen Tucker

Reclassification of document from Earthing Design Manual Section 7.

Version	2.0	**Review Date**	
Date	25/05/2011	**Author**	Stephen Tucker
Completely rewritten to provide a more consistent and practical approach and separated from LV network design			
Version	1.0	**Review Date**	
Date	31/03/2008	**Author**	Stephen Tucker/ Rob Weller
Original			

Contents

Figures

Tables

1 Introduction

This standard provides guidance on earthing of customer low voltage (LV) installations. It brings together a common approach to design and operation and has been written to provide guidance to designers, meter operators, developers and contractors.

This standard should be read in conjunction with the relevant the LV customer connection design standard which take precedence over this standard:

- EDS 08-2100 – LV Customer Supplies
- EDS 08-2101 – LV Customer Supplies up to 100A Single Phase
- EDS 08-2102 – LV Customer Unmetered Supplies

This document is based on ENA EREC G12/5 and also reflects the requirements of BS 7671:2018+A2:2022 (IET Wiring Regulations 18th Edition).

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.

This standard supersedes all previous EPN, LPN and SPN specific guidance on customer installation earthing.

2 Scope

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

For LV network earthing design refer to EDS 06-0016.

For secondary substation earthing design refer to EDS 06-0014.

3 Glossary and Abbreviations

Term[1]	Definition
Caravan*	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)
Class I Equipment*	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)
Class II Equipment*	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)
CNE	Combined Neutral and Earth. A cable where the neutral and protective functions are combined in a single conductor
Customer/Consumer	Any person who has responsibility for premises connected by agreement to distribution networks owned by UK Power Networks
Premise	Any area or building occupied by the customer
DNO	Distribution Network Operator. See distributor
Earth Electrode	A metal rod, plate or strip conductor buried in the earth for the purpose of providing a connection with the general mass of earth
ELI	Earth Loop Impedance. See Earth Fault Loop Impedance
EFLI*	Earth Fault Loop Impedance. 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.
Earthing Systems	See separate definitions and Appendix A for further details
EHV	Extra High Voltage. In the context of this document EHV refers to voltages at 132 kV, 66kV and 33kV
EPR	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. **Note:** 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
Equipotential Bonding	An electrical connection maintaining various exposed conductive parts and extraneous conductive parts at substantially the same potential (voltage)
Exhibition*	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
Exposed Conductive Part*	A conductive part (metalwork) of equipment which can be touched and which is not normally live but which can become live under fault conditions

[1] *Definitions taken from BS 7671.

Term[1]	Definition
Extraneous Conductive Part*	A conductive part liable to introduce a potential (voltage), generally earth potential, but forming part of the electrical installation (e.g. pipework, scaffolding etc.)
High EPR Site	A site where the EPR exceeds twice the permissible touch voltage limit or the 1200V stress voltage limit whichever is the lowest
HV	High voltage. Any voltage exceeding LV (as defined by The Electricity Safety Quality and Continuity Regulations 2002). In the context of this document, HV refers to 20kV, 11kV, 6.6kV, 3kV and 2kV
IDNO	Independent Distribution Network Operator
Main	A low voltage underground cable or overhead line which connects a substation to either a pot end earth, an overhead line earth or to another substation
LV	Low voltage. A voltage exceeding 50V (rms) measured between phases (or phase to earth) but not exceeding 1000V phase to phase or 600V phase to earth (as defined by The Electricity Safety Quality and Continuity Regulations 2002)
Marina*	Facility for mooring and servicing of pleasure craft with fixed wharves, jetties, piers or pontoon arrangements capable of berthing more than one pleasure craft
Mobile/Transportable Unit*	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
Motor Caravan*	Self-propelled leisure accommodation vehicle, used for touring, that meets the requirements for the construction and use of road vehicles (also see Caravan)
OPDD	Open PEN Detection Device. A device that detects a broken neutral and disconnects the supply
PME	Protective Multiple Earthing. A form of TN-C-S earthing. Refer to Appendix A for further information
RCD	Residual Current Device. Mechanical switching device designed to make, carry and break currents under normal service conditions and to cause the opening of the contacts when the residual current attains a given value under specified conditions
Secondary Substation	A substation with an operating voltage of 20kV, 11kV or 6.6kV and may include transformation to 400V. Also termed ‘Distribution Substation’
Second Fix	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
SNE	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
Service	A low voltage underground cable or overhead line, which connects a customer to a main or directly to a substation
Show*	Display or presentation in any suitable location, either a room, building or temporary structure
Stand*	Area or temporary structure used for display, marketing or sales

Term[1]	Definition
TN-C-S*	Terre Neutral-Combined-Separate. A system in which the neutral and protective functions are combined into a single conductor in part of the system. A DNO earth terminal can be provided at the customer's installation. Refer to Appendix A for further information
TN-S*	Terre Neutral-Separate. A system having separate neutral and protective conductors throughout the system. A DNO earth terminal can be provided at the customer's installation. Refer to Appendix A for further information
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. A DNO earth terminal is **not** provided at the customer's installation. Refer to Appendix A for further information
UK Power Networks (Operations) Ltd	UK Power Networks (Operations) Ltd consists of three electricity distribution networks as follows: • Eastern Power Networks plc (EPN) • London Power Network plc (LPN) • South Eastern Power Network plc (SPN)

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 are considered (Sections 4.2 and 4.4).
- The neutral conductor is appropriately sized.
- The earth fault loop impedance is within the specified limits (Section 4.5).
- An earth electrode is provided where required (ECS 06-0026).
- The earth terminal is labelled (ECS 06-0026).

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 earth terminal will be provided.

There are some situations (as detailed in Section 4.4) 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 detailed in ECS 06-0026.

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 use the earth terminal. This decision on whether to use the earth terminal is the responsibility of the designer of the electrical installation in accordance BS 7671, any additional UK Power Networks recommendations and other related industry regulations and guidance.

Note 2: All LV distribution networks should generally be assumed to be PME when providing new supplies, even if they were originally constructed using SNE cables. Therefore, all new installations shall meet the TN-C-S 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 may cause neutral current diversion (refer to Section 5.14.1) and uncertainty when isolating the supplies.

4.3 TT Earth

If the requirements for an earth terminal detailed in this document are not satisfied, a TT earthing system shall be used which will usually require an independent earth electrode and appropriate protection (e.g. RCD) in accordance with BS 7671.

The TT earthing system (and anything connected to it) shall be segregated by a minimum of 2.5 metres from all other earthing systems (TN-C-S, TN-S, TT) and a minimum of 8 metres away from any substation with separate HV/V earths and associated cables to limit the effect of transfer voltage between earthing systems. Where reasonably practicable, consideration should also be given to the presence of underground earth electrodes. The intention of this requirement is to ensure that significant hand-to-hand or hand-to-feet shock risk does not arise due to voltage differences between the two different earthing systems.

The supply, installation and maintenance of a TT earthing system is the responsibility of the customer.

4.4 Special Situations

Refer to Section 5 for more detailed information on all special situations including situations where a PME earth terminal is **not** permitted.

4.5 Earth Fault Loop Impedance

For guidance on earth fault loop impedance refer to EDS 08-2000, EDS 06-0004 and ECS 06-0026.

5 Special Situations

5.1 Overview

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 Section 6.

Table 5-2 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 in accordance with Section 4.3.

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.

Table 5-1 – Special Situations – Use of PME Earth Terminal

Situation	PME Earth Terminal	Refer to the document listed for the PME criteria or alternative earthing system(s)
Exhibitions, shows and stands	No	Refer to Section 5.4.1
Fairgrounds, amusement parks and circuses	No	Refer to Section 5.4.2
Mobile and transportable vehicles and units that contain an electrical installation for outside broadcast, medical services, advertising, catering services etc.	No	Refer to Section 5.4.2
Caravans and motor caravans	No	Refer to Section 5.7
Boats, marinas and similar locations	No	Refer to Section 5.9
Fuel filling stations (forecourt areas)	No	Refer to Section 5.12
Permanent buildings associated with the above installations e.g. living accommodation, office, restaurant, shop etc.	Yes	Provided the building is electrically separated and its electrical installation complies with the bonding requirements of BS 7671
Oil refineries, oil distribution centres and other explosive/flammable environments	No	Refer to Section 5.13
Construction and demolition sites	No	Use either TN-S or TT – refer to Section 5.3
Mines and quarries	No	Use either TN-S or TT – refer to Section 5.11
Railway installations	Yes	Refer to Section 5.2
Farms, agricultural and horticultural premises	Yes	Refer to Section 5.5 – PME shall not be extended into certain areas.
Sports pavilions and Swimming pools	Yes	Refer to Section 5.6
Caravan Sites, Campsites and Sports Pavilions	Yes	Refer to Section 5.8
Mobile homes	Yes	Refer to Section 5.10
Multiple occupancy buildings	Yes	Refer to Section 5.14
Metal-clad buildings	Yes	Refer to Section 5.15

Situation	PME Earth Terminal	Refer to the document listed for the PME criteria or alternative earthing system(s)
EV charging points in the highway	Yes	Refer to Section 5.17
EV charging points in premises	Yes	Refer to Section 5.17
Street lighting	Yes	Refer to Section 5.18.1
Street furniture	Yes	Refer to Section 5.18.2
Communication stations	Yes	Refer to Section 5.20
Mobile Phone Base Stations and Masts associated with Substations	Yes	Refer to Section 5.20
Cathodic protection installations	Yes	Refer to Section 5.21

5.2 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. If the various criteria cannot be satisfied a TT earthing system shall be used in accordance with Section 4.3 or alternatively dedicated TN-S supplies provided directly from a substation.

5.2.1 General

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

1. A sole PME earth terminal shall be provided (to avoid neutral current diversion[2]) unless any existing PME earth terminal is removed, or there is no likelihood of a common metallic coupling between the earth terminals.

2. All installations shall comply with the requirements of BS 7671, including equipotential bonding for PME conditions.

3. Metallic enclosures containing LV equipment shall **not** be 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 of metallic enclosures provided the earthing requirements of Section 5.19 are adopted.

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

5.2.2 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.

5.2.3 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 5.2.5.

2. The earth potential rise during fault conditions shall be less than the tolerable touch voltage limit, refer to EDS 06-0014 for further information and EDS 06-0012 for the limits.

   Note: 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.

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

   Note: ENA EREC G12 indicates that in a typical railway installation the voltage rise will not exceed 25V based on Network Rail testing. However, to satisfy the requirements above the rail operator shall confirm this in writing for the specific site where the LV supply is requested.

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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.

5.2.4 LV Supplies Associated with 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 5.2.5.
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 1 metre 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. If 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[3].
6. The voltage between the running rails and earth shall satisfy the requirements of BS EN 50122-1 i.e. less than 5V for normal running.
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.

   Note: 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.

5.2.5 LV Supplies for Sites Associated 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 1 metre from the PME earth through the soil.
- Simultaneous contact between LV earths and rail/other earths cannot occur (2.5 metres separation above ground).
- The requirements for LV supplies to AC traction systems (Section 5.2.3) and DC traction systems (Section 5.2.4) are both satisfied.

[3] If UK Power Networks are advised that corrosion has been detected, the supply shall be re-assessed using the assessment process in Section 5.2.7 and if appropriate the earth terminal shall be withdrawn and the rail operator advised to use a TT earthing system.
[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.

5.2.6 Other Electrified Systems

Refer to ENA EREP 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.

5.2.7 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 application form EDS 06-0017D (Appendix D).

Form EDS 06-0017E (Appendix E) should then be used to assess the application.

5.3 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.

5.3.1 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.

5.3.2 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 earth.
- TN-S (SNE) earth from a dedicated transformer.
- TN-S (SNE) earth via an isolating transformer.

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

Note: It is not permissible to derive an SNE service from a transformer that also supplies CNE circuits.

5.3.2.1 TT Earth

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 which will usually require an independent earth electrode and a residual current device (RCD) on the customer’s side of the cut-out.

Furthermore, it is recommended that there are no exposed conductive parts before and/or enclosing the RCD and that all trunking is non-conducting, unless it can be demonstrated that they are adequately protected.

The earth electrode shall be a minimum of 2.5 metres from all other earthing systems (TN-C-S, TN-S, TT) and a minimum of 8 metres away from any substation with separate HV and LV earths and associated cables to limit the effect of transfer voltage between earthing systems.

Note: The developer/contractor is responsible for maintaining the earth and protection in accordance with BS 7671.

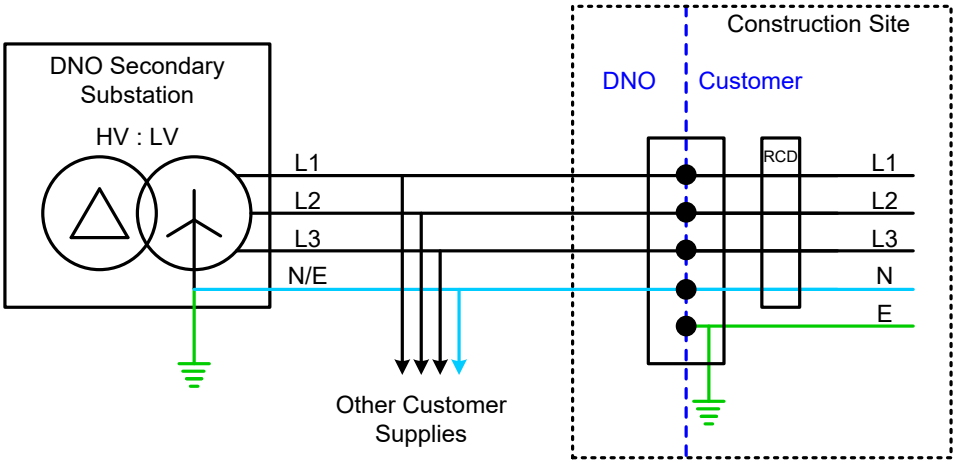


Figure 5-1 – Temporary Building Supply with a TT Earthing System

5.3.2.2 TN-S Earth 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 allow easier transition to a permanent supply when it is required.

Note: If the transformer interconnects with other parts of the LV network or supplies other customers via PME earthing arrangements, they shall be disconnected before the transformer is used to provide a temporary building supply.

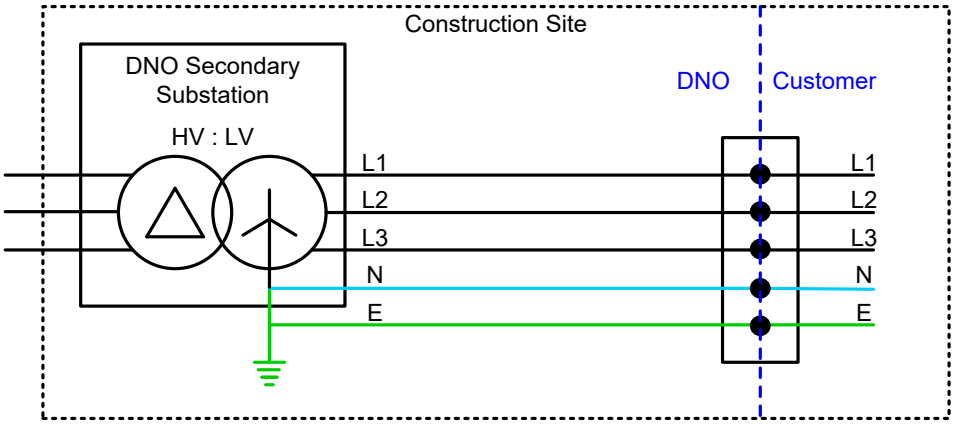


Figure 5-2 – TN-S Earth from a Dedicated Transformer

5.3.2.3 TN-S Earth 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 2.5 metres away from any PME earth electrode or exposed LV metallic cable sheath and a minimum of 8 metres away from any substation with separate HV/LV earths and associated cables to limit the effect of transfer voltage between earthing systems.

Note: The developer/contractor is responsible for maintaining the earth and protection in accordance with BS 7671.

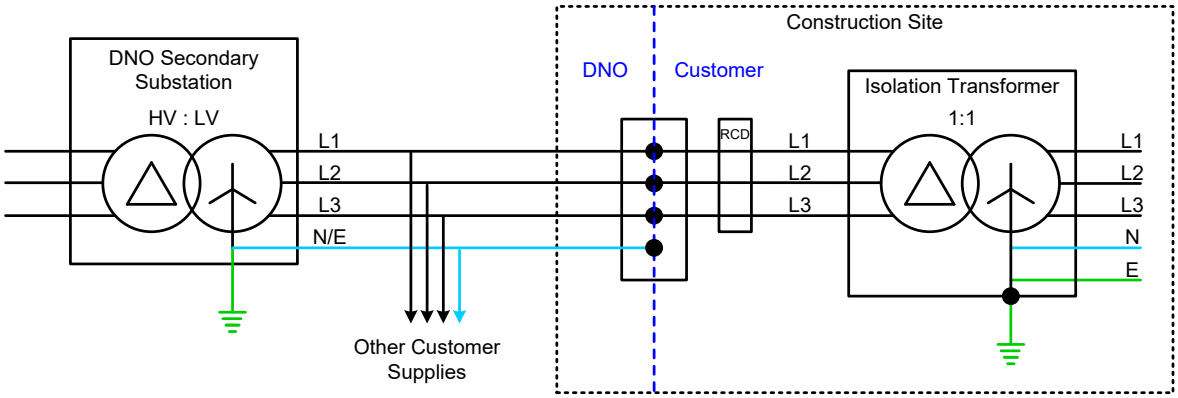


Figure 5-3 – TN-S Earth from an Isolating Transformer

5.3.3 Existing Buildings

A temporary building supply is often required for an existing building during construction works with scaffolding in place which already has a permanent supply. 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 are not 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 2.5 metres 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.

Form EDS 06-0017C (Appendix C) is available to allow a customer to demonstrate compliance with the above and accept responsibility.

5.3.4 Transition to a Permanent Supply

Although it is preferable, it is not always practical to remove the temporary 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 is complete or, a phased handover agreed between the customer and meter operator.
- The building installation satisfies 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 are not classified as extraneous conductive parts, as defined by BS 7671). It will usually be possible to satisfy this requirement 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 is a minimum of 2.5 metres from the permanent supply earth including equipment bonded to it.
- The site is in a reasonable condition and satisfies the meter operator's requirements.

Form EDS 06-0017C (Appendix C) is available to allow a customer to demonstrate compliance with the above and accept responsibility.

5.4 Supplies to Temporary Installations

5.4.1 Exhibitions, Shows and Stands (including music festivals etc.)

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.

5.4.2 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 Section 717 for the earthing and bonding requirements.

5.4.3 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.

5.4.4 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. metallic shipping containers, pods etc.).

If these conditions cannot be satisfied a TT earthing system shall be used in accordance with Section 4.3.

[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.

5.5 Farms, Agricultural and Horticultural Premises

The safety issues associated with farms premises include damp locations, possibility of contact with true earth potential and the presence of livestock.

Note: In addition to the normal shock risks to persons, livestock are very sensitive to small voltage differences and may experience low level shocks from voltages imported via the neutral/earth conductor of a TN-C-S system.

Electrical supplies to agricultural and horticultural premises are considered a special location in BS 7671 and Section 705 details the specific earthing and bonding requirements.

A PME earth terminal can typically be used in farms, agricultural and horticultural premises to earth buildings:

- Not occupied by animals, e.g. farmhouse, offices and shops etc.
- Occupied by animals where a bonded metal grid is installed in the floor.

Note: The electrical installer may use PME for some parts of the installation, and segregate the earthing conductor of each circuit and install a separate earth electrode for other buildings where the full equipotential bonding provision of BS 7671 Section 705 cannot be achieved.

If the relevant conditions or suitable segregation cannot be satisfied a TT earthing system shall be used for the whole installation in accordance with Section 4.3.

Note: It is the responsibility of the customer to ensure that any PME earth terminal is used appropriately, and the installation complies with the requirements of BS 7671.

5.6 Swimming Pools

Electrical supplies to swimming pools and other basins are considered a special location in BS 7671 and Section 702 details the specific earthing and bonding requirements.

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.

Alternatively, a TT earthing system in accordance with Section 4.3 may be used for the entire installation.

Note: It is the responsibility of the customer to ensure that any PME earth terminal is used appropriately, and the installation complies with the requirements of BS 7671.

5.7 Caravans and Motor Caravans

The Electricity, Safety, 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 in accordance with Section 4.3.

Refer to BS 7671:2018 Section 708 for additional 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.

5.8 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.

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 in accordance with Section 4.3.

Note: It is the responsibility of the customer to ensure that any PME earth terminal is used appropriately, and the installation conforms to the requirements of BS 7671.

5.9 Boats, Marinas and Similar Locations

The Electricity, Safety, Quality and Continuity Regulations 2002 preclude the provision of a PME earth terminal to boats, marinas and similar locations.

Electrical supplies to marinas and similar locations are considered a special location in BS 7671 and Section 709 details the specific earthing and bonding requirements.

A TT earthing system shall be used in accordance with Section 4.3.

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.

Where metallic bridges and pontoons connect boats with shore, the structure shall not be connected to PME earth terminal if it could come close to or contact a TT system. It is recommended to use TT for the on-bridge supplies (or to ensure all systems such as lighting are double insulated), however specialist advise should be sought if the structure is close to (or has services which may be bonded to) PME network supplies. A segregation distance of 2.5 metres between the pontoon and any existing shore services is recommended.

5.10 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 5.7.

Refer to BS 7671 Section 721 for the earthing and bonding requirements.

5.11 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 should **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 in accordance with Section 4.3.

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

Note: It is the responsibility of the customer to ensure that any PME earth terminal is used appropriately, and the installation complies with the requirements of BS 7671.

5.12 Fuel Filling Stations

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

Refer to *Guidance for the Design, Construction, Modification, Maintenance and Decommissioning of Filling Stations* published the APEA (Association for Petroleum and Explosives Administration) for further information on the earthing requirements.

Substations located at fuel filling stations have additional requirements, refer to EDS 06-0014 for further information.

Where the fuel filling station is part of larger site, a PME earth terminal may be provided to other permanent buildings (e.g. shops and restaurants that form part of a motorway service area) on the site provided the fuel filling station earth is segregated from the PME earth.

5.13 Oil Refineries and Distribution Centres

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

The TT earthing system shall be provided in accordance with Section 4.3.

Alternatively, an earth terminal from a TN-S system (directly from the transformer neutral) may be used provided 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.

Note: Most large refineries have 11kV or larger supplies and often run as a private network. Care is needed to ensure that different earthing systems are not introduced into these private networks (e.g. additional, standby supplies). The decision to segregate or bond needs careful consideration and a bonded strategy is normally preferred.

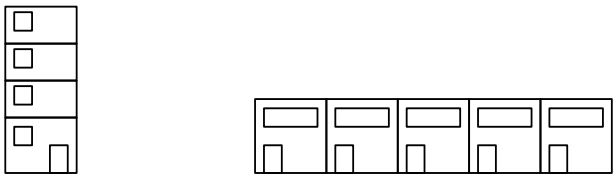
5.14 Multiple Occupancy Buildings

This section should be read in conjunction with design standards EDS 08-1103, EDS 08-2100 and EDS 08-2101 which detail the permissible supply options for multiple occupancy buildings and take precedence over the requirements in this section.

Note: Issues which can arise from incorrect earthing arrangements in these buildings include neutral current diversion (NCD), or occasionally shock risk from neutral voltage displacement (NVD). Multiple supplies can also present an issue in terms of isolation under emergency conditions. Refer to below and Appendix B for further information.

5.14.1 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).



High-rise e.g. Flats Low-rise e.g. industrial units

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 neutral earth electrode which may be impractical, particularly in multi-storey buildings.
- The problems caused by the flow of neutral current (refer to Appendix B) 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 with 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 design standards.

5.14.2 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 conductive parts within the customer's premises. For bonding purposes, the customer's installation shall be considered as 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 considered in accordance with Section 5.14.3 or multiple services to a single intake in accordance with 5.14.4.

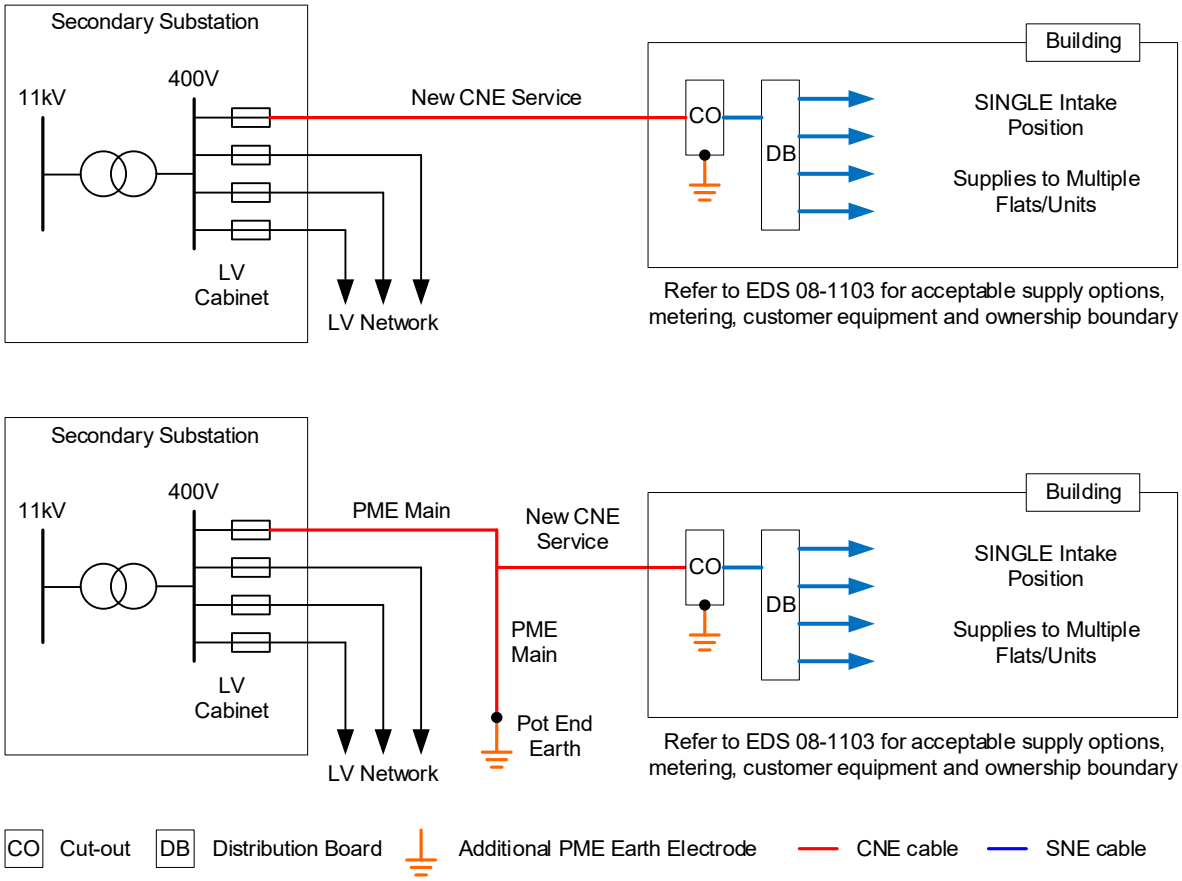


Figure 5-5 – Single Intake Supply Arrangements

5.14.3 New Building Design – Services to Multiple Intakes

It may not be practical to design using a single intake position for a horizontal run of steel-framed residential, industrial or commercial units. 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 suitable bonding 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.

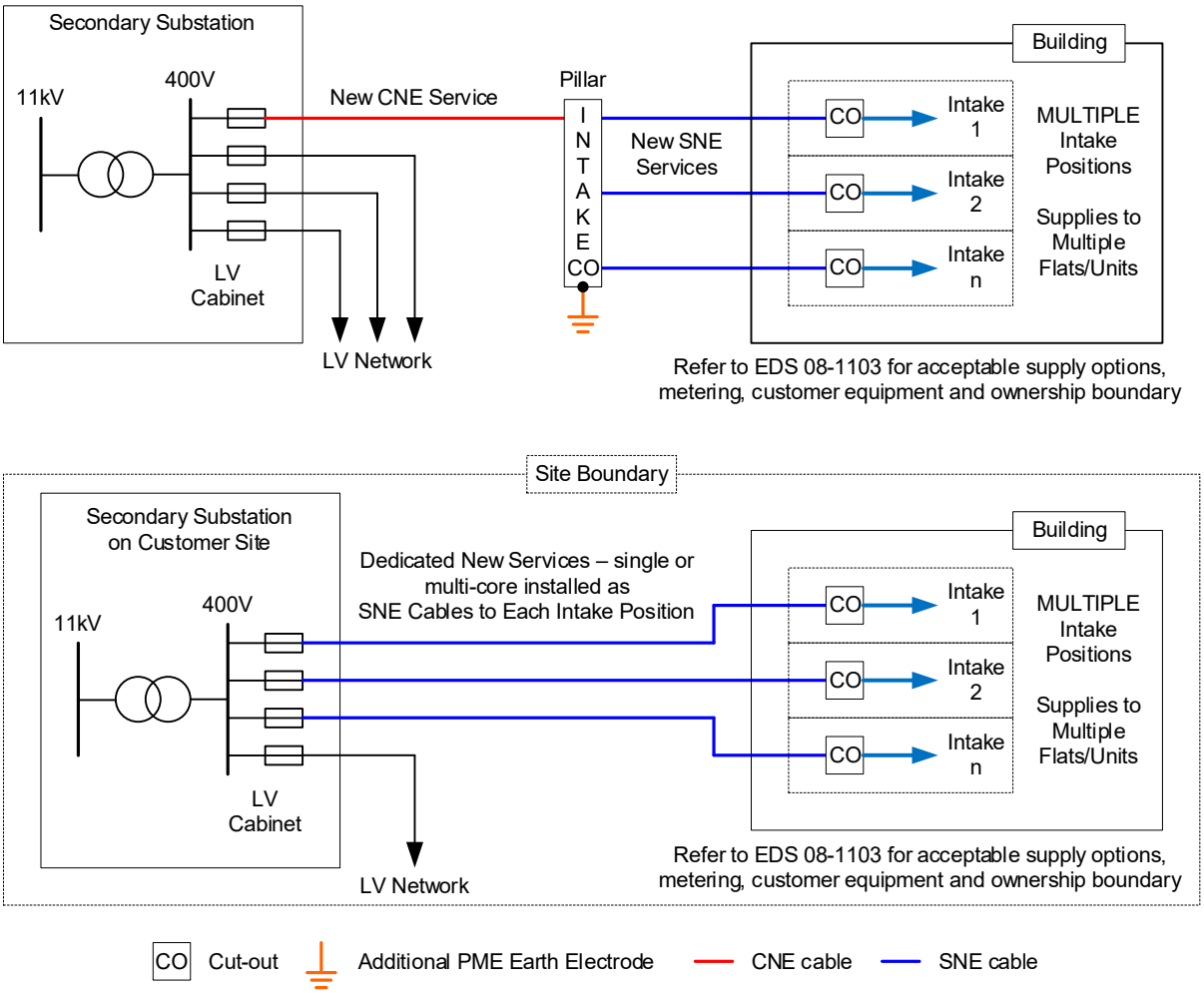


Figure 5-6 – Typical Multiple Intake Supply Arrangements

5.14.4 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 B) 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[6] together using a copper conductor covered in green/yellow PVC with a blue marker at each end (to indicate that it could be 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 11324K (refer to EAS 07-0021) fitted to each end.
- A warning label 07-0009.119 (refer to EAS 07-0021) shall be installed next to the cut-outs.
- 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.

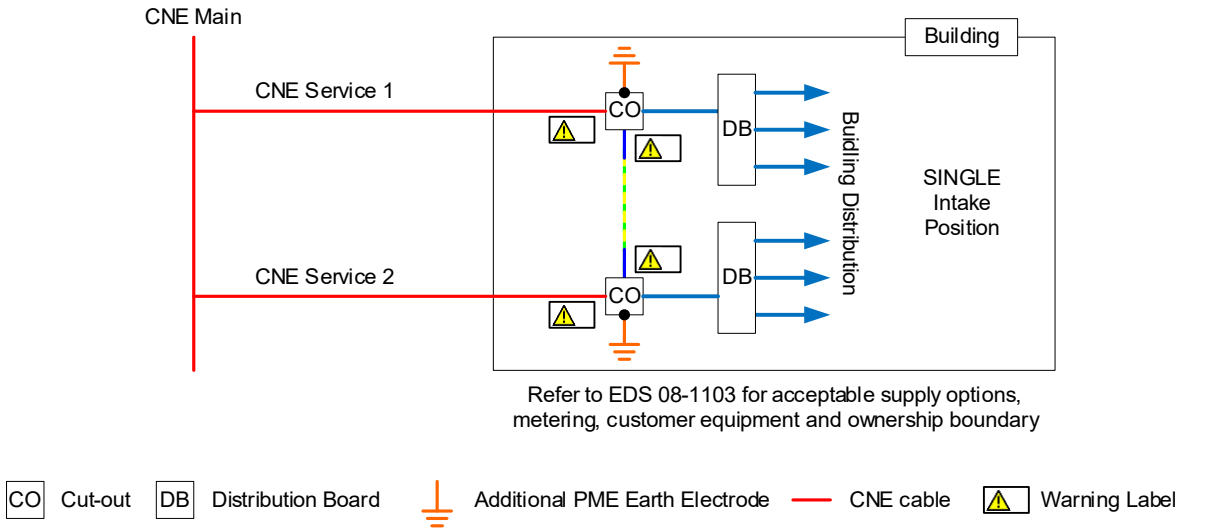


Figure 5-7 – Multiple Services to a Single Customer or Building

5.14.5 Existing Buildings

Wherever possible, i.e. when alterations or upgrades are requested, the requirements for new buildings detailed in Section 5.14.2 or 5.14.3 should be applied to existing buildings. If these cannot be satisfied the options should be based on the multiple services requirements detailed in Section 5.14.4.

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

[6] The neutral/earth bonding conductor prevents excessive current flowing through the customer's bonding in the event of a broken neutral conductor on the distribution network.

5.15 Metal-clad Buildings

Where permanent metal-clad buildings incorporate a steel-frame set in concrete or otherwise bonded to rebar or piles, this will provide a good connection with earth that will reduce the earth potential rise and touch voltages.

A PME earth terminal may be provided to a metal-clad building where the metal cladding is bonded to the steel-frame.

Note: For multiple occupancy buildings the criteria detailed in Section 5.14 shall also be satisfied.

For temporary metallic buildings e.g., shipping containers, market stalls etc. refer to Section 5.4.

5.16 LV Generators

For LV generator connections refer to ENA EREC G98 and G99.

For mobile LV generators refer to ENA EREC G84.

Note: Generators intended for standby (islanded) duty are generally designed to operate with their own electrode system (i.e. in absence of a mains supply). Specific requirements are detailed in the above standards to ensure that the neutral on the customer system is tied to this electrode only when required and not for normal (mains) running.

5.17 Electric Vehicle Charging Points

For guidance on permissible earthing options including use of open PEN protection devices (OPDD) for electric vehicle charging points refer to EDS 08-5050.

5.18 Street Lighting and Street Furniture

5.18.1 Street Lighting and Road Signs up to 500W

This section covers street lighting, road signs and other street electrical furniture where the foundation of the metallic structure is buried, and the electrical load does not exceed 500W.

The following requirements apply to all street lighting supplied by a DNO or street lighting authority using CNE cables and or a local authority or private installation using SNE cables:

- An earth electrode shall be installed at the point of supply (e.g. feeder pillar, feeder column) or at the end of the service supplying more than one lamp column as shown in Figure 5-8.
- An earth electrode shall be installed at the last lamp column position where the service supplies more than one lamp column as shown in Figure 5-8. This is intended to achieve a nominal 100 ohms or lower.
- An earth electrode shall be installed at every lamp column that is installed in an insulated sleeve.
- Metallic lamp columns shall not be used as earth electrodes.
- 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 metal parts (e.g. small doors and door frames) which cannot introduce a potential and cannot foreseeably become live in fault conditions do not need to be bonded.
- Segregated from any substation with separate HV and LV earths by 8 metres.
- The earth terminal and any external metalwork of street lighting fittings mounted on buildings or wooden poles shall be connected to the earth terminal unless the fitting is Class II insulated.

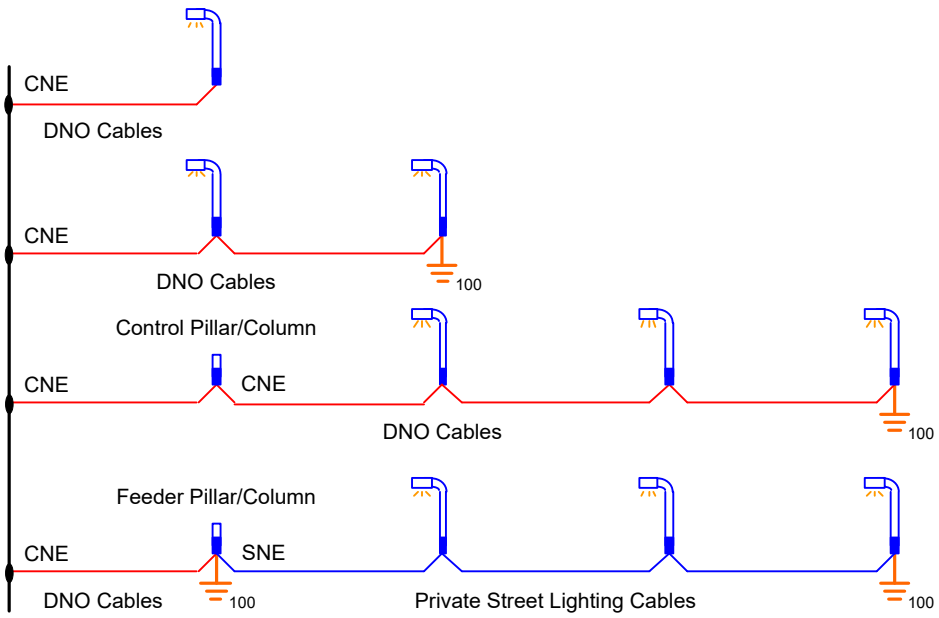


Figure 5-8 – Examples of Street Lighting Earth Electrode Positions

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.

5.18.2 Street Furniture and Other Housings/Enclosures Accessible to the Public Above 500W

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 above 500W.

Note: Supplies to electric vehicle charging points are covered by Section 5.17.

The practice of installing equipment in metallic enclosures is discouraged due to the risk of earthed metalwork becoming live in the event of a broken neutral and the difficulty in managing the touch and step 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 in accordance with Section 4.3.

A PME earth terminal may be provided to any street furniture that is either Class II 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 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 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 2.5 metres, and a minimum of 8 metres away from any substation with separate HV/LV earths.

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

Connection	Maximum Single-phase Load or Three-phase Overall Load Unbalance	Customer Earth Electrode Requirements[7]	Labelling Requirements
Balanced three-phase	No load unbalance	Not required	n/a
Unbalanced three-phase or single-phase	500W	100Ω	Refer to Section 6
	1kW	60Ω	
	2kW	20Ω	
	3kW	14Ω	
	4kW	11Ω	
	5kW	9Ω	
	6kW	7Ω	
	7kW	6Ω	

Note: Where permitted in BS 7671 an OPDD may be used as an alternative form of protection in accordance with ENA EREC G12. Refer to EDS 08-5050 for further guidance on the use of OPDDs.

[7] These values are based on ENA EREC G12/5 and have been selected to limit the touch voltage to 100V.

5.19 Metallic Enclosures

The use of metallic enclosures is discouraged however it is recognised there are some applications e.g. street furniture, communication, metering enclosures where the use of metallic enclosures is acceptable and necessary for mechanical protection. In these circumstances, the requirements detailed below and illustrated in Figure 5-9 shall be applied:

- The enclosure shall be operated and maintained by another utility, communication provider, knowledgeable authority etc. (i.e. **not** an enclosure associated with a domestic, residential or commercial electricity supply).
- The enclosure 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 enclosure and the grading electrode shall be connected to the earth terminal.
- The enclosure shall be positioned at least 2.5 metres from all other earthed metalwork and not connected to the same earth to avoid touch voltage risks arising from inadvertent contact between the pillar and the other earthed metalwork.
- The enclosure shall be positioned at least 2 metres from any substation and at least 8 metres from any secondary substation with separate HV/LV earths.

Note: Electric Vehicles connected to a TT earth are classed as 'other earthed metalwork'.

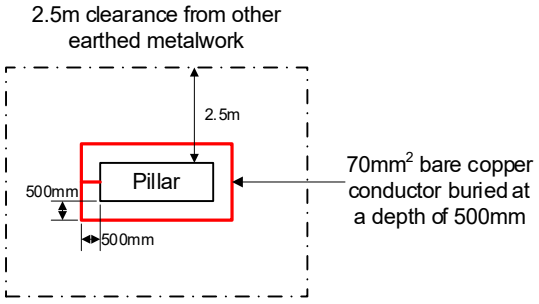


Figure 5-9 – Metallic Enclosure Earthing

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

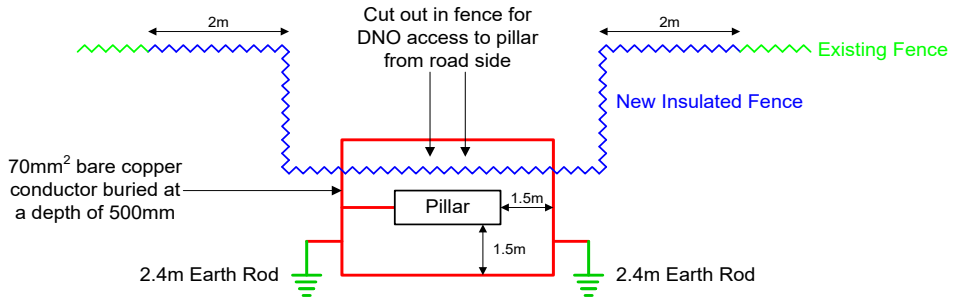


Figure 5-10 – Metallic Enclosure Earthing at Network Rail Sites

5.20 Communication Stations

5.20.1 Communication Stations with 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 in accordance with Section 4.3 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 possible neutral current diversion as described above.

5.20.2 Mobile Phone Base Stations and Masts Accessible to the Public

A PME earthing terminal may be provided to mobile phone base stations and masts with freestanding housings/structures accessible to the public the provided the rules for street furniture detailed in Section 5.18.2 are satisfied.

5.20.3 Mobile Phone Base Stations and Masts Associated with Substations

For mobile phone masts and base stations associated substations refer to EDS 06-0013 (grid/primary substations) or EDS 06-0014 (secondary substations).

5.20.4 Mobile Phone Base Stations and Masts on/in Buildings

Where mobile phone base stations and masts are installed on or within a building refer to EDS 08-1103 for available supply options and then refer to relevant section in this document.

5.20.5 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.

5.21 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 LPS does not exceed 10Ω it should be connected to the UK Power Networks LV earth via a removable and clearly labelled link (to facilitate disconnection under controlled conditions should this be necessary).

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.

5.22 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 in accordance with Section 4.3.

Cathodic protection is covered by BS 7361.

Note: The supply and installation of earthing system and protection is the responsibility of the customer.

5.23 High EPR Sites and National Grid Sites

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

5.24 IDNO Networks

For further guidance on IDNO networks, refer to EDS 08-1101.

6 Installation Requirements

Further details on the following can be found in ECS 06-0026:

- Cut-out earthing arrangement and labelling for TN-C-S, TN-S and TT earthing.
- Cut-out earth electrode.
- Service repair/upgrade earthing options.
- Lopped service earthing.
- Warning labels.

7 References

7.1 UK Power Networks Standards

EDS 06-0004	Earth Fault Loop Impedance Requirements (internal document only)
EDS 06-0012	Earthing Design Criteria, Data and Calculations
EDS 06-0013	Grid and Primary Substation Earthing Design
EDS 06-0014	Secondary Substation Earthing Design
EDS 06-0016	LV Network Earthing Design
EDS 06-0017C	Provision of a Permanent Supply to a Site with a Temporary Supply or Scaffolding Form
EDS 06-0017D	Railway PME Application Form
EDS 06-0017E	Railway PME Assessment Form (internal use only)
ECS 06-0026	LV Supply Earthing Guide
EAS 07-0021	Signs and Labels for Operational Sites
EDS 08-1101	IDNO Networks
EDS 08-1103	Multiple Occupancy Building Supplies
EDS 08-2000	LV Network Design
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 High EPR Sites and National Grid Sites
EDS 08-2109	LV supplies to Mobile Phone Base Stations Mounted on Transmission Towers (internal document only)
EDS 08-5050	Electric Vehicle Connections

7.2 National and International Standards

SI 2002 No. 2665	The Electricity Safety, Quality and Continuity Regulations (ESQC) 2002 as amended (2006)
BS 951	Electrical Earthing. Clamps for Earthing and Bonding. Specification
BS 7671:2018+A2:2022	Requirements for Electrical Installations (IET Wiring Regulations 18th Edition)
BS 7430	Code of Practice for Earthing
BS 7361	Cathodic Protection
BS 7375	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 G12/5+A1	Requirements for the Application of Protective Multiple Earthing to Low-voltage 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 G98	Requirements for the Connection of Fully Type Tested Micro-generators (up to and including 16 A per phase) in Parallel with Public Low Voltage Distribution Networks on or after 27 April 2019
ENA EREC G99	Requirements for the Connection of Generation Equipment in Parallel with Public Distribution Networks on or after 27 April 2019
ENA EREC P24	AC Traction Supplies to British Rail
ENA EREP 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
	Guidance for the Design, Construction, Modification, Maintenance and Decommissioning of Filling Stations published by the APEA

Appendix A – Earthing Systems (informative)

A.1 IEC Standard for the Naming of Earthing Systems

Mains electricity systems are categorized in IEC 60364-1 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).

A.2 TN-S (Terre-Neutral Separated)

In a TN-S earthing system (refer to Figure A-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.

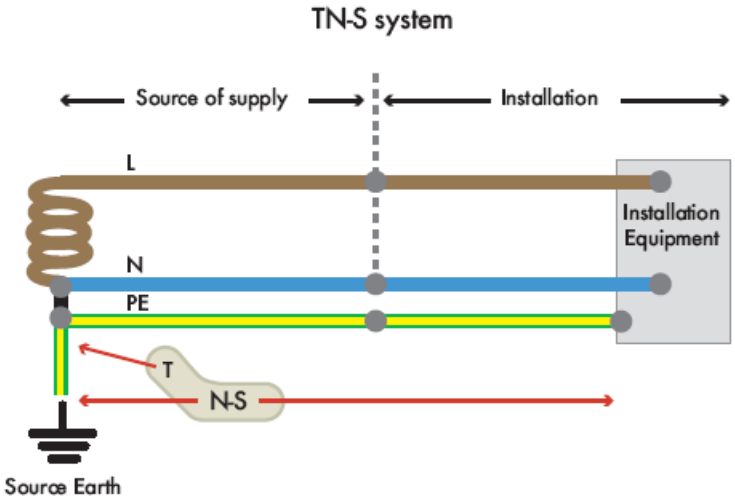


Figure A-1 – TN-S Earthing System

A.3 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 A-2) is a variant of the TN-C-S earthing system but additional earth electrodes are connected to the neutral.

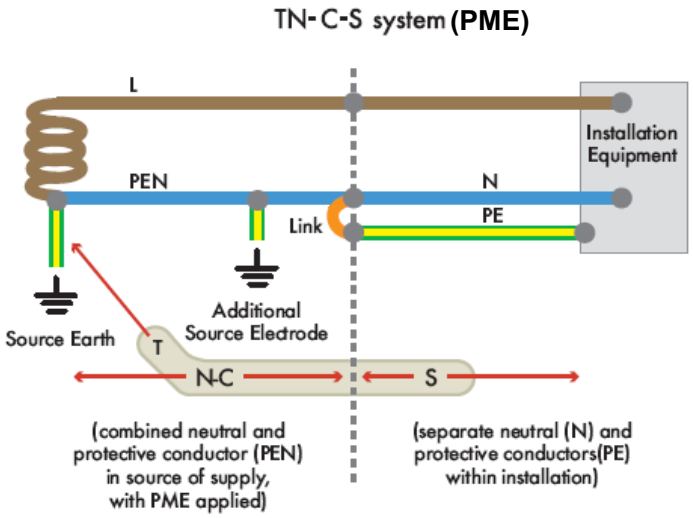


Figure A-2 – PME Earthing System

PNB (Figure A-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.

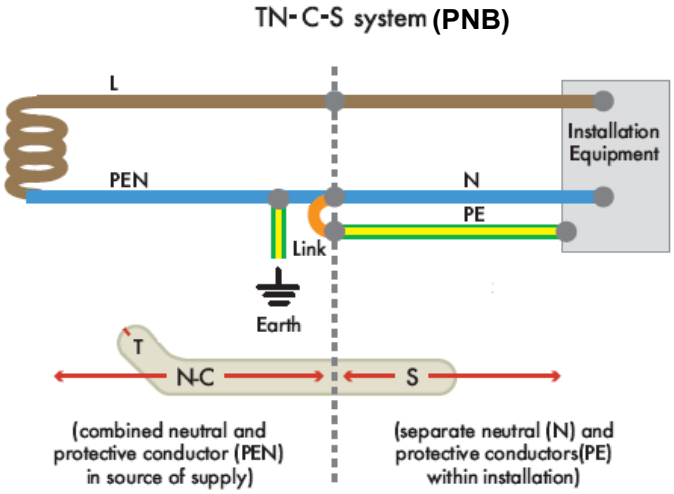


Figure A-3 – PNB Earthing System

A.4 TT (Terre-Terre)

In a TT earthing system (Figure A-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.

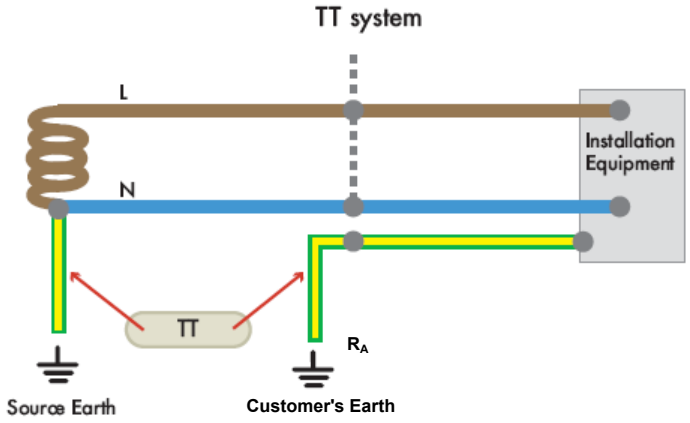


Figure A-4 – TT Earthing System

Note:

- The resistance of the earth electrode shall be low enough to ensure that under fault conditions the voltage on exposed metalwork will not exceed 50V.
- BS 7671:2018+A2:2022 411.5.3 (ii) states that $R_A I_{\Delta n} \leq 50$ V where R_A is the customer's electrode resistance and $I_{\Delta n}$ is the rated residual operating current of the RCD.
- BS 7671 also suggests that R_A should not exceed 200Ω otherwise it may not be stable.
- BS 7671 generally requires the use of an RCD / RCBO for domestic properties, including installations which utilise a distributor's earth terminal; these systems are not necessarily TT systems.

Appendix B – Neutral Current Diversion (informative)

Neutral current diversion (NCD) can occur within the structure of a steel-framed building or buildings with shared metallic services, which are supplied with multiple services from a combined neutral and earth network, due to a broken neutral (Section B.1) or unbalanced load (Section B.2).

B.1 Broken Neutral

When 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 B-1 (a) shows the normal flow of neutral current and Figure B-1 (b) shows the flow of neutral current through the building structure due to a broken neutral.

NCD and the associated risks are usually mitigated 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.

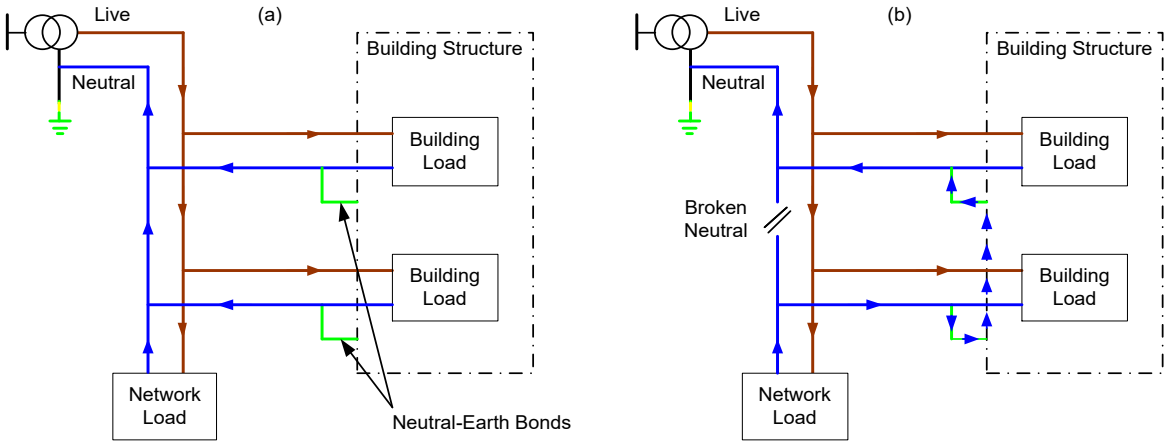


Figure B-1 – Effect of a Broken Neutral when Multiple Services from a CNE Network are provided to a Steel-framed Building

B.2 Unbalanced Load

Unbalanced three-phase loads and single-phase loads cause current to flow in the neutral conductor. NCD occurs when multiple CNE services are provided to the same building and an alternative path exists, for example through the structural steelwork of a building and an earth bond, to the other neutral/earth terminal.

The natural passage of neutral current through the structural steelwork and bonding conductors may result in overheating and consequential fire risk. It is for this reason that BS 7671 recommends certain sizes for customer (protective) equipotential bonding.

Appendix C – Temporary/Permanent Supply and Scaffolding Form

The form below should be completed by the customer requesting energisation of a permanent supply while a temporary supply and/or scaffolding is still in place as detailed in Section 5.3.4.

- EDS 06-0017C Provision of a Permanent Supply to a Site with a Temporary Supply or Scaffolding Form.

Appendix D – Railway PME Application Form

The form below should be completed by the railway operator when requesting a PME supply associated with a railway as detailed in Section 5.2.

- EDS 06-0017D Railway PME Application Form.

Appendix E – Railway PME Assessment Form and Flowchart

The form and flowchart below can be used to assess an application for a PME supply associated with a railway as detailed in Section 5.2.

- EDS 06-0017E Railway PME Assessment Form (internal use only).

Appendix F – Legislation (informative)

The Electricity Safety, Quality and Continuity Regulations 2002 contain several clauses on customers' installations and the provision of earthing facilities. A summary of the relevant regulations is included below.

Citation, commencement and interpretation

1 (5) In these Regulations, unless the context otherwise requires:

Distributor means a party that distributes electricity to customers using electrical lines and equipment that they own or operate.

Consumer means any person supplied or entitled to be supplied by a supplier but in regulations 24, 25 and 26 shall not include, in respect of any supply to meet haulage or traction requirements, any person who is an operator of a network within the meaning of Part I of the Railways Act 1993(1).

Consumer's installation means the electric lines situated upon the consumer's side of the supply terminals together with any equipment permanently connected or intended to be permanently connected thereto on that side.

Electric line means 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; and

(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.

Distributing main means a low voltage electric line which connects a distributor's source of voltage to one or more service lines or directly to a single consumer's installation.

Street electrical fixture means 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.

Service line means any electric line which either connects a street electrical fixture, or no more than four customers' installations in adjacent buildings, to a distributing main.

Supplier means a person who contracts to supply electricity to consumers.

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.