

Category 1 Standard

S1957 The System – Earthing Specification

(formerly Powerlink Technical
Specification SP81201 Rev 4)

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1 Purpose

- 1.1 The purpose of this LU Standard is to apply technical requirements for equipment and systems on the LU power system through the inclusion of a technical specification, previously owned and managed by the Power Service Contractor, UK Power Network Services (UKPNS) Powerlink, as an attachment to this standard.

2 Scope

- 2.1 This Standard applies to equipment and systems on the LU power system.

3 Requirements

- 3.1 The mandatory requirements of this standard are set out in Section 7 as an attachment to this document.
- 3.2 Where an attachment refers to the 'Contractor' it should be taken to mean LU and LU Suppliers following the termination of the Power Service Contract.
- 3.3 Where the attachment refers to the 'System' it should be taken to mean the LU power system including its associated SCADA system and the operational properties.

Note: It is the intention to fully re-work this LU standard into the standards format over a period of time. While the content of the ex-Powerlink specification should not conflict with the remainder of the LU standards suite, should any discrepancies occur, these should be brought to the attention of the LU technical authority.

4 Responsibilities

- 4.1 **The Head of Power Engineering** is responsible for the technical content of this standard. Concessions in relation to this standard shall be directed to the Head of Power Engineering who has overall accountability for compliance with this standard. The Head of Power Engineering may request support from the other technical authorities when reviewing concessions or queries arising from the application of this standard.
- 4.2 **LU and LU Suppliers** shall be responsible for compliance with the requirements of this standard.
- 4.3 **Heads of Profession** are the LU technical authorities for each asset group, and shall be responsible for auditing technical compliance with this standard in accordance with the engineering asset grouping of LU Standard S1041 and with respect to the assurance of assets to which they are accountable for. They shall provide support to the Head of Power Engineering, if requested, with regard to any technical issues arising from concession requests or other queries to this standard.



5 Supporting information

5.1 Background

- 5.1.1 From the 16th August 1998 through to the 15th August 2013 the LU power system was operated, maintained, renewed and upgraded by UKPNS Powerlink under the Power Services Contract. The contract was a Private Finance Initiative contract where UKPNS Powerlink were responsible for setting the detailed technical requirements for the LU power system.
- 5.1.2 At the start of the Power Service Contract on 16th August 1998 LU transferred its detailed technical standards for the LU power system to UKPNS Powerlink. Powerlink has owned and managed these technical standards as Powerlink technical specifications for the duration of the Power Service Contract.
- 5.1.3 The Power Service Contract ceased on the 16th August 2013 and the UKPNS Powerlink technical specifications for the LU power system were transferred back into LU as Category 1 standards.

Note: At the time this standard was produced, it was deemed necessary to utilise a non-standard for standard format. This however, does not diminish the mandatory requirements contained within the attachments.

5.2 Safety, Environment and Customer Considerations

- 5.2.1 Safety, environment and customer considerations relevant to this engineering standard are covered within the text of the attachment.

6 References

6.1 References and Abbreviations

- 6.1.1 Where references and abbreviations are used in this engineering standard they are given within the text of the attachment.

6.2 Definitions

- 6.2.1 Where definitions are used in this engineering standard they are given within the text of the attachment.
- 6.2.2 The following topic specific definitions are created:
- a) Within London Underground's Glossary of Terms (1-622)
(a Category 1 Standard);

Term	Definition	Source
LU	London Underground is the operating company of the former London Underground Limited.	a
Supplier	Supplier to London Underground, the primary organisation or individual that is selected to deliver a product, service or facility to London Underground and contracting directly to London Underground. This includes Consultants, Contractors, Infracos and PFI Contractors and excludes organisations or individuals selected by and contracting directly to them.	a



6.3 Person Accountable for the Document

Person accountable for the document
Phil Carmichael - Head of Power Engineering

6.4 Document History

Issue no	Date	Changes	Author
A1	Aug 2013	Incorporation of UKPNS Powerlink technical specification SP81201 Rev 4 as Category 1 LU Standard following the termination of the Power Services Contract as per DRACCT No. 01934. No technical requirements have been changed.	G Bloch



7 Attachment - Technical Specification SP81201 Rev 4 (Ex Powerlink)

1 Introduction

This specification is for use only within the scope of the London Underground Limited (LUL) Power Service Contract (PSC) with UK Power Networks Services Powerlink (Powerlink). It is one of a series of specifications which mandate UK Power Networks Services Powerlink (Powerlink) technical and associated requirements for equipment for use on The System.

These specifications are supported by Powerlink Work and Operating Instructions, and Design documentation where appropriate. This Specification shall also be read in conjunction with Powerlink document SP80001 “Common and General Requirements for Fixed Installation Power Supply Equipment” and LU Standard 1-106 “Earthing and Bonding of LU Electrical Networks”.

2 Purpose

This specification states the requirements for the design of earthing systems used for mains and plant at all voltages on The System in accordance with the requirements of BS EN 50122-1 and applicable LU, national and international standards.

The requirements take into account existing System assets and provide a standard approach.

3 Scope

This specification applies to new substations, (including transformer rooms, switchrooms, Bulk Supply Points, Track Paralleling Rooms and other electrical supply points) connected to The System, and to existing sites where a Material Alteration takes place.

It shall be used in conjunction with Powerlink equipment specifications containing earthing requirements specific to that equipment.

Note: It is essential that the earthing requirement is addressed as one of the first design considerations and reference made to it in the Conceptual and Outline Design.

4 Definitions

The technical definitions given in the PSC (Schedule 1 – Definitions), European, International and British Standards referred to herein, apply to this specification together with the following:

Auxiliary Earth Electrode	A metal part which is in conductive contact with the earth directly or via damp concrete, whose original purpose is not earthing, but which fulfils all requirements of an earth electrode without impairment of the original purpose. Examples include pipelines, sheet piling, foundations, reinforcing bars in concrete and the steel structure of buildings.
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Bleed (Conductor Rail Earthing) Resistors	Two resistors connected in series between the positive and negative traction conductor rails, connection tappings being provided at the midpoint between the two resistors for a reference connection to earth.
Bond	Connect together, electrically, two or more conductors, whether or not these are normally used for conducting electricity.
British Standard	A standard published by the British Standards Institution. Its alphanumeric identity is prefixed by BS.
Conceptual and Outline Design documentation	The document(s) issued by Powerlink at the Outline Design stage defining the scope of work, specifying performance, unique operational and design requirements, and identifying service location specific electrical, environmental and interface characteristics.
Delivery Points (for supply of power)	For the supply of electricity the outgoing terminals of the relevant switchgear as defined in the PSC.
Delivery Points (for limits of Powerlink responsibility for earthing)	The provision for connection to the earth system at each Delivery Point for the supply of power.
Detailed Design stage	The stage at which the detailed requirements for equipment and/or work are developed. The proposed design, equipment and/or work are checked at this stage for compliance with the PSC and relevant specifications, and where necessary the concessionary request procedure is initiated.
Earth (to) Earth (verb).	To make an electrical connection between a given point (in a system or in an installation or in equipment) and a local earth.
Earth Electrode	This is a conductor in direct contact with the soil and provides the conductive part in electrical contact with earth through which the fault current flows to ground. It can be a rod, tape, steel reinforcing bar segments within building foundations, electrically conducting tunnel lining, or the sheath of some types of cable.
Earth Electrode Test Link	A link fitted to an earth electrode in a test pit/inspection chamber, to permit use of clamp-type earth testers. The link must be readily accessible and identifiable. (See Appendix D).
Earth Electrode System	A collection of earth electrodes in a locality forming an enhanced connection to earth.
Earth Electrode System Test Link	An approved link fitted between the substation main earth bar and the earth electrode system, to permit use of clamp-type earth testers. The link must be fitted within the building, readily accessible and identifiable. It shall be bare copper at least 10cm long and of an equivalent size to 300mm ² and can be removed for normal testing. (See Appendix C).
Earth Potential Rise	The potential on exposed metalwork and the earth electrode or conductor during fault conditions, relative to remote earth. Note that this value will differ at various points on a large earthing system. (See Appendix E).



Earthing Schematic Diagram	A diagram showing the location and connections to Earth Electrode Systems, Main Earth Bars and Subsidiary Earth Bars. Each item of Earth User equipment is identified on the diagram.
Earth Supplier	The LUL Supplier, or third party, who has responsibility for the site and for maintaining an Earth Distribution Network and any associated Earthing Systems excluding the DNO / Grid Supplier
Earth User	The LUL supplier that requires a connection to an Earthing System or Earth Distribution Network for the purpose of earthing their equipment, structures, systems and assets.
Earthing Management Plan	A document describing the methods of earthing and the rationale of earthing arrangements.
Earthing Conductor.	This is a conductor which connects (bonds) plant, equipment and electrodes to the Substation Main Earth Bar and is capable of carrying the prospective fault current.
Equipment	Equipment to include all component parts, cables, accessories and appliances.
Equipotential Bonding	Electrical connection putting various exposed conductive parts and extraneous conductive parts at a substantially equal potential. (BS EN 50122-1)
European Standard	A standard published by the European Committee for Standardisation or by the European Committee for Electrotechnical Standardisation. Its alphanumeric identity is prefixed by EN.
Exposed Conductive Part	A conductive part of equipment which can be touched and which is not a live part but which may become live under fault conditions.
Extraneous Conductive Part	A conductive part liable to transmit a potential including earth potential and not forming part of the electrical installation.
Frame Earth Leakage Protection	A busbar protection scheme reliant on detecting the passage of fault current from the switchgear frame to earth.
Functional earth	Connection to Earth necessary for the proper functioning of electrical equipment (systems and assets). (BS 7430)
High Voltage (HV)	All voltages in excess of the low voltage limit.
International Standard	A standard published by the International Electrotechnical Commission. Its alphanumeric identity is prefixed by IEC.
Interconnecting Earth Bar(s)	(Two) conductors connecting the main substation earth bar with subsidiary earth bars.
Low Voltage (LV)	In relation to alternating current, a voltage exceeding 50 volts rms but not exceeding 1000 volts rms, in each case measured between phase conductors. In relation to direct current, a voltage exceeding 120 volts but not exceeding 1500 volts.



Material Alteration	The factors which determine when attention is required to the earthing of an existing substation. They include: Construction activities that involve more than direct replacement, on a like for like basis, such that they interfere with the integrity of the earthing system. The earth fault level being increased significantly. The construction of circuits supplying the site is changed and so increases the amount of fault current returning via the soil.
Operational environment	The physical and electrical conditions under which the equipment is to operate.
Outline Design stage	The stage at which the main requirements for the equipment and/or work are specified by Powerlink.
Potential Grading	Control of the earth potential, especially the earth surface potential, by means of earth electrodes.
Powerlink Operating Instruction	A document published by Powerlink which provides guidance on the application of the Safety Rules and to direct policy on operational limits and procedures.
Powerlink Specification	A document published by Powerlink which mandates technical and associated requirements for equipment for use on The System. Its alphanumeric identity commences with SP8.
Powerlink Work Instruction	A document published by Powerlink which describes the methods, tools and detailed procedures for the execution of physical work or inspection of Powerlink plant, equipment and buildings.
Power Service Contract (PSC)	The contract awarded by LUL to Powerlink to deliver low voltage three phase and single phase power; dc power; signalling equipment power; low voltage dc power; Docklands Light Railway high voltage a.c. power; emergency power; and compressed air to prescribed delivery points. Note: The performance requirements of the Power Service Contract are contained in the LUL Standard 1-105.
Section 12 Area	An area, below ground level, which is considered to be of greater risk to personnel in the event of a fire. These premises are covered under the Fire Precautions (Sub-Surface Railway Stations) England Regulations 2009.
Substation	Installation on the Underground Network consisting of a building containing rectifiers, dc switchgear, high voltage switchgear and/or transformers and which may contain low voltage switchgear, signal motor-generators, signal switchgear or compressors. For the purposes of this specification, this also includes transformer rooms, switchrooms, Bulk Supply Points, Track Paralleling Rooms and other electrical supply points connected to the System.



Substation Main Earth Bar	The conductor situated on at least one wall of a substation to which all exposed conductive parts, extraneous conductive parts and electrodes are electrically connected.
Substation Main Earth Test Link	See Earth Electrode System Test Link
Substation Subsidiary Earth Bar	An extension of the Substation Main Earth Bar, to other buildings or floor levels, to provide locally the same function as the Substation Main Earth Bar.
Switchgear Earth Bar	The earth bar associated with switchgear, normally an integral part of the equipment, to which switchgear panel metalwork and cable sheaths are connected. In substations where the HV switchgear has frame leakage protection fitted there will be two earth bars. Exposed metalwork containing the HV switchgear will be connected to the frame leakage earth bar. This earth bar passes through a frame leakage current transformer before connection to the substation main earth bar. The earth electrode system and cable sheaths are connected to the substation main earth bar.
The System	System means the electrical conductors and apparatus for the distribution and control of electricity from any Bulk Supply Points (and for the avoidance of doubt, excluding any assets belonging to any Distribution Network Operator) and from and including the Generating Stations to and including the Delivery Points and for the production of compressed air all as at the Starting Date and includes the Electrical Control Equipment, the interests in and rights in respect of the Properties granted under this Contract (PSC) but excludes LU's Distribution System, the IT Systems (other than the SCADA System) and the Telephony Systems the Waterloo and City Line, the District Line from Putney Bridge to Wimbledon and Gunnersbury to Richmond, the Bakerloo Line from Queens Park northwards and the interface with the System for each such part as is set out in the Performance Specification and as altered by the Contractor, any Variation, any Known Third Party Works or adoption of Third Party Works.
Transition Earth Bar	An earth bar allowing the termination of one or more earth connections that cannot be made directly to the main substation or subsidiary earth bar (e.g. non-welded connections). The transition earth bar is connected via a properly jointed dropper bar or main earth test link – to which it is attached.



5 Abbreviations

CRR	Continuous Running Rail. One running rail of each track designated and longitudinally bonded to form one continuous conductor for the length of each traction current section.
DNO	Distribution Network Operator
EPR	Earth Potential Rise
FFL	Finished floor level
LSNH/LSOH	Low Smoke Non-Halogenated / Zero Halogen
LU	London Underground
MDPE	Medium Density PolyEthylene
PAV	Permanent Accessible Voltage
Powerlink	UK Power Networks Services Powerlink
PSC	Power Service Contract
SCADA	Supervisory Control and Data Acquisition
TAV	Temporary Accessible Voltage

6 Legislation and Regulations

The earthing arrangements shall comply with the requirements of all relevant legislation, acts, rules, regulations or orders and amendments thereto, including:

- (a) Health and Safety at Work Act 1974;
- (b) Electricity at Work Regulations 1989;
- (c) Electricity Safety, Quality and Continuity Regulations 2002 (including Electricity, Safety, Quality and Continuity (Amendment) Regulations 2006);
- (d) Construction (Design and Management) Regulations 2007;
- (e) The Railways and Other Guided Transport Systems (Safety) Regulations 2006;
- (f) Fire Precautions (Sub-surface Railway Stations) (England) Regulations 2009;
- (g) New Regulatory Reform (Fire Safety) Order 2005;
- (h) European Union directive 2004/108/CE;
- (i) The Control of Noise at Work Regulations 2005;



- (j) Health and Safety (Safety Signs and Signals) Regulations 1996;
- (k) Provision and Use of Work Equipment Regulations 1998;
- (l) Manual Handling Operations Regulations 1992;
- (m) Lifting Operations and Lifting Equipment Regulations (LOLER) 1998;
- (n) Control of Substances Hazardous to Health Regulations 2002 (as amended).
For substances falling within these regulations the supplier shall provide a risk assessment covering the life of the equipment and its eventual disposal. Materials containing asbestos, chlorinated fluorocarbons (CFCs) or polychlorinated biphenyls, (PCBs) shall not be used.
- (o) The Utilities Contracts Regulations, 2006

Cognisance shall be taken of relevant sources of guidance, for example:

- (i) The Office of Rail Regulation (HM Railway Inspectorate) Railway Safety Principles and Guidance;
- (ii) The Health and Safety Executive guidance notes and other publications.

This information is not exhaustive and does not modify the legal obligations of the supplier.

When required by Powerlink, the supplier shall demonstrate compliance with current relevant legislation and regulations.

The Contractor shall provide advice to enable Powerlink to comply with all relevant legislation for the installation, operation, maintenance and eventual removal of the equipment, including as necessary, but not limited to, provision of safety signs, ancillary or emergency equipment, and appropriate procedures.

7 References and Compliance with Standards

Documents are referred to throughout this Specification by title and/or alphanumeric identity and additionally listed in Appendix A. Some are mandatory, others provide information or guidance. Unless specified otherwise, reference shall be made to the latest editions.

7.1 European, International and British Standards

The installation shall comply with relevant European Standards whether or not reference is made to them and all other relevant standards, and the amplifications and clarifications of these standards specified in this document.

Where European Standards are absent, International Standards or national standards having currency within the European Community shall apply subject to the prior agreement of Powerlink.

7.2 LU Engineering Standards

The installation shall comply with the latest edition of applicable LU Engineering Standards whether or not reference is made to them.

7.3 Order of Precedence

The order of precedence shall be Powerlink standards, including specifications, work and operating instructions, LUL Engineering Standards and then European Standards.



8 General Clauses

8.1 Safety

The existing distribution system has a high degree of integrity and provides for local short time outages for maintenance and faults. However, long outages caused by the failure of the equipment may jeopardise the integrity of the distribution system, disrupt train services and give rise to risk to persons and property.

The equipment when installed shall ensure that the existing high degree of integrity of the distribution system is maintained and where practicable enhanced.

The equipment shall be safe at all times. Provision shall be made to ensure the safety of persons concerned in its installation, operation, maintenance, repair, testing and its eventual disposal. All items and connections for the safe operation, control and protection of the equipment shall be provided whether or not specifically mentioned. The equipment shall be capable of being operated in compliance with Powerlink documents MSP/SRP/020 'Safety Rules Relating to Work/Testing on LV Equipment' and MSP/SRP/025 'Safety Rules Relating to Work/Testing on HV Equipment'.

The earthing installation shall provide protection against electric shock in accordance with EN 61140 and help ensure that electrical values after isolation shall comply with Clause 8.2 of EN 61140.

Where innovative features not previously supplied for use within the London Underground environment are proposed, Powerlink shall be advised at the tender stage.

8.2 Design, Manufacture and Workmanship

The earthing installation shall be designed, manufactured and tested in accordance with current practice, taking into account the environment and electrical distribution system in which it is to be installed and operated. All materials shall be of the quality and of the type most suitable for working under the conditions specified for the full service life of the installation.

8.3 Spare Parts and Consumables

Recommendations shall be provided to Powerlink for the quantities of spare parts and consumables considered necessary to ensure that the installation complies with this specification throughout its specified service life. The extent of commonality with equipment previously supplied or in service shall be indicated.

Recommendations shall include data on prices, availability and delivery times, and expected service life or rate of replacement.

8.4 Description of the Operational environment

Details of the physical and electrical environment of the power systems are provided in Powerlink Specification SP82603 'Physical and Electrical Environment of The System'.

The installation shall be suitable for its rated characteristics when installed in the operational environment described in SP82603, and as may be supplemented by Powerlink.