

Category 1 Standard

S1069

Low Voltage Electrical Installations

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1 Purpose

- 1.1 The purpose of this standard is to ensure that Low Voltage (LV) electrical sub-distribution systems and installations on London Underground (LU) premises are designed, installed, maintained and operated in a safe and effective manner.

2 Scope

- 2.1 This standard applies to all LV electrical distribution, sub-distribution, final circuits and installations on LU premises as follows:
- For installations supplied from the LU Low Voltage Alternating Current (LVAC) supplies, from the Delivery Point as defined by LU standard S1105;
 - For Tunnel Lighting controls supplied from the LU Direct Current (DC) traction conductor rail,
 - For installations supplied by a Distribution Network Operator (DNO) to LU dedicated local High Voltage (HV)/LV transformers, from the point of isolation on the secondary side of the transformer;
 - For installations supplied from a DNO LVAC supply, from and including the outgoing cable at the DNO cut-out.
 - For installations supplied from self generating power supplies, including the power source.
- 2.2 This standard does not apply to Off Line Battery Inverters (OLBIs), DC traction systems and signalling supplies at 33.3Hz and 125Hz.

3 Requirements

3.1 Requirements for safety

- 3.1.1 Safe systems of work shall be employed on electrical systems to ensure compliance with the Electricity at Work Act 1989 as laid out in attachment 1 of this standard, in conjunction with a risk analysis and job-specific method statement which limits the loss of supply to As Low As Reasonably Practicable (ALARP).
- 3.1.2 All personnel undertaking work shall as a minimum be;
- deemed fit and competent to undertake the work in accordance with the Railway and Other Guided Transport Systems (ROGS) regulations
 - trained and certificated to an appropriate level to undertake the work in accordance with;
 - BS7671
 - attachment 1 of this document
- 3.1.3 Where work is deemed to be Safety Critical in accordance with LU standard S1548, personnel shall additionally be compliant with its' requirements.
- 3.1.4 All LV electrical cabling and equipment installed on and used within LU premises shall be safe in both normal operation and under fault conditions and be designed to meet the requirements of British Standard BS7671.
- 3.1.5 All LV electrical distribution systems and final circuits shall be inspected, tested and certified to meet the requirements of BS 7671.
- 3.1.6 Subsequent condition assessments shall be undertaken to meet the requirements of BS7671 for all installations at frequencies not exceeding 3 years.
- 3.1.7 LV electrical systems shall comply with all Cat 1 standards, with further attention given to S1085 in sub-surface locations.
- 3.1.8 The switchgear & distribution equipment sourced from or supporting the following shall not be co-located such that the potential for a common point of failure exists;
- CEPS/Non-CEPS and DNO/LEPS
 - Supply 1 and Supply 2, in stations with 2 independent CEPS supplies
 - Normal and emergency lighting
- 3.1.9 The electrical supply infrastructure and equipment supporting all Emergency Escape systems shall be 2 hour fire rated.
- 3.1.10 Emergency lighting and emergency power system cabling shall be physically separated from other cabling by one of the following:
- Running in separate conduits or trunking;
 - Running in multi-compartment trunking which has full-height metallic barriers between compartments;
 - Running separate armoured cables on separate cable trays, ladder or basket.

3.1.11 Where re-wiring into existing cable management systems is proposed, an appropriate and documented assessment shall be undertaken on any risks associated with not complying with this standard.

3.1.12 Only where the risks have been established as being ALARP shall existing systems be utilised.

Note : To date, single core cables in trunking with multiple circuits present have not been tested and certified as meeting Clause 8.2.2 d) of BS 5266-1:2011 with respect to testing to IEC Standard 60331-3:2009 for a flame application time of 120 minutes. Hence, only compliant multicore cables are to be utilised for emergency lighting when installed within trunking.

When installed within conduit, compliant and certified single core cables may be used.

3.1.13 Residual current devices (RCDs) shall not be fitted on safety critical circuits.

3.1.14 Circuits supplied from battery systems shall be provided with circuit protection no higher than the inverter supply is capable of breaking.

3.1.15 Machines which can be operated by the public shall be protected by RCDs or operate at 110V(55V-0-55V).

3.1.16 Where conditions in a location may give rise to the risk of explosion from gas (including sewer gas) or flammable vapours, the location shall be assessed and classified in accordance with the Dangerous Substances and Explosive Atmospheres Regulations 2002.

- All equipment shall be selected and installed appropriately to suit the Zonal Classification of the location.
- No electrical circuits shall pass through the location except for the final circuits associated with that location.

3.1.17 LVAC electrical equipment shall be designed to operate safely within the parameters and characteristics of LU Cat 1 std 1-124

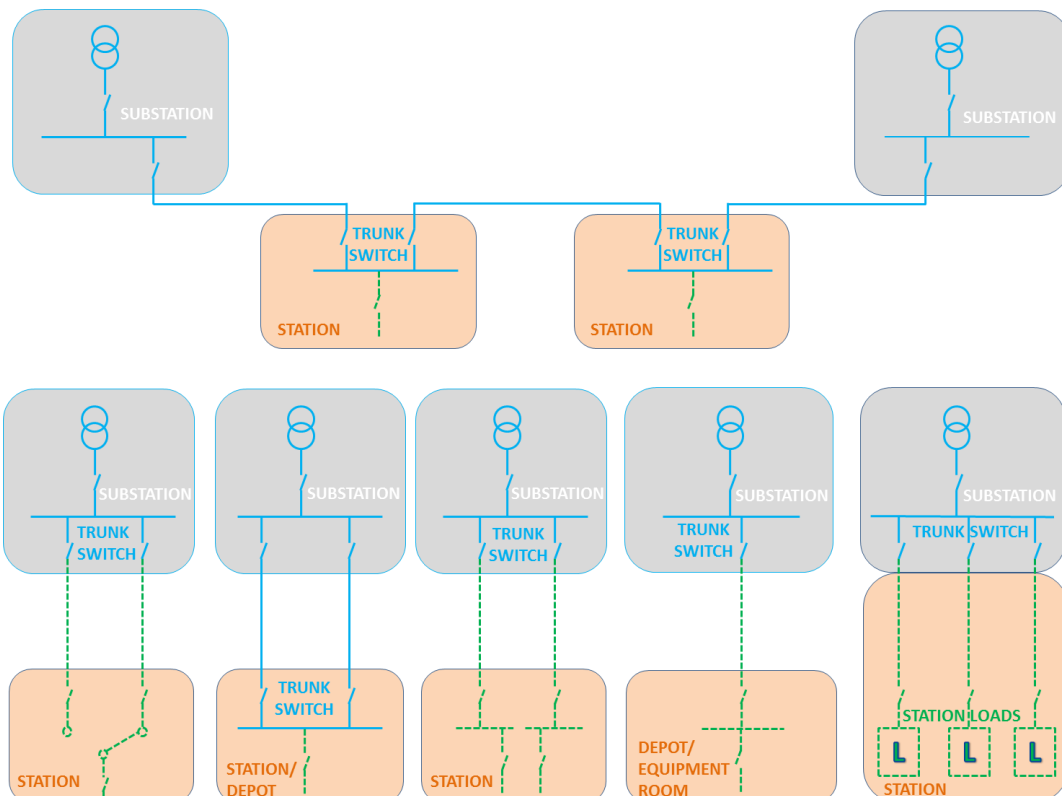
3.1.18 No exposed part of any electrical equipment shall attain a temperature in excess of 60°C when operating at or below rated duty at the maximum rated ambient temperature.

3.1.19 All redundant electrical services shall be removed.

3.2 General Requirements

- 3.2.1 Equipment shall meet the performance criteria specified by Department of Energy and Climate Change in the 'Enhanced Capital Allowance (ECA) Scheme for Energy Efficient Technologies - Energy Technology Criteria List'.
- 3.2.2 Before use Suppliers shall arrange listing of qualifying equipment that is not on the Energy Technology List if required.
- 3.2.3 All LV electrical installations shall be registered in accordance with LU category 1 standard S1100.
- 3.2.4 All electrical equipment providing protection, isolation and control, shall be located such that it is accessible for maintenance during Traffic hours without the need for access equipment and the closure of any public areas.
- 3.2.5 When a circuit is in any way impacted by works,
- the Project shall carry out a dilapidation survey of the circuit and assets being served by it and report findings to the Asset Steward prior to undertaking the works
 - the circuit shall, in its' entirety, be certified as complying with BS7671 upon re-commissioning
 - all new assets shall be compliant with current LU Cat 1 standards
 - any retained existing elements of the circuit need not be compliant with current LU Cat 1 standards
- 3.2.6 Where the circuits' assets are to be renewed or relocated due to an existing non compliance, and this work was not included in the Project's scope of work, then it shall be the responsibility of the Sponsor to ensure that funding is made available so that the circuits' assets, in their entirety, are made compliant with current LU Cat 1 standards.
- 3.2.7 Where the circuits' assets are to be renewed or relocated due to existing non compliances, and this work was not included in the Project's scope of work, it is the responsibility of the Sponsor to instruct either the Project or the Maintainer to carry out the works.
- 3.2.8 The design and installation of electrical equipment and enclosures shall consider;
- Ingress Protection (IP) ratings to BS EN 60529
 - Mechanical strength and impact ratings
 - Corrosion resistance
- and ensure that all electrical equipment and enclosures are suitable for the environment in which they are installed and for the use to which they will be put.
- 3.2.9 All electrical equipment enclosures shall be designed and installed such that:
- all points of access can be fully removed/opened
 - there is a minimum of 1 metre clearance in front of all points of access
 - clear standing space is available in front of all points of access
- 3.2.10 Unless required to meet the requirements of Section 3.4, at designated points of isolation the isolators shall ensure all line phases and neutral are disconnected when opened and automatically re-connected when closed.

- 3.2.11 All new electrical switchgear and final circuit distribution boards shall be installed in Switchrooms, except ;
- in Plant Rooms where the switchgear and final circuit distribution boards are dedicated only to the services associated with the Plant Room
 - final circuit distribution boards, which may be installed in non-public areas local to the point of utilisation.
- 3.2.12 Secure Suites, SERs, Relay Rooms, IMR's, CER's and lift & escalator plant rooms shall have dedicated switchgear and/or distribution boards within, which serves only equipment associated with that room(s).
- 3.2.13 Prior to installation, all new assets shall be calculated for heat gains.
- 3.2.14 All fixings shall comply with LU cat 1 standard S1063. The selection of fixings shall also consider ;
- Mechanical and impact strength
 - Corrosion resistance
 - Wind loading
 - Required performance during fire
- 3.2.15 Typical principles of ownership of Power and LV assets are defined below, along with requirements for isolation. If in doubt, clarification must be sought from the Head of Power Engineering and the Principal Building Services Engineer.



Power Asset – Operation using LU Power Engineer's trained and certified personnel in accordance with Power Engineer's requirements (solid line)

LV Asset – Operation using LV Engineer's trained and certified personnel (dashed line)

- 3.2.16 Work directly on LV equipment identified as a Power Asset, e.g. lengthening, shortening, jointing, replacement etc, requires compliance with LU Cat 1 standard S1900.
- 3.2.17 The delivery of the design, installation and commissioning of work on LV equipment identified as a Power Asset may be undertaken by the LV Engineer.
- 3.2.18 The assurance required by S1900 shall be undertaken by the Project.

Note: The Project shall appoint a Power Discipline Engineer to produce and deliver the necessary assurance required by S1900 for work undertaken by the LV Engineer on LV equipment identified as a Power Asset. Early involvement of the Power Engineering Department in the Project is therefore required. The LV Engineer will not be responsible for delivery of the assurance required by S1900 but will be required by the Project's appointed Power Engineer to sign relevant Parts

3.3 Power Supply Redundancy

- 3.3.1 Redundancy and diversity of power supplies to operational systems shall be provided in order to minimise the impact of power failures on LU services in accordance with Standard 1-123.
- 3.3.2 The nature of the load being supplied shall be the primary consideration when determining the nature of supplies in accordance with Standard 1-123.
- 3.3.3 Where provision of UPS supplies to all loads covered in 1-123 may lead to high capital and maintenance costs, an Operational Review may be undertaken to confirm precisely what proportion of the loads require UPS supplies.
- 3.3.4 For equipment sensitive to power supply perturbations, a Static Transfer Switch may be used in place of a UPS in conjunction with dual/diverse power supplies provided that all loads connected will function as normal when the switch operates in all modes. This includes ensuring that the equipment will return to service without manual intervention upon restoration of the normal supply.
- 3.3.5 Static Transfer Switch installations shall meet the requirements of Clause 7.4.3 of 1-123.
- 3.3.6 Redundancy and diversity of power supplies to Pumps shall be provided in accordance with Standard 1-123 & agreed with the Professional Head, Pumps and Drainage

3.4 Battery Power Supplies

Note: Section 3.4 applies to battery power supplies which are designed for connection to multiple loads. It does not apply to battery power supplies that are self-contained within the equipment they are designed to operate.

- 3.4.1 Central battery systems supporting Emergency Lighting shall comply with BS EN 50171:2001.
- 3.4.2 On stations with a Class A or B and a Class C supply, Emergency lighting shall be provided by via an Off Line Central Battery System complying with LU Cat 1 Standard S1948 and supplied from the stations' class C supply.
- 3.4.3 On stations with a Class C supply only, Emergency lighting shall be provided via either;
- a UPS
 - batteries and inverters integral to each designated emergency luminaire but only with prior agreement from the relevant AP representative

Note: The preferred solution is a Central Battery System, however for small localised Projects within an existing station where a UPS or OLBI solution for the emergency lighting is not in place, luminaires with integral batteries can be utilised only with prior agreement from the relevant AP representative.

- 3.4.4 All central battery systems shall, as a minimum, report the following to the Station, Depot or Building Manager;
- System normal
 - Incoming mains power supply failure
 - Equipment failure
- 3.4.5 Where a UPS is employed to serve an emergency lighting system, any faults detected shall be rectified within the same 4 hour maintenance response time as an OLBI failure.
- 3.4.6 Where a UPS is employed to serve an emergency lighting system, a remote alarm unit shall be provided in the Station Operation Room, complete with all of the alarms as defined in the Section 4.1 in the Rule Book and in S1948.
- 3.4.7 The remote alarm unit in the Station Operation Room shall be provided independent of any other BMS or SMS system provision.
- 3.4.8 All central battery systems shall ;
- in the event of failure of its' main supply, shall be capable of supplying the full design load plus all system losses, for the designed duration
 - have an external bypass facility incorporated to cater for maintenance and failure requirements
 - have an emergency stop function within the room containing the batteries
 - have isolators local to it to enable complete isolation of all incoming and outgoing circuits
 - have an operational procedure notice on the equipment, giving sufficient information to allow the plant to be operated safely and correctly.
 - be designed such that the inverter capacity delivers sufficient energy for all downstream operating and fault conditions without the need to transfer to static by-pass

Note: Where multiple circuits are supplied from the central battery system, when being sourced directly from the batteries, a fault on one circuit must not force the UPS to shut down

3.5 UPS (uninterrupted power supply)

- 3.5.1 The UPS shall be connected to both the class A and C station supplies via a changeover contactor.
- 3.5.2 Where the UPS depends on an incoming supply neutral for a neutral /earth reference, then the neutral connection shall be retained at changeover and when both of the incoming supplies to the UPS are isolated.
- 3.5.3 UPS systems shall be of the insulated-gate bipolar transistor (IGBT) or base design, have near unity power factor and shall be installed with an external maintenance bypass switch.
- 3.5.4 The UPS shall have the ability to be able to be remotely monitored either via a phone connection or a network connection.
- 3.5.5 UPS systems critical to the safe evacuation of the Underground System shall be of a modular, pluggable form with redundancy incorporated within the number of active power modules.
- 3.5.6 The UPS shall be designed for N+ operation to ensure failure of one power module does not impact on the operation of the system.
- 3.5.7 UPS systems shall be designed to enable the replacement of any failed single active power module whilst output to the load is maintained through the remaining healthy modules.
- 3.5.8 The UPS module capacity shall be sized based on the required system redundancy.
- 3.5.9 The required system redundancy shall be determined based on a system RAMS analysis.
- 3.5.10 Battery systems shall conform to the requirements of BS EN 62040, BS EN 50172 and BS EN 50272.
- 3.5.11 Automatic monitoring of battery condition, charge state, output and temperature shall be provided.
- 3.5.12 Batteries shall be designed to be resilient (i.e. no degradation to the specified service life or performance) to the maximum room temperature in which they are installed.
- 3.5.13 Where practicable, batteries shall be installed in a room separate from the inverter and rectifier.

3.6 Transfer and Changeover Switches

- 3.6.1 Indication shall be provided for transfer and changeover switches to indicate the following states:
 - Supply Healthy
 - Supply Bias
 - Supply Availability
- 3.6.2 Static transfer switches shall be used with the exception of the following systems:
 - Motor supplies (e.g. lifts, escalators, etc)
 - Power supply to UPS
- 3.6.3 Integral static transfer switches within UPS equipment is permissible.
- 3.6.4 For the excluded systems above, automatic changeover switches shall be used.
- 3.6.5 A manual maintenance bypass shall be installed around the transfer and changeover switched.

3.7 Plant Room Requirements

- 3.7.1 110V (55V-0-55V) socket outlets and 230V socket outlets with RCD protection shall be provided for maintenance tools in each plant room.
- 3.7.2 A 32A 400V three phase or 230v single phase, (depending on the operating voltage of the permanent pump), emergency pump socket to BS EN 60309-1 shall be provided in permanent pump locations and the socket shall be labelled "Emergency Pump Supply".

3.8 Switchrooms

- 3.8.1 Switchrooms shall be;
- fit for purpose
 - constructed to a minimum life expectancy of 40 years
 - constructed with sufficient strength to allow the wall mounting of switchgear
 - constructed and located to;
 - provide safe and adequate access
 - provide physical security to the equipment within the room and services entering and leaving it
- 3.8.2 Switchroom doors shall :
- open outwards
 - allow sufficient clearance when open for the operation and maintenance of switchgear.
- 3.8.3 Switchroom floors shall be arranged relative to external floors such that the build up of moisture in or near the equipment is prevented.
- 3.8.4 Water pipes of any form shall not pass through electrical switchrooms.
- 3.8.5 A durable diagram showing a schematic arrangement of the local electrical distribution shall be provided within all switchrooms in accordance with BS 7671 and securely fixed to an appropriate surface. The diagram shall be controlled and updated whenever a distribution alteration takes place.
- 3.8.6 Reference to clause 3.2.9 of this standard shall be made.

3.9 Station/Depot 110v Supplies

- 3.9.1 Where the need is evidenced by a documented site specific requirement assessment, following consultation with relevant COO and ERU representatives, 110V (55V-0-55V) socket outlets to BS EN 60309 for maintenance, cleaning and emergency situations shall be positioned in the locations listed below such that equipment with a 15m lead can reach all points in the area they are located:
- Sub-surface station platforms, surface platforms under the canopy, public passageways, booking halls and concourses;
 - Escalator and lift landings;
- 3.9.2 110V (55V-0-55V) socket outlets to British Standard European Norm (BS EN) 60309 for maintenance purposes shall be positioned in the locations listed below such that equipment using a 15m lead can reach all points in the area where they are located:
- In all plant rooms.
 - Depot shed maintenance roads.
 - Depot shed inspection pits.
 - Ventilation shafts, adjacent to equipment requiring maintenance

- 3.9.3 Wherever practical the circuit shall be designed in accordance with BS 7671 and the designer should endeavour to meet the required disconnection times without the need for RCD protection. If however the circuit characteristics are excessive, the use of RCD protection is permitted.
- 3.9.4 Where RCD protection of the 110v circuit is required, a local RCD shall be installed within the socket and a time delayed RCD installed on the secondary side of the transformer within the switchroom.
- 3.9.5 Only RCD's proven to operate on the 110v system shall be used.

3.10 Tunnel Lighting and Power

- 3.10.1 Tunnel lighting shall be supplied :
- via a changeover contactor between Central Emergency Power Supply (CEPS) and DNO supply where available
 - in stations with 2 independent CEPS supplies, via UPS's, one sourced from supply 1 and another from supply 2
- 3.10.2 Power shall be provided within all running tunnels from a dedicated Tunnel Power switchboard located within adjacent stations. The design load of each Tunnel Power switchboard shall be 63A.
- 3.10.3 The Tunnel Power supply circuit within each running tunnel shall be energised when the traction power in the associated traction section is off.
- 3.10.4 Each running tunnel, off each end of each platform, shall allow for a design load of 32A to the mid-point between stations for tunnel power supplies
- 3.10.5 In all running tunnels, at intervals of no greater than 55M (allowing all areas within running tunnels to be reached with a 30M lead), the following socket outlets shall be provided:
- 400v 32A 3-phase and earth, locally protected via an RCBO
 - 2 No. 110v 32A 3-phase and earth, locally protected
 - 110v 16A 1-phase and earth, locally protected via an RCBO
- } *via a locally mounted combination unit incorporating a 10KVA centre tapped transformer*
- 3.10.6 The combined transformer/socket outlet combination unit shall incorporate either a no-volt relay with a manual re-set facility or a no-load self isolating transformer, such that the transformers are not energised during Engineering Hours if they are not required, thus limiting energy usage through transformer losses.

3.11 Metering

3.11.1 Metering is to be provided for each fused fuse switch.

3.11.2 All meters shall be capable of connecting to an IP Network, wired via an RJ45 or wirelessly.

3.11.3 Meters shall display local to the relevant fused fuse switch.

3.11.4 For meters connected to the Station Main incoming switch, they shall, for each phase and Total;

- display instantaneous values of
 - Voltage
 - Current
 - Wh, varh and VAh
 - Absolute Wh, varh and VAh
 - Power: W, var, VA, Vrms, Irms
 - Power Factor
 - Total Harmonic Distortion (THD)
 - Waveform Download
- record to local memory max, min & average all of the above @ 30min intervals for a rolling 6 month period
- capability to export data in .csv format

3.11.5 For meters not connected to the Station Main incoming switch, they shall, for each phase and Total;

- display instantaneous values of
 - Voltage
 - Current

3.11.6 All meter data connections and memory card slots shall be accessible from the front without the need to remove the meter.

3.11.7 In addition, further requirements for the metering of Tenants and 3rd Party supplies are covered with Section 3.25