ENGINEERING DESIGN STANDARD

EDS 08-2000

LV NETWORK DESIGN

Network(s): EPN, LPN, SPN

Summary: This standard defines UK Power Networks policy with regard to all aspects of the design of networks that operate at low voltage

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Date: 13/11/2017

Approved By: Paul Williams

Approved Date: 20/12/2017

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Revision Record

<table>
<thead>
<tr>
<th>Version</th>
<th>Review Date</th>
<th>Author</th>
</tr>
</thead>
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<tr>
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**Reason for change:** Minor version update

**What has been changed:** References to EDS 08-0123 changed to EDS 08-2110

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**Reason for change:** Re-alignment of LV design standards.

**What has been changed:**
- Standard supply sizes for customer loads from EDS 08-2100 added (Section 5).
- Fifth core added (Section 7.6).
- Tong test form added (Appendix A).
- Document renumbered from EDS 08-0136 to EDS 08-2000

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**Reason for change:** The review period had been reached providing the opportunity to clarify some requirements of the standard and provide guidance on common issues.

**What has been changed:**
- Structure has been revised and brought in line with the supporting LV standards.
- The impact of losses on network design has been considered, sections 6.5 and 7.1.
- Supply characteristics for LV are now presented here, section 4.
- Guidance on bunched phase and neutral cables is now available here, section 7.3.

Typical ADMDs are now presented here, section 8.1.
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1 Introduction
This standard defines UK Power Networks policy with regard to all aspects of the design of networks that operate at low voltage.

2 Scope
This standard applies to the EPN, LPN and SPN distribution networks operating at low voltage i.e. 400/230V ac three-phase, 460/230V ac split-phase and 230V ac single-phase – 4 wire, 3 wire and 2 wire systems.

This standard does not address connections to the LV network. For LV connections refer to:

- EDS 08-2102 for unmetered supplies.
- EDS 08-2101 for supplies up to and including 100A (single-phase).
- EDS 08-2100 for supplies above and including 100A (three-phase).
- EDS 08-1103 for supplies to multi-occupied buildings.
- EDS 08-0113 for IDNO connections.

This standard is designed to work in conjunction with the listed standards.

This standard does not apply to IDNO LV network design; refer to EDS 08-0113.
## Abbreviations and Definitions

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHLDZ</td>
<td>Central High Load Density Zone</td>
</tr>
<tr>
<td>EFLI</td>
<td>Earth Fault Loop Impedance – the impedance of the earth fault current loop starting and ending at the point of earth fault</td>
</tr>
<tr>
<td>HV</td>
<td>High Voltage – AC voltages above 1000V</td>
</tr>
<tr>
<td>LV</td>
<td>Low Voltage – AC voltages up to 1000V</td>
</tr>
<tr>
<td>LV Service</td>
<td>A service line is an electric line which connects either a street electrical fixture or a premise, to a distributing main</td>
</tr>
<tr>
<td>MD</td>
<td>Maximum Demand – the peak load condition of a network demand</td>
</tr>
<tr>
<td>MSDB</td>
<td>Multi-Service Distribution Board</td>
</tr>
<tr>
<td>PME</td>
<td>Protective Multiple Earthing – a single conductor for neutral and earthing functions is provided by the DNO, and is connected with the general mass of earth at multiple locations. An earth terminal is provided at the customer’s installation. The customer’s earthing may be connected to this terminal providing the relevant requirements in BS 7671 are satisfied</td>
</tr>
<tr>
<td>PNB</td>
<td>Protective Neutral Bonding - PNB is similar to PME except the neutral conductor is only earthed at one point which is usually located closer to the customer than the transformer and often connected at cut-out</td>
</tr>
<tr>
<td>PoS</td>
<td>Point of Supply – a point in the electrical system where the technical and commercial criteria of supply are specified</td>
</tr>
<tr>
<td>PSCC</td>
<td>Prospective Short Circuit Current – the current that would flow in a circuit, in the event of a short circuit of negligible impedance. It is measured as the RMS (root mean square) value of the ac component. The actual fault current will therefore be less if the protective device has a current limiting feature or appreciable impedance</td>
</tr>
<tr>
<td>UK Power Networks</td>
<td>UK Power Networks consists of three electricity distribution networks:</td>
</tr>
<tr>
<td></td>
<td>- Eastern Power Networks plc (EPN)</td>
</tr>
<tr>
<td></td>
<td>- London Power Network plc (LPN)</td>
</tr>
<tr>
<td></td>
<td>- South Eastern Power Networks plc (SPN)</td>
</tr>
</tbody>
</table>
4 Supply Characteristics

4.1 Number of Phases

LV distribution networks are three-phase.

LV services are single-phase or three-phase as required.

Note: Split-phase or two-phase distribution networks and services are only to be provided where unavoidable; every opportunity shall be taken to replace split-phase systems with three-phase systems.

4.2 Frequency

All LV distribution networks and services operate within 49.5Hz and 50.5Hz.

4.3 Voltage

The values of Table 4-1 apply at the PoS and represent the +10%/−6% ESQCR requirements.

Table 4-1 – Voltages at PoS

<table>
<thead>
<tr>
<th>Supply</th>
<th>ESQCR -6% Voltage</th>
<th>Reference Voltage</th>
<th>ESQCR +10% Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single-phase</td>
<td>216</td>
<td>230</td>
<td>253</td>
</tr>
<tr>
<td>Three-phase</td>
<td>376</td>
<td>400</td>
<td>440</td>
</tr>
<tr>
<td>Split Phase</td>
<td>433</td>
<td>460</td>
<td>506</td>
</tr>
</tbody>
</table>

4.4 Fault Current

The maximum prospective short circuit current values at the point of supply are listed in Table 4-2.

Table 4-2 – Values of PSCC at the PoS by Supply Size and Network Type

<table>
<thead>
<tr>
<th>Supply Arrangement</th>
<th>Service</th>
<th>Radial Networks</th>
<th>Interconnected Networks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Service from Passing LV Main</td>
<td>25A Single-phase</td>
<td>16kA</td>
<td>16kA</td>
</tr>
<tr>
<td></td>
<td>100A Single-phase</td>
<td>16kA</td>
<td>16kA</td>
</tr>
<tr>
<td></td>
<td>100A Three-phase</td>
<td>18kA</td>
<td>24kA</td>
</tr>
<tr>
<td></td>
<td>200A Three-phase</td>
<td>18kA</td>
<td>28kA</td>
</tr>
<tr>
<td></td>
<td>400A Three-phase</td>
<td>18kA</td>
<td>30kA</td>
</tr>
<tr>
<td>Direct from Network Substation</td>
<td>600A Three-phase</td>
<td>25kA</td>
<td>46kA</td>
</tr>
<tr>
<td></td>
<td>800A Three-phase</td>
<td>25kA</td>
<td>46kA</td>
</tr>
<tr>
<td></td>
<td>1600A Three-phase</td>
<td>25kA</td>
<td>46kA</td>
</tr>
</tbody>
</table>
4.5 Typical Earth Fault Loop Impedance

Typical earth fault loop impedance values at the point of supply are detailed in Table 4-3. These values may be exceeded in some situations due to the design of the network and the higher value shall be declared to the customer.

Table 4-3 – Typical Values of Earth Fault loop Impedance at the PoS

<table>
<thead>
<tr>
<th>Service</th>
<th>Earthing</th>
<th>EFLI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 100A Single-phase</td>
<td>PME/PNB Earth Terminal</td>
<td>0.35Ω</td>
</tr>
<tr>
<td></td>
<td>Cable Sheath/Continuous Earth Wire Earth Terminal</td>
<td>0.8Ω</td>
</tr>
<tr>
<td>Up to 100A Three-phase</td>
<td>PME/PNB Earth Terminal</td>
<td>0.35Ω</td>
</tr>
<tr>
<td></td>
<td>Cable Sheath/Continuous Earth Wire Earth Terminal</td>
<td>0.8Ω</td>
</tr>
<tr>
<td>200 to 300A Three-phase</td>
<td>PME/PNB Earth Terminal</td>
<td>0.2Ω</td>
</tr>
<tr>
<td></td>
<td>Cable Sheath/Continuous Earth Wire Earth Terminal</td>
<td></td>
</tr>
<tr>
<td>Exceeding 300A Three-phase</td>
<td>PME/PNB Earth Terminal</td>
<td>0.15Ω</td>
</tr>
<tr>
<td></td>
<td>Cable Sheath/Continuous Earth Wire Earth Terminal</td>
<td></td>
</tr>
</tbody>
</table>

Values for unmetered connections can be found in EDS 08-2102 and EDS 06-0004.

Design values for new networks and network additions are detailed in Section 6.7.

4.6 Power Quality

Refer to EDS 08-1901 regarding compliance details for voltage fluctuations (ENA ER P28), voltage unbalance (ENA ER P29) and harmonic voltage distortion (ENA ER G5).
5 Services

Table 5-1 provides a summary of the supply arrangements appropriate for the varying levels of customer demand. Refer to EDS 08-2100 and EDS 08-2101 for further information.

Table 5-1 – Standard Supply Sizes for Customer Loads

<table>
<thead>
<tr>
<th>MPR (kVA)</th>
<th>Service Cable</th>
<th>Rating and Termination</th>
<th>Max. Fuse Rating (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - 23</td>
<td>35mm² Single-phase Al Split Concentric or Concentric</td>
<td>100A Single-phase cut-out</td>
<td>100</td>
</tr>
<tr>
<td>24 - 69</td>
<td>35mm² Three-phase Al Concentric</td>
<td>100A Three-phase cut-out</td>
<td>100</td>
</tr>
<tr>
<td>70 - 138</td>
<td>95mm² Three-phase Al Waveform</td>
<td>200A Three-phase cut-out</td>
<td>200</td>
</tr>
<tr>
<td>139 - 217</td>
<td>185mm² Three-phase Al Waveform</td>
<td>400A Three-phase cut-out</td>
<td>315</td>
</tr>
<tr>
<td>218 - 277</td>
<td>300mm² Three-phase Al Waveform</td>
<td>400A Three-phase cut-out</td>
<td>400</td>
</tr>
<tr>
<td>24 - 69</td>
<td>35mm² Three-phase Al Split Concentric</td>
<td>100A Three-phase cut-out</td>
<td>100</td>
</tr>
<tr>
<td>70 - 138</td>
<td>95mm² Four Core Three-phase Aluminium Waveform</td>
<td>200A Three-phase cut-out</td>
<td>200</td>
</tr>
<tr>
<td>139 - 217</td>
<td>185mm² Four Core Three-phase Aluminium Waveform</td>
<td>400A Three-phase cut-out</td>
<td>315</td>
</tr>
<tr>
<td>218 - 277</td>
<td>300mm² Four Core Three-phase Aluminium Waveform</td>
<td>400A Three-phase cut-out</td>
<td>400</td>
</tr>
<tr>
<td>278 - 555</td>
<td>Customer Cables</td>
<td>800A LV Way</td>
<td>800</td>
</tr>
<tr>
<td></td>
<td></td>
<td>400A LV Ways</td>
<td>2 x 400</td>
</tr>
<tr>
<td>556 - 1000</td>
<td>Customer Cables</td>
<td>1600A ACB</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td></td>
<td>400A LV Ways</td>
<td>4 x 400</td>
</tr>
<tr>
<td>1001 - 1500</td>
<td>Customer Cables</td>
<td>2500A ACB</td>
<td>n/a</td>
</tr>
<tr>
<td>1500+</td>
<td>Supplies of greater than 1500kVA shall not be provided at LV. Refer to EDS 08-3100 and EDS 08-4100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
6  New Networks

6.1  Radial Single Mains

LV networks shall be designed on the principle of underground radial single mains, giving consideration to proposed customer numbers, customer load requirements, the potential for future load growth and the possible need for interconnection to future adjacent networks.

6.2  New Substations

New LV networks shall where feasible and practical be supplied from a new secondary distribution substation. The number, position, capacity and timing of substation installation on a new development shall consider the:

- Maximum power requirement of the development.
- Available capacity from existing adjacent networks that does not compromise network support and backfeed capacity.
- Potential LV network reinforcement that may be driven by new customer requirements.
- Earth fault loop impedance value and the impact on feeder length.
- Accessibility of the new substation and necessary land rights.

Load growth shall be considered in accordance with the appropriate planning load estimate for the source primary substation.

During the installation of the new substation, spare LV ways on transformer-mounted fuse cabinets (TMFC) or LV boards shall be fitted with 300 mm² aluminium cable of sufficient length to provide additional future LV main joints without entering the secondary substation. These future mains shall be pot-ended and equipped with a PME earth rod as per the requirements of EDS 06-0016.

6.3  Network Design Tools

A suitable modelling tool (e.g. Debut) shall be used for the design of all new LV networks and extensions to existing networks.

Data provided by the model shall include:

- Cable sizes.
- Earth fault loop impedance.
- Voltage drop.
- Voltage dip associated with motor starting, welding equipment and electric showers.
- Voltage rise associated with generation.
- Fuse size.

The model shall consider additional requirements such as future developments, load growth or network design requirements such as providing a network backfeed.
6.4 Network Support

EDS 08-3000 requires that LV networks shall provide a minimum backfeed support to a secondary substation. This shall be:

- 30% of the proposed substation MD for a new ring connected substation.
- 50% of the proposed substation MD for a new tee connected substation.

Where practicable new networks shall be designed to achieve this backfeed target by interconnecting two or more LV feeds, either from the same substation or adjacent substations.

In addition, when a new substation is installed, the opportunity should also be taken to ensure this minimum backfeed requirement is available to adjacent existing LV network substations.

The possibility of future adjacent developments shall also be considered.

Refer to EDS 08-3000 for additional guidance.

6.5 Cable Sizes

New LV underground mains cable shall be 300 mm² aluminium.

Where a cul-de-sac, spur or other short section of LV where a linkbox cannot be installed is to supply a projected 100A or less, 185mm² aluminium cable shall be used.

Services are detailed in the appropriate service standards (refer to section 4).

The appropriate LV cables are specified in EAS 02-0000.

Tri-rated cables are not approved for use within UK Power Networks.

Typically LV cables are laid directly in the ground but where there is a requirement for the cable to be ducted (for example urban environments) refer to ECS 02-0019.

6.6 Load Balance

Services to be supplied from a new LV network shall be equally distributed between the three-phases to avoid overload of a single-phase. Refer to section 8.1 for additional ADMD information.
6.7 Earth Fault Loop Impedance

Radial LV networks shall be designed using the earth fault loop impedance values given in Table 6-1. All new networks and network extensions shall be modelled to calculate the earth fault loop impedance and shall not exceed the listed values.

Table 6-1 – Values of Earth Fault Loop Impedance at the PoS for New LV Supplies

<table>
<thead>
<tr>
<th>Service</th>
<th>Earth Fault Loop Impedance at the Point of Supply</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>New Radial Networks</td>
</tr>
<tr>
<td>Up to 100A Single-phase</td>
<td>0.25Ω</td>
</tr>
<tr>
<td>Up to 200A Three-phase</td>
<td>0.25Ω</td>
</tr>
<tr>
<td>200-300A Three-phase</td>
<td>0.2Ω</td>
</tr>
<tr>
<td>Greater than 300A Three-phase</td>
<td>0.15Ω</td>
</tr>
</tbody>
</table>

6.8 Fuse Sizes

Refer to EDS 05-4001 for the appropriate LV network fuses. Fuse sizes shall consider fault levels at extremities of the feeder, the data for which shall be obtained from protection studies.

6.8.1 50kVA and 100kVA Pad Mount Transformers

Due to HV fuse requirements, the maximum underground cable cross section available to 50kVA or 100kVA pad mount substations is 95mm². This technical constraint supersedes the requirements of section 6.5.

6.9 Maximum Feeder Lengths – Volt Drop and Rise

New LV networks shall be designed such that the:

- Volt drop at the end customer point of supply does not exceed 6%.
- Volt rise at the end customer point of supply does not exceed 10%.
- Earth fault loop impedance at the customers supply terminal does not exceed 0.25Ω as defined in Table 6-1.

This may impact the maximum feeder lengths and shall be determined using a network modelling tool.

6.10 Earthing

The earthing requirements for LV networks, including the positioning of additional PME earth electrodes, are detailed in EDS 06-0016.

6.11 Industrial and Commercial Networks

Consideration shall be given to the greater likelihood of industrial and commercial load causing harmonic distortion and flicker from industrial /commercial equipment. Refer to EDS 08-1901 for additional information.
6.12 Installation of Cables

Refer to ECS 02-0019 for guidance on the installation of LV network cables. LV network cables shall not be placed beneath or within buildings and consideration shall be given to areas of particular concern where ducting is essential, for example:

- Road crossings.
- Across bridges.
- Rail crossings.
- Paved pedestrian areas.
- Town centre locations where future excavation may be difficult because of traffic management issues.
- Any other location where it is realised that future excavation will be difficult and/or expensive.

It shall be noted that when an LV cable is installed in a duct, it may be de-rated by more than 33%. Refer to EAS 02-0000, ENA ER P17 and relevant cable specifications for additional information.

Consideration shall be given for the provision of additional, spare ducts during planned works to minimise future street works. Only approved ducts shall be used (refer to EAS 02-0000).
7 Existing Networks and Extending Networks

7.1 General

Various items of equipment on both underground and overhead LV networks require replacement for various reasons including overloading, voltage issues, condition based, end of life or changes to practise.

Examples of such equipment include:

- Cables.
- Overhead lines.
- LV pillars.
- Link boxes.

Diversions will also require the replacement of existing LV network.

In all cases, consideration shall be given to network rationalisation and potential redesign should an opportunity be presented.

Network connectivity, the ability to transfer and support customers under outage, the introduction of more effective equipment and increased network efficiency should all be considered whenever possible. This may require increasing the capacity of the LV network rather than a like for like replacement; for example moving from a two-way to a four way link box may be a requirement.

The capacity of the LV network shall not be de-rated by any replacement work and tapered LV mains shall be avoided.

When replacement is required:

- Underground cables shall be replaced with the next largest cross section of cable available, for example if load requires a 185mm$^2$ cable be used, a 300mm$^2$ shall be used.
- A maximum 185mm$^2$ cable shall be used for overhead to underground transitions.
- Overhead lines shall be considered for replacement with underground networks at every opportunity.
- Where the retention of overhead lines is unavoidable, conductors shall be replaced with ABC of an equivalent rating.
- LV Pillars shall be replaced with link boxes ensuring that, as a minimum requirement, the LV network connectivity is maintained on a like for like basis.

Therefore only in exceptional circumstances (for example 50/100kVA pad mount substations) or under fault conditions shall an overhead line be retained and 95mm$^2$ or smaller cross section cable shall no longer be used for underground mains. Services are detailed in the appropriate service standards.

For legal considerations refer to Section 8.1.

These requirements should be considered during fault repairs but only if feasible as network restoration remains the priority.

Where a non-standard LV network is to be replaced, consideration shall always be given to conversion to a three-phase system, refer to section 7.5.
7.2 Load Balance

Before work commences the opportunity should be taken to assess the load distribution across the three-phases.

This shall be achieved by data logging of the LV main at the local substation and a survey of each service supply phase. A survey may be completed using service record cards or noted at the time of disconnection from the LV main.

Where data logging cannot be performed an instantaneous load reading of each phase of each LV way of the LV distribution board may be used. The instantaneous maximum and recorded maximum demand readings on the LV board shall be recorded at the same time. The appropriate form is included in Appendix A. This method can provide an indication of network loads but should always be considered inferior to data logging.

When reconnecting services to the LV main customer loads shall be balanced so as to produce the optimum phasor loading at the time of re-energisation. Earthing

The earthing shall comply with the requirements of EDS 06-0016 following any alteration or addition to the LV network. Refer to section 8.1 for additional ADMD information.

7.3 Bunching of Phase and Neutral Conductors

The bunching of LV conductors shall not be used. It is not an acceptable method of reducing loop impedance to solve quality of supply issues or to provide new supplies.

The bunching of conductors has previously been carried out at the remote end of a LV distributor to create a single-phase circuit having a doubled conductor size and has been used as a method of reducing loop impedance of long low-voltage circuits.

At the supply end of the network, the two bunched phase conductors were connected to a single fuse-way and the bunched neutral and third phase connected to the substation neutral. On underground networks, the bunching of cores may have been made in a joint.

Not all locations where conductors have been bunched have been recorded on network records.

A risk assessment of current practices indicates that steps should be taken to reduce the risk of accidental energisation of bunched phase and neutral conductors.

Any alterations to networks including bunched conductor installations shall make provision for the restoration of a conventional network solution.

Where a four-wire aerial cable or three-phase underground cable connects to a split phase system, the unused core shall not be bunched with another core, but left disconnected and insulated from earth and the cores in use.

Circuits containing bunched phase and neutral conductors found and not recorded on operational diagrams shall be noted and a system alteration notice submitted.

A warning notice; EDS 07-0009.97, is to be fixed adjacent to the LV fuse way supplying the affected circuit and at all poles supporting conductors that have been bunched. Notices are to be fixed approximately 300mm below the fuse way or aerial cable.

Sections of network where four-wire aerial cable and three-phase underground cable contain an unused core shall also be marked on the operational diagram.
7.4 Distributed Generation

The current versions of ENA ER G59 and G83 provide guidance for the connection of generation to LV networks.

7.5 Legacy LV Underground Networks

A number of legacy LV underground systems may be encountered across the UK Power Networks licence areas. These are remnants of previous practise and shall not be extended or used for new LV networks (with one exception within the CHLDZ, refer to Section 7.5.7). Each type of legacy network is detailed in this section along with actions that shall be taken should an opportunity arise.

7.5.1 Two-phase Cables Connected to a Normal Three-phase Network

This type of network creates a continuous neutral return current thereby increasing the volt drop both on the three core cable, and the upstream four core cable where an out of balance persists. When diversion/replacement of a two-phase cable is required, the opportunity shall be taken to extend the network as three-phase where practicable. Where this is not possible the redundant core of the new cable shall remain dead and be insulated from the other live cores, neutral and earth.

7.5.2 Split-phase Networks

This system enables the best utilisation of ex direct current three-core cables, but is only connected to two phases of the HV network thus presenting an imbalanced load to the HV network. New split-phase substations shall not be connected.

Where split-phase 460/230V networks are to be replaced or upgraded, the opportunity to convert to a three-phase network shall be taken. Customers connected to the LV network shall be checked for any connected split-phase 460V equipment.

Where a three-phase replacement network cannot be achieved, split-phase transformers are available where only a two-phase HV network exists.

Where the network is to remain as split-phase, the unused ABC core shall remain dead and be insulated from earth and the other cores.

7.5.3 Networks Fed from Scott Transformers

The Scott transformer network was developed to enable best utilisation of ex direct current three-core cables whilst presenting a balanced three-phase load to the HV network. The majority of this type of network is located in the Croydon area; when diversion/replacement of a three-core LV cable connected to this network is required, the redundant core of the new cable shall remain dead and be insulated from the other live cores, neutral and earth.

7.5.4 Phase/Anti-phase Systems

The phase/anti-phase system was developed to enable the best utilisation of ex direct current three-core cables, whilst presenting a balanced three-phase load to the HV network. The majority of this type of network is located in the Twickenham and Kew areas.
Substations supplying a phase/anti-phase system have two conventional Dy11 transformers, each of which supplies an LV feeder pillar or fuse board. The HV and LV connections on one of the transformers have however been adjusted such that each phase on the LV cables connecting to that transformer is electrically 180° apart from each corresponding phase on cables connecting to the other transformer. The two transformers are permanently interconnected via the LV network as shown in Figure 7-1 with three-core cables connected to the four-core cable ring. As can be seen, cables associated with any part of this network will be supplied from two different sources of supply and this shall be clearly defined on the risk assessment when any work on these cables is planned.

When diversion/replacement of a three-core cable connected to this network is required, the redundant core of the new cable shall remain dead and be insulated from the other live cores, neutral and earth.

Provision of three-phase supplies from these substations shall be taken directly from the phase transformer LV pillar, and no attempt made to alter the phase/anti-phase network.

\[
\begin{align*}
V_{\text{Yellow} - \text{Neutral}} &= 230 \, \text{V} \\
V_{\text{Yellow Antiphase} - \text{Neutral}} &= 230 \, \text{V} \\
V_{\text{Yellow} - V_{\text{Yellow Antiphase}}} &= 460 \, \text{V}
\end{align*}
\]

Similarly for Red and Blue Phases

**Note:** Legacy colours are used to define phases in the above diagram. On site, phases may be similarly coloured or different colours used or possibly numbered.
7.5.5 Three-wire Lines Connected to Three-phase Networks

Where three-wire overhead lines, connected to three-phase networks are to be replaced with ABC, the network shall where possible be converted to three-phase and customers balanced over the three-phases. Where this is not possible, the unused ABC core shall remain dead and be insulated from earth and the other cores.

7.5.5.1 Networks fed from Diametric Transformers

A Diametric transformer has three LV windings with centre tapped neutrals, such that each winding provides two phases 180° apart. The LV pillar is split into three sections, one for each winding and has a phase/anti-phase output on two busbars in each section providing six phases in total. There is only a limited amount of LV network supplied in this way, located mainly in the Caterham area and no work shall be carried out on this network without prior consultation with UK Power Networks.

7.5.6 Extensions from Two-phase Mains

When a new underground three-phase CNE cable is to be connected to a two-phase (or split-phase) mains cable, only two of the new cable phase cores can be used. The third phase core shall remain de-energised and insulated from the other cores and earth. There is a high risk that the neutral core will be overloaded and damaged if the third phase core is utilised to supply load from the same phase as one of the other cores.

7.5.7 CHLDZ

Within the LPN network, there are a variety of system types associated with LV and 11/6.6kV networks. Areas of central London continue to be supplied by interconnected LV networks with the associated 11/6.6 kV feeders operating in discrete feeder groups. In effect, the 11/6.6kV and LV levels are integrated and this precludes straightforward alterations to either without affecting the integrity of the whole network.

The LV network is interconnected to both support the local load densities and provide support to LV customers under HV fault conditions. Therefore any proposal to modify or extend central London networks shall first be approved by UK Power Networks.

A more detailed description of the CHLDZ is provided in EDS 08-3000.

7.6 Fifth Core and Switched Wire Supplies

Where work is required on an existing dedicated lighting network or “fifth core” network the opportunity shall be taken to supply the existing dedicated lighting network from a single point of supply. This work includes:

- Network alteration.
- Removal of time switches from supplying secondary substations.
- Decommissioning and removal of LV boards or link boxes with fifth cores.
- Any work that will render a dedicated lighting network non-operational.

Historically the fifth core is supplied by a common phase consistently within an operational area. The specific common phase should be identified and the consistency maintained within the area.
7.6.1 Substation Refurbishment or Replacement

An approved cut-out shall be installed within a secondary substation to directly supply a dedicated lighting network of up to 100A total load per network as follows:

- 100A single-phase for 1 dedicated lighting network.
- 100A three-phase for up to 3 dedicated lighting networks.
- Fused 10-Way MSDB for up to 10 dedicated lighting networks.

The cut-out shall be supplied by an appropriate service cable jointed on to an available LV distribution cable as close to the secondary substation as is practical and safe.

The cut-out shall be internally wall mounted if sufficient space if available. If insufficient space is available or the secondary substation is a compound type, a brick built cubicle (refer to EDS 08-2110) or LV pillar (refer to EAS 07-0001) shall be used to provide suitable accommodation.

The local authority shall be contacted and instructed to equip all dedicated lighting network devices with appropriate controls to allow for the timed function of all devices.

If individual supplies from a dedicated lighting network are to be replaced or altered, consideration shall be given to supplying the dedicated lighting network directly from the secondary substation.

If this solution is not feasible then supplies shall be transferred from the dedicated lighting network to the LV distribution network. Refer to EDS 08-2102.

7.6.2 Link Box Replacement

A maximum of four 100A single-phase cut-outs shall be installed within an approved highways pillar.

The cable supplied by the substation shall be terminated into the bottom entry of first cut-out. The remaining cut-outs shall be loop connected and supplied by the first cut-out. The remaining fifth core cable(s) shall be terminated into the outgoing side of each cut-out and each shall be labelled appropriately.

Direct jointing of the fifth core around the new link box or connecting the fifth core directly to the LV main is not acceptable.

7.6.3 Control Point or Column

The use of a control point or column placed inside street lighting to energise the fifth core from a common phase at a point outside of a substation, is not acceptable. Refer to section 7.6.1.

7.6.4 Mains Fault Repair

If an LV main requiring repair contains a fifth core that is assumed to still be in use, the fifth core shall be jointed through to maintain the circuit. The neutral shall only be connected in one joint.

7.6.5 Over Head Supplies

Where equipment is supplied by a fifth core, refer to EDS 08-2102.
8 General Requirements

8.1 Typical ADMD

Table 8-1 provides guidance on typical customer ADMDs.

Table 8-1 – Typical ADMDs in kVA

<table>
<thead>
<tr>
<th>Type of Property</th>
<th>Day</th>
<th>Night</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2 Bedroom with Gas Central Heating</td>
<td>1.2</td>
<td>0.3</td>
</tr>
<tr>
<td>3 Bedroom with Gas Central Heating</td>
<td>1.5</td>
<td>0.3</td>
</tr>
<tr>
<td>4 Bedroom with Gas Central Heating</td>
<td>1.8</td>
<td>0.5</td>
</tr>
<tr>
<td>5+ Bedroom with Gas Central Heating</td>
<td>2.4</td>
<td>0.5</td>
</tr>
<tr>
<td>1-2 Bedroom with Other Central Heating</td>
<td>1.5</td>
<td>2</td>
</tr>
<tr>
<td>3 Bedroom with Other Central Heating</td>
<td>1.9</td>
<td>2.5</td>
</tr>
<tr>
<td>4 Bedroom with Other Central Heating</td>
<td>2.1</td>
<td>3</td>
</tr>
<tr>
<td>5+ Bedroom with Other Central Heating</td>
<td>3.1</td>
<td>2.3</td>
</tr>
<tr>
<td>E7 Property with 1 Heater &amp; Water Heating</td>
<td>2.2</td>
<td>2.1</td>
</tr>
<tr>
<td>E7 Property with 2 Heater &amp; Water Heating</td>
<td>2.5</td>
<td>4.6</td>
</tr>
<tr>
<td>E7 Property with 3 Heater &amp; Water Heating</td>
<td>2.8</td>
<td>10</td>
</tr>
<tr>
<td>E7 Property with 4 Heater &amp; Water Heating</td>
<td>3.4</td>
<td>12.5</td>
</tr>
<tr>
<td>15kW Electric Boiler (On E7)</td>
<td>4.5</td>
<td>16.2</td>
</tr>
<tr>
<td>19kW Electric Boiler (On E7)</td>
<td>5.7</td>
<td>19.8</td>
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<tr>
<td>Small shop</td>
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</tr>
<tr>
<td>Church</td>
<td>50</td>
<td>-</td>
</tr>
<tr>
<td>Garage / workshop</td>
<td>30</td>
<td>-</td>
</tr>
<tr>
<td>Take away</td>
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<td>-</td>
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<tr>
<td>Pub / bar</td>
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<td>-</td>
</tr>
<tr>
<td>Café</td>
<td>15</td>
<td>-</td>
</tr>
<tr>
<td>Beauty salon</td>
<td>10</td>
<td>-</td>
</tr>
<tr>
<td>Care Home</td>
<td>100</td>
<td>-</td>
</tr>
</tbody>
</table>
8.2 Low Carbon Loads

This category includes any new low carbon or derivative technology to be supplied by the LV distribution network, for example: electric vehicle charging points and domestic heat pumps.

Until such time as a sufficiently large user base has been installed to allow for greater load profiling of this technology; it shall be assumed that no diversity will be applied to these loads.

The addition of some low carbon loads is notifiable to UK Power Networks (for example heat pumps). This data shall be collected for network planning and design use.

8.3 Legal Consents

UK Power Networks shall ensure that its interests are adequately protected by sufficient legal arrangements.

EDP 08-0006 provides guidance on the appropriate legal agreements that may be reached, including guidance on the Section 37 planning procedure.

EDS 07-3101 provides guidance on the legal requirements for secondary substations.

In addition, refer to EDS 08-0100 for guidance on the termination of wayleaves and the diversion of existing LV networks.

All new LV networks shall be underground and located wholly within the public highway.

Where the crossing of private ground in unavoidable, installation shall only be acceptable with written consent from the landowner prior to any works.

Diversion of overhead lines with new overhead lines shall be considered only if no underground solution is feasible.

LV network cables shall not be placed beneath or within buildings.

8.4 Environmental Issues

All work shall be carried out with due regard to the environment. Environmental issues shall be taken into account at every opportunity, for example:

- Water pollution.
- Waste management.
- Noise dust and odour.
- Ground contamination.
- Changes to the natural environment (landscape, wildlife and flora).
- Rivers, watercourses and flood plains.
- Archaeological disturbance.

Reference shall be made to HSS 01 026 and the suite of HSS environmental and community issue documents.
At every opportunity consideration shall be given to the environmental designations and requirements of English Heritage and Natural England, for example:

- Areas of Outstanding Natural Beauty (AONB).
- Sites of Special Scientific Interest (SSSI).
- Ancient monuments.
- Ramsar sites (Wetland conservation).

In addition an assessment of LV network routes shall be made to identify the presence of any protected species when an opportunity is presented. Specially designated sites are shown on Netmap. The government website Multi Agency Geographic Information for the Countryside (MAGIC) also provides information. Failure to identify protected species, prevent damage to habitat or fail to comply with any recommendation may lead to prosecution and a fine.

8.5 Network Records

For guidance on the recording of LV networks refer to EOS 09-0100.

8.6 Disconnections

The design requirements of service disconnections are covered in the appropriate connections design standard (for example within EDS 08-2101 for LV connection under 100A single-phase).

Disconnected cables shall, where feasible and practical, be recovered. Where dead cable must be abandoned in public land, this shall be marked on network records and recovered at a later opportunity should one arise.
9 References

9.1 UK Power Networks Standards

EAS 02-0000  Approved Equipment List – Cables and Joints
ECS 02-0019  Installation of Underground Cables LV to 132kV
ECS 03-0054  Connection of LV Large Services to Secondary Distribution Substations
EDS 05-4001  Fuse Ratings at Distribution Substations
EDS 06-0004  Earth Fault Loop Impedance Requirements
EDS 06-0016  LV Network Earthing Design
EDS 07-0009  Signs and Labels for Operational Sites
EDS 07-3101  Pre-Design Requirements for Secondary Substations
EDP 08-0006  Operational Property Consents – Types of Legal Consent
EDS 08-0100  Advice on Response to Requests and Charging for Diversion or Removal of Electric Lines and-or Plant on Private Land (Internal use only)
EDS 08-0113  Guidance for the Application of ENA Engineering Recommendation G88 and G81 Inset Networks (IDNOs and other licenced DNOs)
EDS 08-1103  Multi-Occupied Building Supplies
EDS 08-1901  Guidance for the Connection of Customer’s Disturbing Loads
EDS 08-2100  LV Customer Supplies Above 100A Single-phase
EDS 08-2101  LV Customer Supplies up to 100A Single-phase
EDS 08-2102  LV Customer Unmetered Supplies
EDS 08-2109  LV Supplies to Mobile Phone Base Stations Mounted on Transmission Towers
EDS 08-3000  HV Network Design
EDS 08-3100  HV Customer Demand and Generation Supplies
EDS 08-4100  EHV Customer Demand and Generation Supplies
EOS 09-0100  Site Recording of Cables Plant and Equipment
HSS 01 026  Schedule 9 Statement 2011 Electricity Act 1989
9.2 National and International Standards

ENA ER G5
Energy Network Association Engineering Recommendation (ENA ER): Planning Levels For Harmonic Voltage Distortion

ENA ER G59
ENA Recommendations for the Connection of Generation Plant to the Distribution Systems of Licenced Distribution Network Operators

ENA ER G83
ENA Recommendations for the Connection of Small-scale Embedded Generators (Up to 16A per Phase) in Parallel with LV Distribution Systems

ENA ER P17
ENA ER Part 1 Current Rating Guide for Distribution Cables

ENA ER P28
ENA ER Voltage Fluctuations

ENA ER P29
ENA ER Voltage Unbalance

ESQCR
Electricity Safety, Quality and Continuity Regulations 2002 as amended.

Multi Agency Geographic Information for the Countryside (MAGIC)
Can be found at: http://www.magic.gov.uk/
## Appendix A - Tong Test Form

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<tr>
<td>Project Reference</td>
<td>Date</td>
<td>Time</td>
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### Measurements

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<tr>
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<th>kVA</th>
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<tbody>
<tr>
<td>Maximum Demand (red needle)</td>
<td>kVA</td>
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<tr>
<td>Actual Demand (black needle)</td>
<td>kVA</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Way</th>
<th>Designation</th>
<th>L1 Red (A)</th>
<th>L2 Blue (A)</th>
<th>L3 Yellow (A)</th>
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### Sign-off

<table>
<thead>
<tr>
<th>Comments</th>
<th>Engineer</th>
<th>Signature</th>
<th>Date</th>
</tr>
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<tbody>
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The completed form shall be retained in the project file.