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ENGINEERING DESIGN STANDARD

EDS 07-3102

SECONDARY SUBSTATION CIVIL DESIGN

Network(s):	EPN, LPN, SPN
Summary:	This standard details the civil design requirements for secondary substations. It includes specific requirements for GRP enclosures, brick-built, integral and basement substations.

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Circulation

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New document for secondary substation civil design. Document supersedes EDS 07-0102			

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1 Introduction

This standard details the civil engineering requirements for secondary distribution substations and includes:

- General requirements for all substations.
- Specific requirements applicable to each substation type.

This standard shall be read after confirming the pre-design requirements outlined in standard document EDS 07-3101.

Refer to Appendix A for a list of standard substation drawings.

2 Scope

This standard covers the civil design and construction requirements to be complied with in the establishment of new 11kV and 6.6kV secondary substations for use in UK Power Networks LPN, EPN and SPN license areas; it applies equally to existing secondary substations to be extended or refurbished. It is intended for the use of both UK Power Networks and customers.

This document does not define responsibilities of stakeholders. This should be discussed with or defined by the corresponding UK Power Networks directorate making use of the standard.

3 Glossary and Abbreviations

Term	Definition
ADSL	Asymmetric Digital Subscriber Line
ACB	Air Circuit Breaker
CDM	Construction (Design and Management) Regulations
EML	Expanded Metal Lathing
GRP	Glass Reinforced Plastic
HV	Voltages above 1000V; generally used to describe 11kV or 6.6kV distribution systems but may include higher or other legacy voltages
LV	Voltages up to 1000V; generally used to describe 230/400V or 230/460V distribution systems
PSTN	Public Switched Telephone Network
RMU	Ring Main Unit
RTU	Remote Terminal Unit
SCADA	Supervisory Control and Data Acquisition
SF_6	Sulphur Hexafluoride (gas used as a dielectric and insulating material in switchgear).
Secondary Substation	Substation connected to a secondary distribution network that supplies an LV network and/or directly supplies a customer or customers at either LV or HV
Substation	Substation is used throughout this document to refer to a ‘secondary substation’
SWL	Safe Working Load

4 General Considerations

4.1 Overview

All designs shall comply with current British/European standards and local legal requirements. Where the requirements of UK Power Networks exceed those of the Building Regulations or Local Authority, then UK Power Networks specifications shall be adopted.

UK Power Networks' standards rationalise the design across the three network licensed areas. Consequently, it is inevitable that this may raise the specification of some designs to meet overall network requirements or introduce variants not previously considered in individual licensed areas.

Whilst it is appreciated that third party considerations may influence the design, the requirements outlined in this document shall be incorporated in the final substation design that is issued 'For Construction', reflecting the specific site conditions.

The plant layout and specification within any substation is the exclusive responsibility of UK Power Networks. As not all site-specific situations can be covered, the designs shall be checked to be sustainable, safe and secure in and around the substation environment. A written agreement shall be obtained for any deviation from the guidelines given in this document.

UK Power Networks only accepts approved items to be installed in the substation, however for alternative products to be sourced, the process described in EDS 08-1150 shall be followed. UK Power Networks approved civil and substation materials, such as doors, lintels and associated accessories are listed in EAS 07-0000.

4.2 CDM Requirements

The design shall comply with health and safety legislation and shall be safe to be constructed, operated and maintained. In accordance with the CDM regulations, a Hazard Elimination and Management List (HEML) shall be produced for every new substation design. This list shall be populated at the start and throughout the lifecycle of the project to identify and mitigate any residual risk. Design risk assessments, generic and site specific hazard risk assessments shall be completed and included in the CDM documentation for the substation.

5 Substation Types

All secondary substations shall be selected in accordance with the criteria detailed in EDS 07-3101 where location, land/legal rights and risk assessment considerations are outlined.

Substations containing one transformer are classified as a 'single' substation whereas a substation containing two transformers is a 'two-transformer' substation. UK Power Networks substations shall contain a maximum of two transformers. Should the electricity load requirements demand three or more transformers, a combination of 'single' and 'two-transformer' substations shall be used.

6 General Substation Requirements

6.1 Access

Unrestricted access to UK Power Networks substations, plant and equipment shall be provided at all times to ensure supplies can be restored to customers at the time of a fault. For this reason access via security staff or by prior arrangement is not acceptable.

6.1.1 Personnel Access and Locking Arrangements

Access into substations shall use UK Power Networks standard key locking; it shall be via ground level doors, set to open safely from the edge of the public footpath.

If the substation is located behind additional locked gates or doors, these shall be locked in the standard UK Power Networks master locking suite. Lock cases provided by third parties shall be capable of accepting standard UK Power Networks cylinders and 'hasp and staples' shall be capable of receiving the standard heavy duty padlock by UK Power Networks.

Where substations are within gated developments or high security compounds with controlled access via electronic key fob or other electronic locking mechanism, then a key switch override facility shall be provided by the customer and operated by the UK Power Networks master key. All electrically operated gates/doors shall be set to failsafe into the open position to permit access in the event of loss of electrical supply.

Where access to substation doors is likely to be compromised by parking vehicles, preventive measures should be installed, ideally in the form of fixed or removable bollards. Alternatively, protection may be afforded by the creation of a locally raised kerb (220mm high) in front of the doors.

Access doors within buildings that have a shared access route to the substation may be fitted with a special dual cylinder mortise deadlock case, this is designed to accept two Euro Profile (or Scandinavian) cylinders fitted with a thumb-turn, one provided for UK Power Networks use and one for the customer, the operation of either cylinder will open the lock.

6.1.2 Access Route for Plant

To deliver large items of plant to the substation a low-loader vehicle with a hydraulic mounted crane is normally used. The weight of the fully loaded vehicle can be up to 32 tonnes, with individual items of plant of up to 5000kg. The roadway giving access to the substation shall be capable of sustaining the axle weight of the lorry in transit whilst undertaking unloading activities and as such should be essentially level, (gradient shall be no steeper than 1:10) and with room enough to deploy outriggers.

The plant access route should not be via a 'traffic sensitive' area likely to cause difficulties if substation plant needs to be replaced. Plant shall be off-loaded directly onto the corresponding plinth or as close to substation doors as possible to minimise the need for manual handling.

The minimum clear headroom from ground level to the top of the crane arm for off-loading and manoeuvring is 6.5m, if lifting plant over fences or other type of obstacle, an allowance for the additional height of the obstruction shall also be taken into account.

Plant drop zones remote from the substation location should not be more than 10 metres from the substation doors; any deviations shall be discussed and agreed by all parties involved in the project. The area between the plant drop zone and the substation shall be flat and level or laid to nominal falls only.

The route between the plant drop zone and the substation shall be as direct as possible. Routes that involve the manual manoeuvring of plant shall be avoided. Corridors on the plant access route shall be a minimum of 2000mm wide generally with pinch points not less than 1500mm and provide a minimum clear height of 2500mm. If plant needs to be rotated along the plant access route, a 2500mm by 2500mm clear area shall be provided.

It is important to note that the minimum clear dimensions for moving of plant shall be maintained throughout the life of the substation and shall not be compromised by the future installation of pipework, tray-work or similar.

Future plant replacement as well as initial plant installation shall be considered as part of the design. If a fault develops it will be necessary to exchange the plant safely, quickly and with the minimum disruption to the site.

The structural stability of the plant access route should be confirmed as part of the design submission. The entire plant access route shall be capable of sustaining the load of the heaviest piece of equipment in the substation.

6.1.3 Access for Generator Cables

Maintenance or repair activities may require that the substation be temporarily connected to an externally located power generator. For this reason, a secure and safe facility for generator cable access shall be provided for all substations.

The cable access facility varies with the substation type. For standalone brick-built and integral substations, a built-in cable flap is provided with the approved louvre doors. Standard GRP enclosures have a cable flap in the sidewall. Generator cable access in basement substations shall be an approved cable hatch at a location agreed by UK Power Networks.

6.2 Operational Clearances

The design shall meet UK Power Networks operational requirements, minimum dimensions where quoted shall be adhered to at all times. It is mandatory that all persons switching within a substation should have a clear and direct route of escape through an outward opening door. Consideration shall be given to locating the plant and equipment within the room relative to door positions in order to ensure a clear egress route. When designing substation layouts, in addition to being possible to replace faulty items of plant whilst leaving the surrounding plant in-situ, the following mandatory clearances are required:

- The distance between the front of the high voltage switchgear and the front of a LV distribution board shall be a minimum of 1500mm clear.
- A minimum working space of 750mm is required between an adjacent wall and a cable end box.
- The width of any personnel escape route between items of plant shall not be less than 900mm.
- The maximum distance from the point of switching to the nearest escape door shall not exceed 5000mm, if this figure is exceeded or the layout of the room prevents clear and direct access to the door then an additional escape door will be required. Additional escape doors may also be specified at the designer’s discretion if the substation is of an unusual shape.
- In front of a switch or LV board/cabinet where operational works are carried out, a passageway of minimum width 900mm should be maintained from the front of any opening access doors.

General access clearance around plant is to be at least 750mm; this can be reduced to the rear of the transformer provided there is sufficient access available on the other three sides.

6.3 Plant

The design shall meet UK Power Networks operational requirements. A standard ground-level single substation will be designed to accommodate the following items of plant fitted with bottom entry cable boxes:

- Transformer: typically supported on two 50mm wide x 1250mm long integral channels in contact with the floor at approximate 500mm centres.
- Transformer-mounted ring main unit (RMU), circuit-breaker or switch.
- Transformer-mounted LV cabinet or ACB (air circuit breaker).
- RTU (remote terminal unit), wall mounted for remote switching.

The substation shall accommodate all items of plant as detailed on the electrical design. The individual modules of the substation detailed in the standard drawings shall be multiplied where appropriate and arranged to make the most efficient use of the space available.

All new secondary substations shall be designed to withstand or safely relieve internal pressure due to a fault on the plant.

Plant shall be close-coupled rather than cable-connected wherever possible.

To prevent transformer vibrations causing noise nuisance, wherever possible, substations shall be located a minimum of 10m from residential properties. In addition, 500kVA transformers and above, shall be mounted on approved anti-vibration pads.

6.4 Concrete and Reinforcement of Foundation

Foundations and reinforcement details shall be designed to suit local site conditions.

For freestanding foundations using an earthing ring arrangement, the standard floor slab shall be a minimum of 215mm thick reinforced concrete of the following characteristics:

- Ground contaminants shall be removed, local soft spots shall be excavated and brought up to foundation formation level with a designated GEN1 mix to BS 8500-2.
- Structural concrete shall be poured on 50mm GEN1 mix concrete blinding on 1200 gauge geo-membrane, on sand blinding, on well-compacted DTp1 type material.
- Foundations shall sustain weight of plant in any position (5000kg max).
- A sulphate resistance cement combination to BS EN197-1:2011 shall be used unless otherwise specified by the designer.
- RC32/40 concrete mix with 20mm aggregate to BS 8500-2 shall be used unless otherwise specified by the designer.
- All reinforcement shall have a 50mm minimum cover to provide a four-hour fire resistance.
- Sharp external edges above ground level shall have 25mm x 25mm chamfers.
- Top 150mm of all concrete works shall be shuttered to provide a fair face finish.
- Top of all concrete works shall be finished smooth and level within +/-2mm over 2000mm.
- Ribbed bar reinforcing to BS 4449, strength grade B500B.
- Steel fabric reinforcement square mesh to BS 4483.
- Bending schedule to structural engineer’s design.
- Reinforcing bars shall be electrically continuous across the substation’s foundation reinforcement. The reinforcement design shall indicate where welded or exothermic type connections are required.
- The finished floor shall be sufficiently hard to prevent chipping or crumbling.
- Minimum compressive strength of the concrete after 28 days shall be 40N/mm².
- Steps are not permitted within the substation.
- On fully bunded substations a hydrophilic water seal along the construction joint between kicker and concrete walls (e.g. Hydrotite CJ-0725 or similar) shall be used.

In urban areas, for brick-built substations it may be more efficient to introduce an earthing system using an earthing mesh, which implies some alterations to the reinforced concrete specification above described, as follows:

- The earthing design shall include a mesh laid within a 50mm topping screed to control the touch potential around the equipment.
- The earth mesh shall be independent from the reinforcement.
- The earth mesh shall be laid across the whole substation/ switchroom footprint (excluding trenches);
- Two connections from each sheet of mesh shall be made directly to the marshalling bar/ring.
- Steel fabric reinforcement square mesh to BS 4483, A393, A252 and A142.
- The wearing screed shall be 50mm to 100mm deep with a minimum compressive strength of 40N/mm^2 after 28 days. Float finish to +/-2mm over 2000mm.

Refer to Section 6.16 for further information on earthing.

6.5 Roof

The roof shall consist of a concrete slab to give blast and fire resistance. The standard roof shall be a minimum 180mm thick reinforced concrete slab with. The reinforced concrete slab shall comply with the following details:

- Reinforcement to structural engineers detail with sufficient concrete cover to achieve a 4-hour period of fire resistance.
- Ribbed bar reinforcement to BS4449 – Strength grade: B500B. Fabric reinforcement to BS4483.
- RC32/40 mix concrete mix with 20mm aggregate to BS 8500-2
- Roof slab shall be monolithic and cast in situ.
- Roof slab to project 150mm beyond supporting brickwork and to incorporate a drip detail to the eaves (freestanding substation only).
- Roof shall be fully weatherproofed; the standard detail shall have a 20mm mastic asphalt finish in two coats to underlay of felt on a minimum 1:80 fall to the rainwater outlet. Edge of slab provided with a GRP roof edge trim.
- The top of the asphalt shall receive two coats of solar reflective paint.
- The introduction of insulation or preformed void fillers that provide the falls on the slab, are not acceptable for substation roof applications.
- Hollow pot beams, pre-cast concrete planks and lightweight concrete placed on metal profiled decking are not permitted.

6.5.1 Pitched Roof Construction

A pitched roof is permitted above the reinforced concrete roof slab specified in Section 6.5. The roof slab shall be laid to falls and provided with two coats of waterproofing treatment/or built up proprietary roofing.

Roof trusses or joists shall be secured to the concrete slab and all roof voids suitably ventilated. All tiles shall be double-nailed to battens.

The use of lead flashings and lead-free flashings should always be considered. Fascia and soffit boards should be of low maintenance UPVC or similar approved and not timber unless expressly required by the Local Planning Authority.

Guttering and rainwater associated kit should be low maintenance UPVC or similar. Rainwater downpipes should terminate below ground level into back inlet gullies or similar drainage, discharging to local surface water sewer with permission from the local water services company or a dedicated soakaway.

6.5.2 Green Roof

Acceptable when specially required by the local authority. The green roof shall be supported by an outer structure independent from the substation's walls and roof, and shall be drained to avoid stagnant water building up over the roof slab of the substation. The design should allow roof voids to keep dry conditions.

6.6 Masonry

6.6.1 Generally

Common brick (e.g. Flettons) are acceptable providing that they comply with of the following:

- 20N/mm² minimum compressive strength.
- F1 freeze/thaw resistance (durability).
- S1 active soluble salts content in generally but if the walls are provided with a complete protection against water penetration (e.g. thick layer of suitable render, cladding, inner leaf of a cavity wall, internal walls) there is no requirement for active soluble salts content (S0).
- 23% maximum water absorption.
- Clay masonry unit for unprotected masonry to BS EN 771-1.

Subject to site conditions or project specification, other properties may need to be detailed in the design documentation.

For the erection of brickwork, the following shall be observed:

- Bricks to be frogged and laid frogged up.
- Neat struck joints and walls to provide a flush finish internally.
- Providing that non-combustible material be used, brickwork walls may be rendered or clad externally if specifically required by the planning conditions.
- Brickwork shall not be projecting nor of a design that provides footholds to act as a climbing aid.
- Brickwork shall incorporate a proprietary DPC membrane at 150mm above the external finished ground level.
- Brick walls shall be built off 150mm high reinforced concrete upstand/kicker.
- Blockwork walls are not permitted.

6.6.2 English Bond Walls

Brickwork shall be 215mm fully bonded brickwork to BS EN 771-1 laid English bond. Common bricks to be 'frogged' and laid with 'frogs' facing upward.

6.6.3 Stretcher Bond Walls (freestanding brick-built substation only)

Two skins of brickwork laid in 'stretcher bond' with EML and a horizontal bed joint reinforcement every third course with no cavity.

The inner skin shall be of common bricks laid frog up, external facing brick to harmonise with adjacent brickwork. It is important the frogs be fully filled to obtain the required level of fire resistance.

6.7 Lintels

Brickwork wall openings (e.g. openings for doors, vents) shall be provided with proprietary single concrete lintels, with a minimum of 150mm end bearing unless otherwise specified by the manufacturer.

Fire rated doorsets require an approved four hours fire rated concrete lintel of one piece construction, with the steel reinforcement sufficiently covered to provide the required fire rating.

Steel lintels or dual concrete lintels mounted side by side shall not be used for fire rated doors.

6.8 Doors and Accessories

Approved substation doors shall comply with the following:

- Sized to provide a clear opening suitable to accommodate the largest section of plant expected to pass through that door.
- Designed with leafs to swing back 180° to give good access when installing plant.
- Designed to open outwards for emergency escape.
- Connected to the substation earthing system via an earthing lug on the doorframe.
- Louvered and escape doorframes surrounds shall receive a mastic pointing externally.

6.8.1 Louvered Doors

Louvered doors are installed at freestanding and integral substations where there is no requirement for fire resistance. In addition to the general considerations described above, louvered doors shall allow for:

- A galvanized anti-vermin mesh, 10mm² on the internal face of the louvre.
- Emergency escape ironmongery; two-point locking and panic bar fitted with hasp and staple with internal override. The arrangement permits escape from within the substation even if the hasp and staple is secured externally with a padlock.
- Steel frames fixed into brickwork openings with M10 sleeve type anchor or chemical resin fixings.
- Connections to the substation earthing system via the earthing lug on the doorframe.
- Fixings after 150mm reinforced concrete upstand.
- A built-in flap for temporary generator cables.

6.8.2 Fire Rated Doors

Substation doors that open into a building or where fire resistance is expressly requested by the fire officer, in addition to the general specification, fire rated doors shall meet the following criteria:

- Fire test in accordance with BS 476-22 for four hours when mounted in accordance with the manufacturer's instructions.
- Supplied with standard three-point locking and panic bar furniture.
- Steel frames shall be fixed into brickwork openings with M12 sleeve type anchor bolt or chemical resin fixings, 75mm of which should be located within the supporting structure.
- Threshold fixings shall be countersunk and/or flush so as not to constitute a trip hazard.
- Fire rated doorsets shall be mounted on a 150mm high cast in-situ RC upstand; this supports the angle doorframe surround that overlaps the brickwork and acts as a bund to contain potential oil spills.
- Doorsets to receive a four-hour intumescent mastic infill (Lorient Poly products or similar equivalent) where the frame meets the supporting structure, mastic to be applied both internally and externally in accordance with manufacturers' installation instructions.

6.8.3 Escape Doors

Escape doors into uncontrolled areas shall exit into a lobbied area. It is essential to ensure that these are clear and useable at all times, it is imperative that operatives can escape from a hazardous area into an area of safety designated in the fire escape route of the development.

6.8.4 Door Stays

All door leafs shall have approved heavy duty stays to lock the doors open safely at 90 degrees, unless otherwise needed due to site specific plant access requirements (e.g. door leaf requiring 180 degrees swing).

Door stays shall not be used on fire doors.

6.9 Finishes

External brick-built substations are left in a natural brick finish, but can be rendered if required. Walls and ceilings shall receive two coats of white emulsion paint for dust sealing internally.

Decorative non-combustible cladding treatments are permitted if required by the Local Planning Authority but should be avoided if these are likely to pose any maintenance liability.

Floors shall receive two coats of red or grey concrete floor paint.

Steel doors and louvres should be powder coated, standard colours are Grey 16 A 11 and Moss Green 14 C 39; other colours to BS 4800 can be specified if required to harmonise with adjacent colour schemes.

6.10 Cables

6.10.1 Cable Entries

Cable entries into substations should be direct into cable trenches. Cable ducts for mains cable entry will be as specified on the standard drawings, non-standard arrangements will require assessing/agreement by UK Power Networks. Generally, UK Power Networks requires the provision of cable ducts or pipes from the substation to the back edge of the public footpath.

The installation of underground cables shall be in accordance with ECS 02-0019.

6.10.2 Cable Supports

Cable supports, where specified, shall consist of a Unistrut P1000T (41 x 41) slotted channel secured to walls at 600mm centres. If drop rods are used then Unistrut P1001T (83 x 41) slotted channel secured to walls for lateral support shall be specified to enable cables to be cleated either below or above the Unistrut.

The weight of main cables varies depending upon type, size and material used therefore for design purposes a weight no less than 11.5kg/m for each cable should be assumed.

If Unistrut cable supports are required to be fitted to the underside of blast ceilings then the Unistrut cable supports shall be provided and installed by an approved contractor at the time of the initial install.

Unistrut shall not be retrospectively fitted to the blast ceiling by non-approved installers as the additional weight of the cables and Unistrut could compromise the ceilings performance in a blast event. In these circumstances, the Unistrut should be fixed wall to wall independent of the ceiling above.

6.10.3 Service Cable Slots

Service cable slots are sized to suit the number and size of cables required. Openings shall be kept as small as possible so as not to create ‘weak spots’ within the substation fabric. All service cable slots shall use an approved four-hour fire rate seal (e.g. Promaseal or similar) where the cables leave the substation to maintain fire separation at all times.

6.10.4 Winching Eyes

Long cable runs require a cable winching eye. Where required, a suitable anchor point with a pulling ring with an internal diameter of 80mm opposite the incoming cable position shall be provided. Winching eyes can be within the cable trench or 500mm above the substation floor.

The pulling ring shall be capable of sustaining a horizontally applied SWL of 1500kg; test certification shall be issued before usage. In all cases, as part of the design documentation, supporting calculations prior to installation shall be produced.

6.10.5 Cable Pits

Where cable pits are specified (e.g. on a narrow access road where excavation in the roadway would compromise the normal access to a building or development) they shall be provided with removable covers specified to suit the environment in which they are located.

Cables and joints in pits shall be blinded with sand before being energised to protect them from mechanical damage and to prevent the possible spread of fire.

6.11 Ducts

All cables shall be installed in approved ducts. The ducts shall be laid in a straight line wherever possible, laid level and/or finish flush to the external face of the boundary retaining wall being accessible from the pavement. If sites are working to reduced levels or cover during the construction phase then the ducts shall be suitably protected to prevent crushing from site traffic.

Proposed duct routes should take into account nearby tree roots, structures, existing services, cable pits and drainage routes. The cable duct shall be fully accessible from both ends of the run.

All ducts terminating into the ends of trenches shall be finished flush with the internal face of the trench and infilled locally with weak mix concrete in both faces of the trench wall. After cable installation, all cable ducts shall be sealed.

On completion of the building of a substation with oil containment specification, the cable entries shall be sealed internally with an approved duct-sealing system, to prevent the ingress of water and gas into the substation. The sealing arrangement shall be removable to enable the cables to be installed and the cables entries resealed.

6.11.1 Cable Ducts – Plastic

Unless otherwise specified by UK Power Networks the approved plastic cable ducts shall be 125mm internal diameter twin-walled high-density polyethylene ducting. Refer to EAS 02-0000a.

6.11.2 Cable Ducts – Steel

Where cables pass through or under a building, steel duct shall be provided in lieu of the standard plastic duct. In order to avoid potential induction currents all three phases of a circuit shall be accommodated within a single steel duct.

The steel ducts shall:

- Comply with BS EN 10255.
- Have a minimum internal diameter of 125mm.
- Consist of a welded steel tube with no internal protruding seam or an equivalent seamless design. Any surface of the seam shall be smooth to the touch throughout.
- Have all joints screwed and socketed, with the internal edges of the pipe bevelled.
- Have the pipes to be close-butted within the socket/collar. The ends of the ducts shall be de-burred and finished smooth to the touch.
- Be of medium duty and supplied in either red oxide or self-colour finish.
- For excessively long runs or for particular applications, ducts with an internal diameter of 150mm may be specified.
- Be puddle-flanged where they pass through retaining walls straight into a substation.
- Be fitted with internal expanding pipe bungs; these will be removed when UK Power Networks install the cable and they are required to be resealed an approved duct sealing system (e.g. RDSS Rayflate or similar).

Galvanised ducts are not acceptable as the galvanising process can leave the ducts with an abrasive finish internally.

6.12 Cable Trenches

Ground level substations shall be designed to incorporate cable trenches for the HV and LV cables. Cable trenches shall be:

- A minimum of 1000mm deep, to accommodate cable bending radii and enabling the connection onto switchgear with bottom entry cable boxes.
- A minimum of 600mm wide.
- Grated over with open mesh GRP gratings for safety at all times (See Section 6.13).
- Infilled with sand to a level 100mm above the highest duct and a minimum of 500mm below the top of the grating to effectively exclude the build-up of manufactured or natural gas. The resulting void above the sand will also act as a sump for any oil loss from the transformer.

6.13 GRP Gratings

An approved GRP floor grating supported on mild steel galvanised beams shall cover the cable trenches. Gratings shall be easily removable and seated level with no noticeable rocking. Floor gratings shall consist of approved 38 x 38mm deep moulded fibreglass, open type with gritted surface side upwards, and coloured green. Refer to EAS 07-0000.

The standard gratings span in two directions which allows ‘cable cut-outs’ to be created for the incoming cable entry positions. It is important to maintain sufficient bearing at all times. Individual gratings shall be no larger than 1200 x 1200mm.

6.14 Ventilation

6.14.1 Overview

Adequate ventilation shall be provided to dissipate the heat generated by the transformer and other equipment. Substations shall be designed to achieve this by using natural ventilation, generating a cross flow of air over the transformer(s) and other plant.

The size of the inlet and outlet louvered areas for substation are shown in Table 6-1. The figures assume 50% efficient louvered vents.

Table 6-1 –Area Requirements for Ventilation System

Transformer Size [MVA]	Inlet Vent [m^2]		Extract Vent [m^2]		Total Louvered Area [m^2]
	Free Air*	Louvered Area	Free Air*	Louvered Area	
1.0	0.75	1.5	0.75	1.5	3.0
1.5	1	2	1	2	4.0

* Assuming a 50% air efficiency

Basement substation have further requirements as detailed in Section 7.4.

6.14.2 Vents Location

The most common ventilation arrangement is via low level ‘inlet’ louvres within the doors and high level ‘outlet’ louvres behind or adjacent to the transformer position on the opposing side of the substation.

It is important that the ‘outlet’ louvres are located as high as possible and are not sited immediately above any wall-mounted LV board. Substantial vertical separation is required between inlet and outlet openings. Inlet and outlet openings should preferably be clear of pedestrian areas and shall be located to prevent entry of noxious gases such as vehicle exhausts, pollutants such as smoke, soot, dust and ash.

The areas outside the louvres shall not be subjected to fire risk. Louvres shall not vent into areas where heat or smoke dissipation would compromise adjoining escape routes. Louvres are not permitted to vent into bin stores, loading bay areas, undercrofts or underground car parks.

The position of any soft landscaping shall be considered at the design stage to ensure that the airflow through the louvres is not compromised either at inception or in the future.

In some cases, where the roof of the substation is external and exposed to open air, weatherproof ventilation turrets of the same specification as the substation walls/roof and with louvered vents installed may be used. These shall not be located directly above the main substation equipment and should be fixed securely.

6.14.3 Louvered Vents Requirements

Louvres shall be an approved UK Power Networks design and fully secured to the substation structure, all fixings to be accessible from within the substation only.

Louvres shall be of mild steel construction, fully welded into a steel frame and secured internally by suitable anchor fixings into the brickwork (with no external fixings). The steel blades shall be individually welded into the frame for security and to prevent the blades becoming dislodged in the event of overpressure within the substation. In section view, the louvered panels shall be vertical (not sloping or raked).

Louvre blades shall be of a profile to prevent the ingress of driving rain and prevent foreign objects inserted through. The louvered vents shall be fitted with vermin facilities.

Louvre frames surrounds shall receive a mastic pointing externally.

Aluminium, timber or proprietary louvre blade systems that ‘snap in’ are not permitted.

6.15 Electrical Services

All substations shall be fitted with lighting and power in accordance with EDS 07-1119. Where applicable typical lighting and power requirements, compliant with EDS 07-1119, have been included in the standard substation design drawings.

Note: For sites with separate HV and LV earths, refer to EDS 07-1119 for specific power and lighting requirements.

6.16 Earthing

All secondary substations shall have an earthing system designed in accordance with EDS 06-0014 and constructed in accordance with ECS 06-0023. Where a customer has agreed with UK Power Networks to design the earthing system reference shall also be made to EDS 06-0019.

Standard earthing arrangements are included with each substation drawing. GRP substations shall have a buried perimeter earth electrode. The earthing preference for all freestanding brick-built substations is a buried perimeter earth electrode. An internal mesh electrode is acceptable in basement and integral substations.

Substation construction shall not commence until the earthing design has been provided by the project's electrical designer. For UK Power Networks projects, this will include a secondary substation earthing construction and test form and an earthing drawing.

On completion of the earthing system construction, the installer shall complete the appropriate part of the secondary substation earthing construction and test form and, together with an earthing test certificate, submit to UK Power Networks for approval.

Substation fit-out contractors shall connect to the earth tape terminations. The earthing system should be installed at the same time as the excavation and foundations construction works by a specialist subcontractor. The tape and rods shall be protected from damage during the remainder of the construction works and the plant installation and commissioning works.

6.17 SCADA and Communications

All secondary substations should be designed to be able to accommodate a Type E RTU. If the substation input/output requirements involve the installation of a second Type E RTU, the substation should be suitably designed to accommodate this. All RTUs require a 13A unswitched fused spur in accordance with EDS 07-1119.

If the RTU equipment is located below ground level, a suitable route for the feeder, Ethernet cable or PSTN/ADSL cable should be designed into the installation to enable the aerial or router to be installed above ground or the PSTN/ADSL cables routed to the RTU.

Refer to Section 6.2 for relevant operational clearances.

Refer to ECS 05-9202 for further details.

6.18 Signage

It is a mandatory requirement that all substations display external signage accordance with EDS 09-0019.

Plant containing SF_6 or Formel NF gas as an insulator shall be clearly identified at entrance points in accordance with EDS 09-0019.

6.19 Waterproofing

Substations shall be designed to BS 8102:2009, Grade 2 ‘better utility requiring a dry environment’.

A proprietary bitumen based waterproof concrete sealer shall be applied to all below ground external concrete surfaces prior to backfilling.

Watertight sealing of all ducts with or without cable shall be carried out prior to commissioning using purpose made stop ends or bungs. The use of non-purpose made duct seals, for instance rags, newspaper, timber boards, will not be acceptable.

Cable entries using steel pipes shall be puddle flanged where there is a possibility of water tracking around the duct entry position.

Proprietary hygroscopic treatments may be specified depending upon the circumstances.

Retaining walls on basement substations provided with a proprietary cavity drainage (Delta or similar) are required to be protected with the standard UK Power Networks specification brickwork. An alternative approach is to set the substation wall slightly back from the retaining wall so that any ingress or water is arrested before it enters the substation.

6.20 Future Works

Both initial plant installation and future plant replacement shall be considered at the design stage. If a fault develops, it will be necessary to exchange the plant safely, quickly and with the minimum disruption to the site or the main premises.

The future maintenance requirements together with possible additions and alterations to the installed plant shall also be considered at the design stage.

The building fabric and accessories shall be selected to be inherently ‘low maintenance’.

Where new substations are to be disguised using planting schemes, the substation design shall ensure that the proximity and type of planting will not compromise future access, obstruct ventilation louvres if not maintained or allow plant or tree roots to interfere with cables and cable routes.

6.21 Records

‘As-built’ records shall be produced and made available at the time of handing over of the site to UK Power Networks for operation. ‘As-built’ electronic records shall be stored in the asset register and shall include:

- Marked up as-built drawings detailing all structural and dimensional details when different from the ‘For Construction’ drawings.
- Cable and circuits within the substation including size, depth and position of ducts, cables and pits.
- Location of earth rods and earth electrode.
- Earthing test certificates.
- Substation access position and exact position of plant access hatch.
- Non-standard access arrangements.
- Feeds relevant but external to the substation.
- Maintenance periods, procedures, and equipment supplier information for all equipment and plant.

7 Specific Substation Requirements

7.1 Freestanding Brick-built Substations

This substation type shall be truly freestanding wherever possible although it is acceptable to attach the substation to intake rooms, garages, bin stores or similar non-residential premises.

If it is intended to attach the substation to an adjoining premise then the opportunity should always be taken to position the UK Power Networks substation furthest away from any residential dwellings to mitigate potential concerns regarding noise pollution.

A minimum clear headroom of 2500mm is required. The freestanding substation construction should not contain any structural steelwork inside the substation.

7.2 Integral Substations

Integral substations shall be located on an outer face of the larger building accessible from a public footpath. Wherever possible, integral substations shall not be located immediately adjacent to or below domestic dwellings.

While freestanding substations are subject to thermal losses on all sides and through the roof slab, this is not the case for integral substations. With less thermal losses occurring, the cooling inside the chamber is achieved by constantly exchanging the air, for this reason, integral substations shall be located at a corner of the larger building with venting on both external faces to generate cross flow ventilation.

Hot air from the substation shall be ducted to outside air directly and independently from any other ventilation system. Ventilation ductwork shall be rated for four hours fire resistance built of the same specification of the walls and roof or using an approved steel ductwork arrangement.

A flat soffit shall be provided on new buildings except where the roof or floor design requires down-standing beams; if refurbishing a building that has existing downstand beams, the clear headroom shall be measured from the bottom of the lowest beam to the floor level.

Where steelwork is required for the larger structure, all steel members inside the substation shall be encased in concrete with sufficient depth of cover to provide a four-hour period of fire resistance; alternatively, the steelwork can be protected with an approved four-hour fire resisting cladding.

Intumescent paint or fire sprays are not permitted.

7.3 GRP Substations

The GRP enclosure shall be supplied and delivered by UK Power Networks unless agreed otherwise. Refer to EAS 07-0000 for approved GRP substation enclosures.

The top surface of the concrete shall be finished with a surface hardener or a suitable wearing screed for impact and abrasion resistance.

The gratings shall be positioned on the face of a wall to be supported on 50 x 65 x 6mm mild steel angle fixed to wall with M12 anchor fixings at 400mm centres (e.g. ‘Hilti HST Anchor or similar approved).

Grating for the oil spill channel detail in fully bunded substations do not require the angle supports but a 40 x 40mm concrete recess instead.

Floor trenches shall finish flush with the finished floor level to prevent trip hazards.

7.4 Basement Substations

The guidelines given in this section apply to new substations and existing sites where it is intended to modify the larger building associated with the substation and the structure, access or ventilation system need some alteration to suit the new condition.

7.4.1 Internal Chamber

A minimum clear headroom of 2800mm is required within substations at basement level as these are equipped with plant that has top entry cable boxes.

Basement substations contain the items listed in Section 6.3 but with configurations where approved top entry or wall-mounted equipment may be available for use.

7.4.2 Building Fabric

Walls and roof shall have a four-hour fire rating to UK Power Networks specification, typically reinforced concrete or brickwork. Blockwork and plasterboard are not permitted.

7.4.3 Ventilation Requirements

Basement substations shall be ventilated by using passive ‘stack’ ventilation principles, where the system is driven by the difference in air pressure between the cold air ‘inlet’ and the hot air ‘outlet’. For this to work efficiently a dedicated inlet and outlet ventilation duct is required, ideally on opposite sides of the transformer.

The cold air ‘inlet’ is trunked to low level, 500mm above substation floor level, and the hot air ‘outlet’ is via a slot at high level.

Cross-sectional area for ventilation ducts shall comply with the free air figures stated in Table 6-1, similarly the size of the external louvered vents shall comply with the louvered area figures presented in Table 6-1.

Ventilation ductwork should not exceed a total length of ten metres and shall contain no more than two changes in direction. Ductwork in excess of ten metres may be considered only if the duct arrangement is predominantly vertical and has an increased 25% of cross-sectional area, any excess should be no longer than 5 metres in any circumstance.

Ventilation ductwork shall not contain other services, give access to other portions of the building or form part of the ventilation system for the larger building. The strength and fire rating of the walls of ventilation ducts are required to be the same as those specified for substation walls (four hours fire resistance).

It is important that the outlet louvres are located as high as possible and are not sited immediately above any wall mounted LV boards, when present.

Ventilation shafts are an extension of the substation and as such shall be constructed to the same specification as the substation for walls/floors/soffits. Ventilation shafts shall be constructed from standard 215mm fully bonded brickwork or cast in-situ reinforced concrete, with sufficient cover to steelwork to achieve a four-hour fire rating.

All ductwork associated with basement substations shall be of an approved four-hour fire resisting construction (e.g. Durasteel SMT or similar approved). An approved licensee only shall install the ductwork; a letter of conformity is required for every installation. All ventilation ductwork proposals shall be subject to acceptance by UK Power Networks.

7.4.4 Personnel Access

Access to basement substations shall be, in accordance with the 'Type A Access and Egress' characteristics as defined in EDS 07-3101 and open to the air in accordance with BS 9999:2017.

7.4.5 Plant Access

Where substations are located within basements or below ground level, provision shall be made for the safe movement of plant. Wherever possible plant movement shall be made by a lorry-mounted crane parked adjacent to an appropriately sized plant access hatch or open lightwell.

7.4.5.1 Plant Access Hatch

If plant access is required via an opening within the ground floor slab then a horizontal plant access hatch shall be provided. The hatch shall be located external to the substation area, near the substation doors in common areas to minimize manhandling. Locations that involve the manhandling of large items of plant in excess of ten metres or along corridors shall be avoided.

The minimum clear headroom from ground level to the top of the crane arm for offloading and manoeuvring is 6.5m. If lifting plant over fences or other type of obstacle, an allowance for the additional height of the obstruction shall be taken into account. If the plant is to be lowered down a lightwell or through, a plant access hatch then the height of the drop shall be considered to take into account the length of the lifting slings.

Plant access hatches shall provide a minimum clear opening of 2000 x 1530mm for 1000kVA transformers and below; for 1500kVA transformers the minimum clear opening shall be 2150 x 1680mm with the hatch covers removed. The approved hatch covers are designed to be installed flush with the finished floor, so that when the covers are removed no additional reinstatement is necessary. A lightweight (B125) cover shall be specified for internal use and a heavier duty (C250) external type in areas subject to vehicular movement. A minimum of 1000mm clear working space is required around all sides of the hatch at both ground and basement levels.

Hatches sited in tenanted areas or areas usually occupied by persons can only be permitted where unobstructed access can be maintained and legal covenants permitting this access are in place. It is preferable for the hatch to be located in an area clear of any overhead buildings or structures with a minimum headroom of 6.5m. The area surrounding the access hatch shall be designed to allow for the heavy-duty delivery vehicle, which weighs 32 tonnes when fully loaded with plant. An adjacent on-site space shall be provided for the temporary storage of the hatch covers.

Access to the 'plant access hatch' is required at all times; no permanent or demountable structures shall be positioned over the hatch or within the surrounding zone designated as working space.

Services, sprinkler pipes, conduit or similar are not permitted to pass under the plant access hatch; the full hatch opening shall be clear at all times.

Hatches should always be located on a flat area with the surrounding area laid to falls to prevent possible 'ponding' local to the hatch position. Hatches can be installed within ramps providing that the fall of the ramp is less than 1:10.

For projects with a decorative floor finish on the approved hatch access cover, the Customer shall provide four brass studs or strips clearly identifying the location of the hatch within the final finish. Lifting loops for the removal of the cover shall be kept within the substation.

The creation of ‘soft spots’ or ‘break-out’ sections of concrete slabs is to be avoided due to the disruption and time delays associated with future plant replacement. UK Power Networks will seek solutions that remove the need to locate, break out and then reinstate areas wherever possible.

Plant access hatches shall not be used for personnel or general day-to-day access.

The proposed location of the plant access hatch shall be reviewed and accepted by UK Power Networks.

7.4.5.2 Running Beams

Where access for a lorry-mounted crane is not possible and a running beam is required to lower the plant to the basement below, the beam shall be of the running type fitted with a travelling trolley.

The beam shall be a permanent fixture and extend over the whole of the hatch and in addition shall extend past the plant access hatch by a minimum of 2000mm to enable plant to be attached to the lifting tackle whilst on a permanent surface. During the plant installation process the plant is lifted clear of the ground and then moved into position over the open plant access hatch where it is slowly lowered by a hand operated chain hoist down to basement level.

Running beams shall be fitted with a travelling trolley permanently attached to the beam and retained by welded stop ends at both ends of the beam. The beam and the trolley are both required to be tested to a SWL of 6000kgs and certification shall be provided to UK Power Networks prior to first use. Beams shall be permanently marked with the SWL rating and shall be checked, tested and, where appropriate, re-certified prior to use by the operator in accordance with LOLER 98.

The running beam position shall be aligned with the centre of the plant access hatch and parallel with the longest side and extend two metres past the hatch opening. The minimum distance from the suspension point of the trolley to the top of the plant access hatch is 3200mm. Beams should not be installed more than 4.5m above plant access hatches as this can introduce additional risk in terms of access to the suspension point. Services, ductwork, conduit or similar shall be kept clear of the running beam; the travelling trolley shall be able to travel freely from one end of the beam to the other at all times.

7.4.6 Cable Access

High-level cable entries into basement substations shall not be above wall mounted LV board(s).

When designing a substation with high level cable entry a minimum of 1.5 x 1.5m clear floor area shall be provided to create a clear space locally where a scaffold tower can be safely erected to facilitate pulling and cleating cables at height.

Steel ducts shall be specified for entry into basement substations, refer to Section 6.11.2 for steel cable ducts details.

8 References

8.1 UK Power Networks Standards

ECS 02-0019	Installation of Underground Cables - LV to 132kV
EAS 07-0000	Approved Equipment List - Civils and Substations
EAS 07-0021	Signs and Labels for Operational Sites and Equipment
ECS 05-9202	Secondary Substation Communications Equipment Requirements
ECS 06-0023	Secondary Distribution Network Earthing Construction
EDS 06-0014	Secondary Substation Earthing Design
EDS 06-0019	Customer EHV and HV Connections (including Generation) Earthing Design and Construction Guidelines
EDS 07-1119	Substation Electrical Services
EDS 07-3101	Pre-design Requirements for Secondary Substations
EDS 08-1150	Selection, Assessment and Approval of New Technology and Equipment
EDS 09-0019	Safety Sign and Identification Labelling of Equipment

8.2 Other Standards

BS 476-22	Fire tests on building materials and structures. Method for determination of the fire resistance of non-loadbearing elements of construction
BS 4449	Steel for the reinforcement of concrete - Weldable reinforcing steel -Bar, coil and decoiled product -Specification
BS 4483	Steel fabric for the reinforcement of concrete
BS 4800	Schedule of paint colours for building purposes
BS 8500-1:2015 +A1:2016	Concrete. Complementary British Standard to BS EN 206. Method of specifying and guidance for the specifier
BS 8500-2:2015 +A1:2016	Concrete. Complementary British Standard to BS EN 206. Specification for constituent materials and concrete
BS EN 197-1:2011	Cement. Composition, specifications and conformity criteria for common cements.
BS EN 771-1:2011 +A1:2015	Specification for masonry units. Clay masonry units
BS EN 10255	Non-alloy steel tubes suitable for welding and threading. Technical delivery conditions

Construction Design and Management Regulations 2015 (CDM 2015)

Lifting Operations and Lifting Equipment Regulations (LOLER 1998)

Appendix A – Drawings List

Drawing Reference	Drawing Title **Note:** Most drawing references contain three sheets. Sheet 1 for civil/building details, Sheet 2 for earthing design and Sheet 3 for small power and lighting.
EDS 07-3102.01	Unit or Padmount Substation in a GRP Enclosure
EDS 07-3102.02	Unit or Padmount Substation on Bunded Foundation in a GRP Enclosure
EDS 07-3102.03	Elevated Unit or Padmount Substation on Bunded Plinth in a GRP Enclosure
EDS 07-3102.04	Metered Ring Main Unit in a GRP Enclosure
EDS 07-3102.05	Ring Main Unit in a GRP Enclosure
EDS 07-3102.11	Freestanding Brick-built Substation for a Single Metering Ring Main Unit (Earth Ring)
EDS 07-3102.12	Freestanding Brick-built Substation for Two Metering Ring Main Units (Earth Ring)
EDS 07-3102.15	Freestanding Brick-Built Substation for a Single Transformer up to 1500kVA (Earth Ring)
EDS 07-3102.16	Freestanding Brick-Built Substation for a Single Transformer up to 1000kVA with ACB & LV Boards (Earth Ring)
EDS 07-3102.17	Freestanding Brick-Built Substation for Two Transformers up to 1000kVA each with ACB & LV Boards (Earth Ring)
EDS 07-3102.20	Integral Substation for a Single Transformer up to 1500kVA
EDS 07-3102.21	Integral Substation for a Single Transformer up to 1000kVA With ACB & LV Board
EDS 07-3102.22	Integral Substation for Two Transformers up to 1000kVA
EDS 07-3012.25	Integral Substation for Metering Ring Main Unit
EDS 07-3012.26	Integral Substation for Two Metering Ring Main Units
EDS 07-3102.30	Basement Substation for a Single Transformer up to 1000kVA
EDS 07-3102.31	Basement Substation for a Single Transformer up to 1500kVA
EDS 07-3102.40	Standard Plinth for Micro Substation
EDS 07-3102.41	Standard Plinth for Compact Substation
EDS 07-3102.42	Timber Fence Details and Earthing Layout for Closed-Boarded Fenced Sites
EDS 07-3102.44	Plinth Designs for Distribution Switchgear and Transformers
EDS 07-3102.50	Plinth Design for Freestanding 6 & 8-Way LV Pillars
EDS 07-3102.51	Plinth Design for Remote Terminal Unit
EDS 07-3102.60	Brick Firewall for Secondary Substations

Appendix B – Drawing Revision History

Drawing Reference	Latest Rev.	Changes in latest revision
EDS 07-3102.01	C	Drawing notes and layout revised ; revised to show 1500kVA transformer
EDS 07-3102.02	C	Drawing notes and layout revised
EDS 07-3102.03	C	Drawing notes and layout revised
EDS 07-3102.04	C	Drawing notes and layout revised
EDS 07-3102.05	C	Drawing notes and layout revised
~~EDS 07-3102.10~~	~~B~~	Withdrawn
EDS 07-3102.11	A	New drawing
EDS 07-3102.12	A	New drawing
EDS 07-3102.15	C	Drawing notes and layout revised. New 3+1 leaf door fitted. Upgraded to up to 1500kVA transformer
EDS 07-3102.16	C	Drawing notes and layout revised. New 3+1 leaf door fitted. Upgraded to up to 1000kVA transformer
EDS 07-3102.17	C	Drawing notes and layout revised. New 3+1 leaf door fitted. Upgraded to up to 1500kVA transformer
EDS 07-3102.18	A	Withdrawn
EDS 07-3102.20	C	Drawing notes and layout revised. New 3+1 leaf door fitted. Upgraded to up to 1500kVA transformer
EDS 07-3102.21	C	Drawing notes and layout revised. New 3+1 leaf door fitted.
EDS 07-3102.22	C	Drawing notes and layout revised. New 3+1 leaf door fitted.
~~EDS 07-3102.23~~	~~B~~	Withdrawn
EDS 07-3102.25	A	New drawing
EDS 07-3102.26	A	New drawing
EDS 07-3102.30	C	Drawing notes and layout revised
EDS 07-3102.31	A	New drawing
EDS 07-3102.40	C	Drawing notes and layout revised
EDS 07-3102.41	C	Drawing notes and layout revised
EDS 07-3102.42	C	Drawing notes and layout revised
EDS 07-3102.44	D	Drawing notes and layout revised
EDS 07-3102.50	C	Drawing updated for revised pillars
EDS 07-3102.51	A	New drawing
EDS 07-3102.60	A	New drawing
~~EDS 07-3102.BP~~	~~C~~	Withdrawn. Small Power & Lighting drawing appears as sheet 3 on each drawing
~~EDS 07-3102.GP~~	~~B~~	Withdrawn. Small Power & Lighting drawing appears as sheet 3 on each drawing
~~EDS 07-3102.GE~~	~~A~~	Withdrawn. Earthing detail appears now as sheet 2 on each drawing
~~EDS 07-3102.BE~~	~~B~~	Withdrawn. Earthing detail appears now as sheet 2 on each drawing
~~EDS 07-3102.ME~~	~~C~~	Withdrawn. Earthing detail appears now as sheet 2 on each drawing