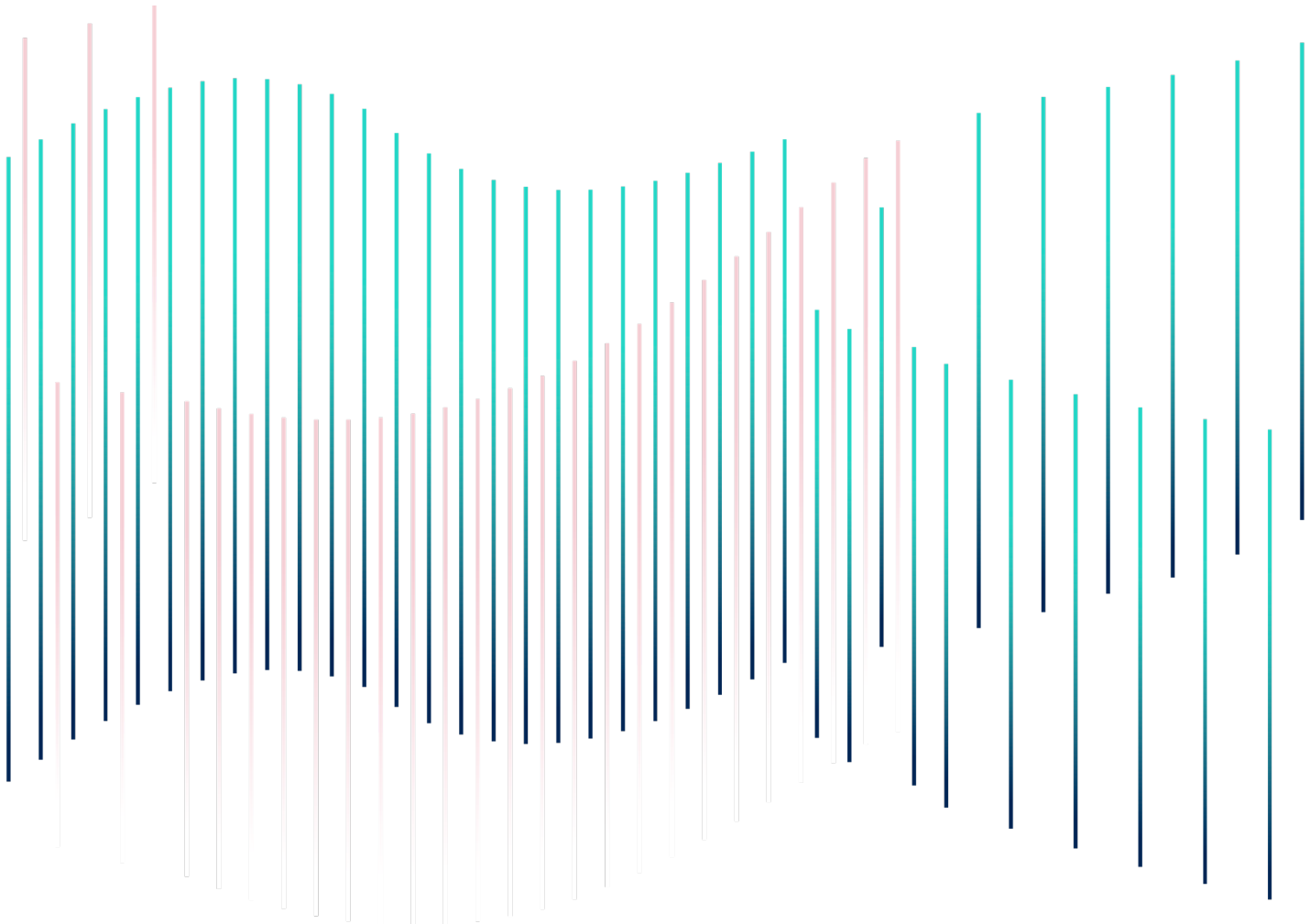
Appendix to ENA Engineering Recommendation G81 Part 3 & 6

Installation records for housing developments and I&C installation



1. Document Control

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Role	Name	Comments	Date
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2. Contents

3. Introduction

This document forms Aurora Utilities (AUL) Appendix to the Energy Networks Association (ENA) Engineering Recommendation G81 Part 3&6 - Installation records for housing developments and I&C installation.

This document should be read in conjunction with ENA EREC G81 Parts 1 through 6 and provides specific information to be used in the design and planning of AUL IDNO networks.

This document should be read in conjunction with the other AUL Design Policy and Standards and Health, Safety, Environment and Quality Policy and Standards.

The principles of any design are to be agreed with AUL principles from the outset of the design process and should comply with this document and the G81 documentation of the host DNO where applicable.

This document contains a summary of the information contained in AUL product specification.

Please note that AUL is unable to provide copies of external documentation, standards and specifications referenced in this document, but copies may be obtained from the relevant issuing body (such as the British Standards Institution (BSI) or Energy Networks Association)

Where the requirements of AUL are not specified then any works shall be carried out in accordance with the best industry practice, complying with all appropriate legislation, including those referred to in the ENA G81 documents. The ICP must obtain approval from AUL before any work onsite commences.

The following sections details the procedures which shall be followed when handling and installing power cables. These procedures are based on safe working practices and are designed to minimise the risk of damage to the cable to be installed.

4. Excavation and Cable Laying

Work onsite to install LV/HV underground cables that are to be adopted by AUL shall not be carried out until the proposed Network has been formally approved by AUL and that the work is to be undertaken by a NERS accredited ICP or their approved NERS accredited sub-contractor who has undertaken the ICP validation process. Cable installation shall not commence until AUL have validated the contractors that will be used for each specific installation.

Excavation work shall ensure that best practice techniques are used towards safe excavations, shoring, access and egress and depths forming confined spaces. Types of ground, for movement or contamination shall all be formally risk assessed. There shall also be a controlled process to prevent insufficient or excess cover over cables when line and level approach is used in the installation process, it is not acceptable for assets to be outside of NJUG recommended positions in public highways or private ground as this can present a hazard for those carrying out work in the future.

All joint holes will be excavated to the appropriate dimensions for the type and quantity of the apparatus to be installed as required within the jointing instructions for the relevant type of joint.

The installation of new mains cables in the footpath will be carried out in accordance with the requirements of NJUG Publications.

Where cables are laid direct, care shall be taken to ensure that the bottom of the trench is substantially smooth and free of sharp edged stones. The back-fill around the cables will be made up of fine granulated, compactable sand, marker tape, and then good quality material free from sharp edged stones and rubble.

Rollers of sufficient number and type for straight runs and bends shall be used, 'bell mouths' will be used to prevent damage on duct entries. Cable pulling tensions and radius of bends will be controlled and in line with tables appropriate to cable sizes and manufactures recommendations.

All reasonable measures must be taken to ensure the correct physical separation is made between AUL underground cables and those of another IDNO/DNO, preferentially this will be by placing them on the opposite side of the road. In situations where it is unavoidable to lay cables on the same side of the road as existing cables owned by another DNO, then marker tape identifying the cables as AUL shall be used, and the proximity of other cables and services shall be accurately recorded on the 'As Laid' drawing.

To avoid damage to the over sheath and/or insulation of cables in cold weather, PVC sheathed cables (Waveform, service and multicore cables) shall be maintained above 0°c and Polyethylene sheathed cables shall be maintained above -5°c for a minimum of 24hrs before laying or bending.

Cable installation within buildings shall only be carried out through pre-agreed designs with AUL. Troughs, trays and ducts shall have been purposefully designed in relation to standards governing the suitability for the building type and route, taking into consideration the cable type/s any segregation required, weights, diameters, bending radii and environment. All cable 'run' designs shall conform to regulations and standards. See G81 part 2/5. Installation shall be carried out with care using appropriate equipment to avoid damage and stress on the cables.

4.1 Working in the Vicinity of Live Cables or Plant

All HV/LV cables and Equipment must be treated as Live unless a permit has been issued by an Authorised AUL Engineer or Authorised Validated ICP confirming that they have been isolated.

Any works carried out on or around AUL equipment will be managed with due consideration for the safety of the general public and personnel working on the Network.

Attention is drawn to the requirements and recommendations contained in the Health and Safety Executive guidance notes HSG47 "Avoiding Danger from Underground Services"

4.2 Cable Ducts

Ducts installed that are not immediately required, shall be left with a suitable draw cord in place, and sealed using an approved method. All Ducts shall be proven clear and clean before drawing the cable.

All ducting entering a Substation, Chamber, Draw Pit, or Building shall be suitably sealed to prevent the ingress of Water or Gas regardless of whether there are cables passing through them.

The installer of the ducting must seal the gap around the ducts and the structure to prevent the ingress of Water or Gas.

After the installation of the cables is complete, the installer will seal the incoming ducts around the cables to prevent the ingress of Water or Gas. The method of sealing the ducts must be agreed in advance and the type of Mechanical seal, Sealant, or Expanding foam must be approved by AUL.

Where ducts are to be installed in concrete, prior agreement will be required from AUL. If an agreement is reached, then steel pipes will be required. The pipes shall be a medium quality steel, screwed, and compliant with BS1387:1985 suitable earthing and bonding of these pipes will then have to be designed in relation to the environment and other factors as per AUL Earthing procedure. A design for shallow coverage of cables scenario may be appropriate, using standard ducting, sand covered with 'stock board' (recycled polyethylene boards) electricity marked, sand covering finished with concrete and surface embedded 'marker blocks' (300mm * 300mm * 150 mm) for electricity cables below. Agreement to be reached specifically tailored to each scenario.

Generally ducting will be plastic 'Rigi-Duct' and shall be connected in accordance with the manufacturers' recommendations. The ducts will be black in colour and marked with the legend 'Electric Cable Duct' on two diametrically opposite sides.

For small service cable entries, pre-formed plastic ducting may be used when compliant with the AUL Materials Specification, and the current NJUG publications. The duct shall be black, marked with the legend 'Electric Cable Duct' on two diametrically opposite sides.

4.3 Cable Pulling

The cable installer shall handle the cables with care and shall examine and check the cable for damage during and immediately following the cable installation. Any damage that occurs will have to be rectified immediately and notified to AUL, temporary repairs will not be acceptable. Any subsequent damage found, will be repaired and charged to the ICP. Any cables that are damaged during the installation process will have to be replaced.

Where the cable installer is to use a winch, it must be fitted with a swivel eye. The swivel eye must be in good working order and able to freely rotate to prevent the cable twisting during the installation. The winch must be fitted with an adjustable tension limiting devise. The maximum pulling force must not exceed the values in appendix A – Mechanical Pulling Force. Cables shall be pulled via a cable sock fitted to the nose of the cables, and secured in place.

Where cables are being installed into open ground, buildings or service tunnels, rollers must be used to guide and support the cables. The rollers should be in a serviceable condition, moving freely and the surfaces are to be without damage. When using rollers, they should be positioned to suit the cable size such that at no time they are dragging on unprotected surfaces. At duct entries, a bell mouth should be attached with roller positioned to give central access into the bell mouth.

Immediately following the installation of cables, the ends of each cable shall be inspected for damage and then secured against the ingress of moisture by fitting heat-shrink caps.

4.4 Cable Protection

Cables must be protected and marked to comply with Regulation 14 of The Electricity Safety, Quality and Continuity Regulations 2002.

Cable Tile/Tape and or Plastic Warning Tape shall be installed above all Cables / Ducting that are relevant to the installation.

Where it has been agreed in writing with AUL that cables can be installed with less than the specified cover, 'stopboard cable marker tiles' must be laid over the sand covered

cables before re-blinding and covering with concrete to Highway Authority and Utility Committee (HAUK) specification and studded with ‘Low/High Voltage cable below markers’ to flush level, (preventing tripping hazards); This is to provide additional protection and safety.. The concrete surface mounted ‘markers should be positioned at maximum 2m intervals along the length of ‘restricted depth’ cables. These locations will be clearly identified on the ‘As Laid’ drawings.

Where cable tape/markers are removed from existing cables during works, or have not been previously installed, they shall be replaced or installed as these instances are found.

4.5 HV Single Core Cable

Single core cables shall be installed in Trefoil format, bound together at one metre intervals with nylon cable ties. The nylon cable ties shall have a smooth internal surface and have a minimum loop tensile strength of 54kg.

Where cables are installed within buildings or Substations they shall be supported by suitable cable cleats.

These cleats shall be selected with the following taken into consideration:

- The specific diameter of the cable being installed.
- Fault rating of the installation.
- Spacing of cleats in accordance with manufacturers recommendations.

4.6 HV Polymeric Cable Sheath Testing Procedure

Each section of polymeric cable being laid shall have a sheath test carried out before being jointed, this must where practicable be carried out as soon as possible and before backfilling just in case there is a fault on the cable.

A 5kV test is required, the HV test equipment is connected between the screen wires at one end and a temporary earth stake driven into the ground adjacent to the ends to be tested, for each single core cable in turn, (the screen wires must be prevented from coming into contact with anything likely to affect readings for the duration of the test). Care must also be taken when installing the temporary earth rod as there may be other utility equipment below.

Each core must be tested at 5kV for 1 minute, if there is leakage current in excess of 10mA or the insulation resistance is less than 100MΩ there is at least one sheath fault which must be located and repaired before continuing with any other cable laying. It is possible there may be a faulty batch of cable, if suspected this must be followed up through the supplier as soon as practicable with AUL notified of any issues. A risk assessment shall be carried out by an authorised person for this activity prior to any testing work progressing.

Repairs to sheath faults must be reported to AUL with agreed repair methods being formulated. Each location shall be retested with test results being submitted to AUL along with other data requested and accurate locations identified as specified in the As Laid procedure.

4.7 Cable Depth of Cover & distance from other Utilities Equipment

The installed cables shall be laid in accordance with the depths and orientation listed within the NJUG Guidelines.

4.8 Cable End Protection

All cut ends of cables, including cable left on the drum, shall be sealed immediately and not left exposed to the atmosphere. This applies whether the cables are cut at the stores, in the yard or onsite. All end caps, including factory fitted end caps, shall be examined after laying and any cap found to be damaged shall be removed and the cables resealed immediately.

4.9 Service Installations

The cable installation shall be in accordance with the relevant National Joint Utilities Group Publications with 'ducted' cable running perpendicular to the road where practicable, ensuring any deviations are minimal. and the cable design with limits set as per AUL specification, there shall be no de-rating of the service cables unless specifically agreed with AUL in writing and supported by specific cable calculations (cavity service entry is not permitted, which de-rates the service cable).

The meter cabinet and installation arrangement shall be of the type agreed with AUL as detailed in the G81 materials section. The meter cabinets must be installed in such a way that does not reduce the manufacturers' fire resistance rating. The standard method of service entry into the meter cabinet shall be by means of a white, ultra violet proof PVC preformed tube (hockey stick) with an outside diameter of 38 mm and a wall thickness of 2 mm. The tube shall be fixed to the outside wall by a single bracket normally midway between the base of the meter cabinet and ground level.

If alternative arrangements are proposed, these arrangements shall be agreed in advance and supported by appropriate drawings. Where agreement has been reached for an alternative service position because of planning constrains etc, the following stipulations must be complied with.

In all circumstances the meter must not be unduly exposed to accidental damage and shall be designed in such a way that the air temperature around the cut-out will not exceed 30ºc.

Cable entry to internal service positions shall be via a 35mm tube with a minimum bending radius of 450mm, this shall be designed such that the service cable is as short as practicable, being brought upwards through the concrete floor. The Service position should be on the wall of the house as close as possible to the LV mains cable.

All Service position equipment including the metering equipment shall be fixed to a meter board of resin bonded compressed wood chipboard (or other Approved material). The cabling between the Customer's main switchgear (consumer unit) and the switch disconnector/neutral block where applicable shall not exceed 2 metres. The meter board will be of minimum size 600 x 300 x 12 mm or a size suitable for the purpose in line with AUL materials specification.

The board shall be installed such that:

- The bottom is a minimum of 500mm above floor level

- The top is a maximum of 2m above floor level
- A minimum of 750mm-access space is available in front of the board.
- It is directly above the Service entry tube

Spacer tubes are fitted to ensure the board is mounted clear of the wall, where the board must be positioned against a timber framed wall or wall with potential for drilling into the back of the meter board, a metal plate of min 1mm shall be installed immediately behind the meter board and be solidly earthed to the combined Neutral Earth block of the PME terminal.

Company termination equipment will be physically separate from water or gas equipment. Where reasonably practicable in separate cupboards, however at least 300mm apart and not above or below the installation.

Once the service cable has been installed, the ducts must be sealed both internally and around the entry into the cabinet.

Black polyethylene service ducting (32mm) shall be used between the hockey stick/cable entry duct and footpath 'Joint position' or road crossing duct. This shall be of continuous length with no joints, Black is the only colour to be used for AUL electrical service cables, to prevent confusion with other utility services. Wherever possible joint positions must avoid the entrance to driveways.

There should not be any consumer equipment in an external meter cabinet except for the consumer's outgoing tails to their consumer unit. Looped services to other properties are not permitted.

Industrial and Commercial Service locations must be designed such that the meter location is directly next to an outside wall in the direction of the cable run, and hence there will be minimum cable exposed internally. Ideally the metering cabinet will be directly above the cable entry into an approved metering cabinet or room.

Ideally a separate room would be allocated for security and prevention of damage to the installation, there will also be other switched equipment in the vicinity which will need protecting against accidental contact. Regulations will need to be checked for compliance if there is any other equipment proposed, such as Gas pipes and meters.

AUL has several preferred solutions for Service Positions and equipment for Commercial and industrial applications, further discussion and approval will be required before acceptance. All ducts associated with these shall be appropriate to cable sizes as stated in AUL technical data.

4.10 LV Cable Jointing

LV jointing and termination kits are identified within the AUL Materials Specification. If there is not a specification for a particular joint, details can be obtained from AUL.

All joints are to be constructed in accordance with the specific instructions issued by the joint kit manufacturer and filled with 2-part resin.

All compression tools and connectors used must be approved by AUL.

The location of joints shall be clearly identified on the 'As Built' record drawings, which shall be available prior to energisation, and the Jointers job card along with the manufactures batch number used.

All LV jointing and terminating shall be carried out by NERS accredited personnel who has been validated by AUL. The name of the jointer completing the joint shall be identified on records.

Jointing bays should not be back filled until such time as the resin / joint filler has fully hardened.

Joints must be kept dry until such time as the resin / joint filler has fully hardened.

Joints to be adopted by the upstream DNO must comply with their associated G81 documents.

4.11 HV Cable Jointing

HV cable terminations and jointing kits are specified within the AUL Materials Specification. If there is not a specification for a particular joint or termination, details can be obtained from AUL.

All joints and terminations are to be constructed in accordance with the specific instructions issued by the joint kit manufacturer.

The location of joints shall be clearly identified on the 'As Built' record drawings, which shall be available prior to energisation.

All HV jointing and terminating shall be carried out by NERS accredited personnel who have been validated by AUL. The name of the jointer completing the joint shall be identified on records.

Jointing bays should not be back filled until such time as the resin / joint filler has fully hardened.

Joints must be kept dry until such time as the resin / joint filler has fully hardened.

Joints to be adopted by the upstream DNO must comply with their associated G81 documents.

4.12 Underground Link Boxes

LV link boxes are specified within the AUL Materials Specification. These are generally installed as an isolation position as close as practicable to the LV Main cable and identified Point of Connection (POC).

The link boxes shall be installed in the footpath and shall be supported on a suitable concrete slab. After jointing is complete, a brick built (or approved alternative) pit shall be formed around the link box which shall support an approved footpath cover, details of which can be found in the AUL Materials Specification.

The design of the pit and selection of the cover will be appropriate to the imposed loading that may be expected in such a location.

Each link box shall be fitted with an AUL identification label stating:

- Rating of link box
- Point of Isolation
- Points of Supply
- Emergency Contact Number

The link box must be the approved type of the upstream DNO.

5. Cable Trench Details

Cable Trench details should be in accordance with the NJUG Guidelines. Cross section details of the trenches should be shown on the 'As Laid' drawings Typical trench drawings can be made available if required.

6. LV Service Terminations and Layouts

6.1 Multi-Occupancy Dwellings

For Maisonette Type Domestic Buildings:

A black low density polythene ducting with an external diameter of 38mm and internal diameter of 32mm, shall be installed into the fire-resistant meter cabinets. These meter cabinets shall be installed on an external wall, at ground floor level of the building.

The cabinets shall be sited so that the top of the cabinet is no higher than 1800mm from finish ground level, and the bottom of the cabinet no lower than 500mm from finished ground level.

A single phase service and meter will be installed in each cabinet. The cabinet shall be large enough to accommodate a meter and a time-switch. The minimum space that would be required, will generally be 350mm x 350mm.

A PME Earth Terminal shall be provided for each service.

For Multiple Storey Domestic Buildings please refer to the ENA G87 document. Only None - Building Network Operator (BNO) schemes will be adopted by AUL. Diagrams for the service layout within rooms are available from AUL, these demonstrate the space to be allocated within a 'metering room' for all the equipment, depending on numbers of flats to be serviced.

Whilst AUL will not be acting as the BNO, the service installation must comply with BS7671 and have LSOH cables leading from the multi panel board towards the properties.

7. New Substation Buildings

Only approved equipment shall be installed on AUL Networks. Second Hand equipment shall not be installed, unless formal approval has been given by the Network Manager or his nominated representative. AULs policy is to adopt only New Approved Equipment from Third Party New Connection Contractors.

AUL will agree the details for the Civil Works required for each Substation and will inspect each Substation for compliance during the construction process.

An approved substation enclosure shall be erected and made lockfast or appropriate measures taken to prevent access prior to any equipment being energised as detailed in this document. The size and design of enclosures will depend upon the nature and location of the site and on the equipment to be enclosed.

All enclosures shall have a 1 metre gap between walls and the site boundary. Wherever possible or unless required for expected future extensions, the area of the site purchased should be the minimum required. Additional areas of land are costly to maintain and serve no useful purpose to the Company. The land shall be obtained through legal consent via the developer.

The risk level with regards to vandalism shall indicate locations where there is the potential for high incident rates, these would be indicated by the proximity of a proposed substation to a ‘meeting place’ likelihood, i.e. adjacent to shops or a school in a region with historic incident rates have been medium to high. On a new site it is difficult to assess the likelihood however some new positions may be adjacent to know issues.

Where there is evidence to suggest the new substation could attract vandalism, a higher protection level of enclosure shall be installed. The type of enclosure in this situation shall be agreed between the ICP and AUL, however it is likely to be of either Galvanised steel or brick

Due to the complex nature of some Substations within Towns and Cities, it is likely that some Substation buildings will be one-off designs taking into account the available footprint of the proposed Substation, and any architectural constraints.

Substations that are to be located integral to the new development shall consider the necessary ventilation, fire regulations and access requirements. The substation design shall be provided by the developers Architect.

The contact details for any information regarding proposed sub-stations are normally provided during the quotation process for a new connection. Legal consents will also be required for cables and access, sufficient and suitable plans will be required for these.

In most cases the substation will be aligned to the Host DNO G81 statement. In these cases, it is important that the specification is followed which will preferably be a GRP design for which there are many suppliers and designs available. All suppliers to DNOs are approved by AUL.

7.1 Civil Works

The ICP will liaise with the developer regarding the secondary substation location, size, base and housing required and obtain approval from AUL.

AUL will provide the ICP with details of S/S civil work requirements to enable drawings to be prepared and agreed. The site, and any access road that is being constructed at the same time, shall be cleared of all top soil and vegetation. The developer will construct the S/S foundation, plinth and housing (where applicable).

The site position orientation and level shall be checked and excavation carried out for the standard plinth appropriate to substation apparatus and total enclosure type. The base of the excavation shall be rammed and blinded prior to shuttering being secured in position and checked for level. Further detail of generic AUL requirements are covered below.

AUL will inspect the S/S civil works and approve, prior to plant/switchgear being installed.

7.2 External Distribution Substation Enclosures (Basic Requirements)

There are situations where a DNO substation specification may not be acceptable to a developer, it will still be incumbent on an ICP to build acceptable designs for the DNO along with AUL approval as these are operational premises and, in many cases, the DNO personnel will be carrying out work within these at some stage.

The following alternative construction of enclosures may be applied at the discretion of AUL:

Where a developer requests a masonry/brick constructed enclosure in lieu of a standard GRP enclosure then this shall only be installed after a contractual agreement has been signed to cover the additional costs associated with this type of enclosure.

Local Planning Requirements

Where Local Planning requires a brick fascia enclosure, a mock brick GRP enclosure shall be installed. Where this is deemed unacceptable by the Local Planning department formally in writing, then subsequent to a site assessment by AUL a masonry/brick enclosure may be installed.

For Substation enclosures, the following items shall be incorporated into the design as a minimum:

- Foundations; Excavations to be kept free from water at all time.
- All concrete to be grade C28/35 with min. cement content of 300 Kg/m3 and max. w/c ratio of 0.6. Cement to be Sulphate Resisting to BS 12. Aggregate size to be 20mm maximum.
- Cover to reinforcement be 50mm. Minimum lap of A252 mesh reinforcement to be 400mm
- Reinforcement mesh to be supported on proprietary chairs. Mesh is not to be trodden into the concrete surface.
- Floor slab, front and rear walls and base of cable pit (where ‘bunded’ as within 50m of water course) to be 200mm thick C28/35 concrete with A252 mesh reinforcement

as indicated, 50mm cover. Floor slab to be steel float finish to plus or minus 3mm in 3m length.

- Trench fill foundations up to underside of floor slab to be C28/35 concrete.
- The concrete plinth and chamfers above ground level, and external to the building to be Type B finish to BS8110. The concrete should be thoroughly compacted and all surfaces should be true, with clean arises. Only very minor surface blemishes should occur, with no staining or discoloration from the release agent.
- 1200g (250µm) visqueen membrane beneath floor slab, laid on 25mm sand blinding, all on top of 150mm thick, well compacted subbase.
- Adequate Ventilation to be provided. The details of the approved suppliers can be found in the AUL Materials Specification. A minimum of 1.5m² of free area is required. It is essential that the external area around the louvers is kept clear. For guidance a 1000kVA releases 10.5kW of heat, ventilation must allow for this to be vented.
- In addition to the above, an allowance must be made for any disruptive failure pressure from HV Equipment which may be up to 250MVA or 16kA enclosed within a rear vented Steel housing. In the case of a GRP this may be achieved by using a Manufacturers 'Lifting Roof' design with 'capture facility' to allow the roof to return to its normal resting position; In brick-built housings via additional vents suitably positioned away from any likely public gatherings.
- Where a reinforced concrete roof is not an option and a tiled roof to the developer's specification is being built: Ceilings to be double boarded with 'Promat Supalux boards' (or Equivalent), 12mm thick, staggered centres, to give 1 hr fire resistance. All joints to be sealed with intumescent mastic. Clearances to buildings in proximity to this to be risk assessed as suitable for the 1hr spread potential.
- Cavity walls to comprise 102.5mm outer leaf facing brickwork laid in stretcher bond, 75mm un-insulated cavity, and 100mm 7N/mm2 fair face dense concrete block inner skin.
- Facing bricks to be F2, S2 quality. Brick colour and type to be agreed with the local planning authority.
- Outer facing brickwork and inner fair face blockwork to have bucket handle finish joints.
- Mortar designation iii to BS5628, 1:6 cement: sand with plasticiser for all brickwork and blockwork above DPC.
- Wall ties to cavity walls to be Type 2 to PD 6697 (Masonry General Purpose). Ties at 450mm vertical and 900mm horizontal staggered centres.
- Wall ties to be placed 225 mm from door and vent opening reveals at 225mm vertical centres.
- At all door and vent openings, the cavity to be closed with blockwork and vertical /horizontal DPC.
- Substation doors are to be compliant with the AUL Materials Specification and may incorporate vents to form part of the overall building design. Wooden doors will not be used on AUL Substations. Right hand leaf viewed from outside to open out, with a dual locking facility to meet the requirements of the local DNO. Passive leaf to be secured with 16mm spring loaded bolt top and bottom. Both door leaves fitted with 90 degree hold open door stays. Each door leaf to have a minimum of 3 number heavy-duty stainless-steel hinges with dog bolts.
- Security strip to be provided to the leading edge of the opening door.
- Door sets to be fitted with weather seals. Door frames to be 1.5mm nominal thickness zinc coated steel sheet to BSEN 10152 (BS6687). Construction can be either single or double rebate providing there is sufficient width to cover any vertical damp proof course, and to provide sufficient fixing points.
- Mastic pointing to frames externally.
- All steelwork to be hot dip galvanised to BS EN ISO 1461:2009.

- 24hour Vehicle access is required to the Substation doors.
- If the Development is secured by means of access gates, and the Substation is located within these gates, then the access will be available by use of an over-ride key, which will be located within a secure box on an adjacent wall. Access via a security guard will not be acceptable under any circumstances.
- 1000mm clear paved access around the Substation enclosure. Where this access strip forms a corridor at the sides and rear between the site and other boundaries, then unauthorised access around the Substation will be prevented by means of a barrier such as palisade fence on either side at the front of the enclosure. (Any fences with touch potential to earthed attachments on the substation shall be suitably assessed and any risk mitigated via earthing/bonding to AUL standards.
- 750mm clearance around all HV Equipment.
- Building services – to include as a minimum Distribution Board, lighting, Socket Outlet, and auxiliary feed for protection equipment. Switch-rooms will also require thermostatically control tubular heating. All wiring to comply with BS 7671.
- Cable pit covers to be 50mm thick GRP gratings, light grey in colour, with 50mm x 50mm cellular structure and an anti-slip top surface. Cable pit cover plan dimensions to be not greater than 1m x 1m. Minimum cable pit cover width to be 300mm.
- GRP gratings to be supported on 50x50mm formed concrete recesses cast into the pit wall, or galvanised steelwork supports as per drawing details. Gratings to be seated level, without noticeable rocking and finish flush with the concrete floor level.
- Gratings to be installed on completion of the floor construction, and cable cut-outs to be formed after cable installation.
- Covers to be manufactured by Fibergrate Ltd, or similar approved
- GRP Enclosures are to be compliant with the AUL Materials Specification.
- To comply with Regulation 3(4) of The Electricity Safety, Quality and Continuity Regulations 2002, all cable entries into the Substation must be sealed. The installer of the ducts must seal the gap between the outside of the ducts and the building structure. The installer of the cables must seal the annular gaps between the cables and the insides of the ducts where the cables at all duct entry points. The type of seal selected must provide a liquid and gas tight seal, this may take the form of Mastic, Expanding foam, or a Mechanical Seal. The manufacturer's details are to be provided for approval prior to fitting.
- Metal frames, reinforcing mesh, structures and equipment shall be bonded in line with AUL Earthing specification.

7.3 Integral Distribution Substation / Customer owned

For Substation Enclosures that form part of the building fabric of the Development, then the following items shall be incorporated into the design in addition to those identified above.

The minimum spatial envelope shall be no less than that indicated on the appropriate AUL drawing detailed within this document. In addition, no single dimension shall be less than that indicated within the appropriate drawing. Where other dimensions are offered by the customer/developer this shall be by negotiation with AUL on a site-by-site basis

- The building fabric must provide 3hour fire protection.
- Ventilation for transformer losses up to 10.5kW for 1000kVA within an environment that does not exceed 30°C. Ventilation shall also be included for any disruptive failure pressure from HV Equipment which may be up to 250MVA or 16kA enclosed within a rear vented Steel housing of equipment.
- The exit points of such ventilation described shall not be designed such that a normal 'gathering place or open public space will be affected by any severe outflows.

- Where cables run through free space within a building, in areas such as basement car parks, the cables must be mechanically protected with the use of appropriately sized steel pipes. Alternative solutions may be proposed, and shall be agreed on a project specific basis. (Suitable Earthing arrangements to be agreed over any steel pipe 'runs' in line with AUL procedures and BS EN 7671 Regulations).
- Basement Substations will require blast proof steel doors. These doors will require a specific opening forming from reinforced concrete, or solid engineering brick.
- Cable troughs shall be designed to meet the cable sizes, bending radii, numbers of cables and positions for all cable runs, including earthing which will require holes for earth rods in appropriate positions, the design will be as specified previously.

7.4 Commissioning

Prior to Energisation, all Equipment shall be visually inspected and Mechanically & Electrically tested.

Where it is deemed by the AUL Engineer that the equipment does not comply with the requirements outlined in above sections, then where this cannot be resolved on site, the Equipment shall not be energised and a defect report shall be submitted to the Network Manager detailing the appropriate defect.

The substation commissioning results shall be formally recorded and signed where appropriate. Where required in line with ownership of equipment, the inspection and test data shall be recorded on the appropriate proformas provided by the DNO.

7.4.1 Visual Inspection

A visual inspection shall be undertaken once the equipment has been delivered to site in accordance with Appendix E- Equipment Check List and Appendix F- Substation Commissioning Progress Card- *'Visual Inspection'.*

7.4.2 Mechanical Testing

On site mechanical tests shall be undertaken at site in accordance with Appendix G - Substation Commissioning Progress Card- *'Mechanical Testing'.*

7.4.3 Protection Testing

Standard Protection Commissioning

For substations supplying a network transformer, typically time lag fuses (TLFs) will be employed to protect the transformer and the cable section between the RMU and the transformer. Where no on-site CT wiring modifications have occurred (including alteration to CT changeover link positions), then protection testing shall be limited to visual verification of CT ratios and TLF ratings.

7.4.4 Electrical Insulation Testing

All HV Equipment shall be electrically tested where appropriate.

7.4.5 Pre-Energisation Checks

Details the Pre-Energisation checks to be undertaken. Appendices E to G are to be used within the process and details recoded as they are worked through.

NB Cables shall not be energised unnecessarily i.e. where there is no impending requirement to supply properties fed by that cable.

8. Other Plant and Equipment Tests

The following tests are required as a minimum, and the specific project testing and commissioning plan shall be submitted to AUL at least four weeks prior to starting of the testing for comment.

Each LV Service:

- Polarity / Phase Rotation (3 phase)
- Recorded Voltage at Cut-Out
- Insulation Resistance 500 / 1000V
- Earth Fault Loop Impedance at Cut-Out
- Perspective Short Circuit Current
- The Cut-Out terminals should be checked with a torque driver and should be tightened to 3.25Nm.

Each New section of LV Main:

- Insulation Resistance Phase to Phase 500 / 1000V
- Insulation Resistance Phase to Neutral / Earth 500 / 1000V
- Continuity
- Polarity / Phase Rotation
- Voltage

Each PME Electrode:

- Earth Resistance

Earth Resistance:

- Overall value measured at the Substation
- At the HV / LV Substation – the combined HV / LV earth mats (<1Ω)
- Tape Joints – doctor test results

LV Fuse Cabinet / Feeder Pillar:

- Insulation Resistance 500 / 1000V
- Earth Fault Loop Impedance
- Perspective Short Circuit Current

HV / LV Transformer:

- Insulation Resistance HV / LV Winding – Earth
- Pressure Test
- Voltage and Phasing Checks – Voltage parameters Phase to Neutral 230v to 245v Phase to Phase 400v to 425v
- Tap Setting +/- % (value) recorded
- Oil Moisture Content ppm
- Oil Electric Breakdown Strength kV / Gap
- Confirmation of PCB Content (< 2ppm)

HV Switchgear

- Insulation Resistance at 5kV
- Pressure Test
- Protection Test, (Secondary Injection or Dummy HV Fuse Test).
- Functional Test of Interlocks and Operation
- Insulation Resistance Test of any Loose Test Devices.
- Bus-bar Resistance if the work on site includes connection of Bus-bars (New to New, and New to Existing)

- Gas Pressure of Equipment Satisfactory

HV Cables:

- Screen and Insulation Resistance at 5kV
- Pressure Test L1, L2, L3 to Earth
- Pressure Test L1, L2 to L3
- Pressure Test L1, L3 to L2
- Continuity

9. Plant, Equipment and Cable Records

- AUL has a statutory obligation to record the following information:
- Cable Routes
- Cable Depths
- Cable Types and Sizes
- Duct Routes and Sizes
- Cable Joint Locations
- Cable Joint and Service Phasing
- Earth Rod Locations and conductor runs.
- LV Link Boxes, Pillars and all other items of HV / LV Plant and Equipment
- Transformer Tap position
- Supply Voltage

It is imperative that all relevant information is accurately collated on site as the work progresses to enable the obligations to be met.

AUL must be able to Measure, Record and Produce information on the level of accuracy on Network Connectivity, therefore every effort must be made to produce detailed records.

9.1 LV and HV Cables (up to and including 33kV)

As cables are laid, their position must be plotted to an accuracy of no less than ±0.1 metres, onto an appropriate architect's plan to a scale that is appropriate to the installation. The new installation shall be plotted in Red, so that it stands out from the background.

The cables being installed are to be shown accurately in relation to all existing cables and services exposed during the course of the excavation works. Cross sections of the cable trenches are to be produced to clearly identify the position of the new cables in relation to existing services.

The record drawings shall accurately detail the dimensions to all known Building Structures, Front Edge of Kerbs, Boundary Lines (Fences, Walls etc.), and the back edge of Footpaths.

The record drawings shall accurately detail the cable route, cable depth, size and number of cores, cable identification, installer's details, and cross section of trenches.

9.2 Cable Jointing

Persons responsible for the cable jointing must ensure that records of all joint locations are accurately recorded onto an appropriate architectural plan to a scale that is appropriate to the installation.

The record drawings shall accurately detail the dimensions to all known Building Structures, Front Edge of Kerbs, Boundary Lines (Fences, Walls etc.), and the back edge of Footpaths.

The Joint Bay record sheet shall include the following information as a minimum:

- Project / Scheme Number
- Joint Bay Identification Number
- Joint Bay Location
- Joint Type
- Name of Jointing Contractor / Company
- Jointers Name
- Date of Jointing
- Phasing / Colours and Core numbers of mains and service connection
- Location of Earth Wires and Pins
- Details of inspections by any Third Parties
- Photo of Joint
- Joint Manufacture Batch Number
- GPRS co-ordinate

9.3 Duct Installation

Details of all duct runs shall be shown in Cross Section Drawings, and must include the following as a minimum:

- Internal Diameter
- Construction Material & Colour
- Covers
- Marker Tape Depth
- Duct Depth
- Formation
- Installed Cables (including cable size for identification)
- GPRS co-ordinate

9.4 Substations

The site-specific Substation drawings shall include the following as a minimum:

- Position of Substation in relation to existing Ordnance Survey features
- Route of Incoming Cables
- Route of Outgoing Cables
- Route of Earth Conductors, bonding and electrodes
- Bending Radii of all Cables
- Access Details to the Substation
- Ventilation positions and louver type
- Equipment Locations and dimensions
- Building Services
- Type of Doors installed
- Use of adjacent Buildings / Land
- Fuse and protection details
- Legal details
- GPRS co-ordinate of all 4 corners

9.5 Link Boxes, Pillars and LV Cabinets

The installation drawings shall include the following as a minimum:

- Location
- Type / Manufacturer
- Manufactures Batch Number
- Rating
- Cable Configuration
- Circuit details (names & drawing if required for detail)
- Spare Ways
- Photo
- GPRS co-ordinate
- Fuse and protection details
- Jointer's name
- Company

9.6 Service Records

Each service connection shall have the following level of detail as a minimum:

- Full Postal Address
- Property Type
- MPAN No
- Service Cable Size / Type
- Service Cable Length
- Joint type
- Manufactures Batch Number
- Main Cable Size / Type
- Service Duct Size
- Service Duct Material
- Cut-Out Rating
- Cut-Out Type
- Fuse Size
- Phase
- Voltage
- Earth Fault Loop Impedance
- Jointers Name
- Company
- Date Installed
- Record drawing for each service. Dimensions are to be given in metres to the nearest 100mm.
- Photo
- GPRS location of Joint

(I&C records require specifics as per the design layout in addition to the above)

10. Appendix A – Mechanical Pulling Force

Cable Type	Cable Size mm2	Method to be used	Maximum Tension	
LV Cables			**kN**	**kgf**
W/F CNE	95	Double eye stocking	3.0	305
W/F CNE	185	Double eye stocking	7.0	713
W/F CNE	300	Double eye stocking	7.0	713
HV Cables				
11kV XLPE Triplex	70	Double eye stocking on each core	6.1	630
11kV XLPE Triplex	95	Double eye stocking on each core	8.4	855
11kV XLPE Triplex	185	Double eye stocking on each core	16.3	1665
11kV XLPE Triplex	300	Double eye stocking	19.6	2000
11kV XLPE Single core	95	Double eye stocking	4.0	407
11kV XLPE Single core	185	Double eye stocking	6.3	642
11kV XLPE Single core	300	Double eye stocking	9.0	917
11kV XLPE Three core	95	Double eye stocking	7.5	764
11kV XLPE Three core	185	Double eye stocking	11.8	1200
11kV XLPE Three core	300	Double eye stocking	14.7	1500

11. Appendix B – Minimum Bending Radii

Cable Description	Minimum radius of bend	
	On route (m)	At termination (m)
LV Services		
35mm² 1 core LV service	0.13	0.13
LV Cables		
35mm² 3 core W/F CNE	0.45	0.45
95mm² 3 core W/F CNE	0.65	0.50
185mm² 3 core W/F CNE	0.85	0.54
300mm² 3 core W/F CNE	0.95	0.62
HV Cables		
70mm² 11kV XLPE Triplex	0.55	0.43
95mm² 11kV XLPE Triplex	0.57	0.45
185mm² 11kV XLPE Triplex	0.70	0.55
300mm² 11kV XLPE Triplex	0.80	0.60
95mm² 11kV XLPE Single Core	0.42	0.42
185mm² 11kV XLPE Single Core	0.49	0.49
300mm² 11kV XLPE Single Core	0.55	0.55
95mm² 11kV XLPE Three Core	0.70	0.70
185mm² 11kV XLPE Three Core	0.75	0.75
300mm² 11kV XLPE Three Core	0.80	0.80

Note: All figures to be verified with the manufacturer's data sheets prior to installation.

12. Appendix C – Joint Hole Dimensions

These dimensions are suggested minimum requirements, however the actual must consider all local site and ground conditions and be adequate to allow cable jointing to be carried out as required by the jointing specification.

Joint Type	Length (mm)	Width (mm)	Depth (mm)		
			Footpath, Building Sites and Unsurfaced	Agricultural	Carriage way
LV Mains – 1 phase service joint	1000	800	650	1200	950
LV Mains straight or breech joint	1200	1000	650	1200	950
LV Mains pot end	1000	800	650	1200	950
11kV straight joint	1500	1000	900	1300	1050
11kV breech joint	2000	1200	900	1300	1050
11kV pot end	1200	1000	900	1300	1050

13. Appendix D - Plant Data Form

Transformer	
Substation Name	
Tx Designation (eg T1)	
Make	
Year Made	
Rating (kVA)	
Type	
Serial Number	
Vector Group	
Nom Voltage (Prim/Sec)	
Tap Range % (-)	
Tap Range % (+)	
Tap Range % Step	
Impedance	
Oil Quantity (litres)	
Breather	
Conservator	
Weight (Tonnes)	
Protection Type:	
Settings	

LV Boards	
Make	
Year	
Type	
Rating (Amperes)	
Number of Ways	
Circuit names Left to Right	
Protection type	
Circuit Protection setting/value	
RTU	
Make	
Year Commissioned	
Serial Number	
Actuator SW1	
Actuator SW2	
Radio/BT	
Earth Fault Passage Indicator	
Make	
Type	
Serial Number	
Year of Commission	
How many fitted	
Circuit/Feeder fitted to	
Battery Date	

RMU/CB/Switch	**No.1**	**No.2**	**No.3**	**No.4**	**No.5**
Make					
Year Made					
Year Commissioned					
Type					
Serial Number					
Rating (kVA)					
Rating (Amperes)					

Protection CT Ratio					
Settings					
Operating Mech					
Duty					
Circuit Name					

HV Earth	Tested Value	Ω	
LV Earth	Tested Value? Link to HV in?	Ω Link In Y/N	
EPR Value V	Step Potential V	Touch Potential V	
Transfer Potential V	= Difference between Source EPR where > Secondary Sub EPR		

14. Appendix E – Equipment Checklist

Switchgear

Check Item	Action	Required Standard
Main Equipment	Visual	Type & Rating as required
CTs & VTs & Instruments	Visual	Type & Rating as required
External Condition	Visual	Free form rust, damage & oil leaks
Breather/Explosion Vent	Test	Unobstructed
Gaskets	Visual	Correctly fitted
Covers, Tanks, Doors	Test	Secure
Cable Boxes (internally)	Visual	Bushings & terminations clean & undamaged
Auxiliary Contacts, Switches	Visual	Correctly fitted, undamaged
Secondary Connections & Wiring	Test	Correctly fitted, secure
Spout Bushings & Isolating Contacts	Visual	Clean & undamaged
Electrical Trip/Close	Test	Correct operation
Earth Circuit Continuity	Test	Test satisfactory with earth switches closed
Labels	Visual	Operational & circuit as required
Earth Bonding & Connections	Visual	Correctly fitted, secure
Primary & Secondary Insulation	Test	Between phases & to earth satisfactory
Primary & Secondary Test Continuity of Switchgear & Busbars	Test	Test satisfactory with switches/breakers closed

Transformers (1000kVA and below)

Check Item	Action	Required Standard
Main Equipment	Visual	Type & Rating as required
External Condition	Visual	Free form rust, damage & oil leaks
Insulating Oil- Level	Visual	Filled to correct level
Gaskets	Visual	Correctly fitted
Breather	Visual	Transport plug removed, unobstructed
Drain Plug Valve	Visual	Tight, free from leaks
Tap Change Switch	Test	Correct operation, locked
Internal Tapping Links	Visual	Correct position, secure
Cable Boxes (internally)	Visual	Bushings & terminations clean & undamaged
Bushings & Insulation in Air	Visual	Clean, undamaged, secure
Spark Gaps	Measure	Correct for voltage
Earth Bonding & Connection	Visual	Correctly fitted, secure

LV Equipment

Check Item	Action	Required Standard
Main Equipment	Visual	Type & Rating as required
External Condition	Visual	Free form rust, damage & oil leaks
Interior	Visual	Assembled correctly, undamaged
Contact Alignment	Operate	Correct in all fuse & link positions
Operating Handles	Operate	Correct operation, undamaged
Transformer Isolating Links	Operate	Correct operation, lockable
Inter-phase & Earth Screen	Visual	Secure & correctly fitted Barriers
Locking Facilities	Visual	Correct
Auxiliary Supply Connection	Visual	Secure
Labels	Visual	Circuit, Resuscitation, **PME** fitted as required

15. Appendix F – Substation commissioning progress card

SUBSTATION ..... PROJECT JOB NO .....

Equipment Type	Manufacturer	Serial Number(s)
Switchgear		
Transformer		
LV Equipment		

Visual Inspection

The equipment has been inspected on-site in accordance with the **Appendix 1** of the Equipment Check List

The transformer ***has/has not** been filled with insulating oil

The switchgear ***is/is not** filled with SF6 gas

The equipment is ready for use

Signed ..... Date …….....

16. Appendix G Mechanical Testing Protection Testing

Operational Checks	Operate	Operate mechanism	
Operational Locks Fitted	Visual		
Interlocks	Operate	Correct operation	
Switch Position Indicators	Visual	Correct flagging & colour	
Operating Handles	Operate	Correct operation, undamaged	
VPIS (voltage presence indication system)			
Test Prods/Extensions	Operate	Correct fitting, operation, interlocks	
Spout Bushings & Isolating Contacts	Visual	Clean & undamaged	
Shutters & Mechanisms	Operate	correct operation & colour	
Racking Mechanism	Operate	Lubricated, correct operation	
Locking Facilities	Visual	Correct	

17. Appendix H - Protection Results

The following protection has been tested and the results recorded in accordance with this G81 document.

Protection Type	Comments

Name ……..Signed ..... Date ..... .

Electrical Insulation Testing

The equipment has been tested and the results recorded in accordance with the AUL specification

Pressure Test Value	Voltage Used

Name ……..Signed ..... Date .....

Pre-Energising Checks

The following checks have been carried out and signs fitted prior to energising:

Earth Resistance Value HV ..... Ohms LV ..... Ohms

LV fuses fitted correctly Yes/No

Bonding and Earthing Complete Yes/No

Property Notice fitted Yes/No

PME label attached Yes/No

Danger of Death notice displayed Yes/No

Name……..Signed ..... Date ..... .