Network Standard

Document No.
NS110

Title:
Design of Underground Residential Subdivisions

Approved Date	23/10/2024	Revision		6	
Lifecycle Stage	Design; Construct	Internal Use		External Use	☒
Technical Approver		Authorised By			
Name	Matthew Cupples	Name		Murray Chandler	
Designation	Senior Engineer	Designation		Head of Network Strategy & Future Grid	

Revision

No	Date	Description	Technical Approver	Authorised By
5	16/09/2024	Conversion to new format and addition of protection requirements	Matthew Cupples	Murray Chandler
6	23/10/2024	Addition of single core cables for 100A services and 300AL4 for over 200A services.	Matthew Cupples	Jacob Bayley

Table of Contents

List of Annexures

Scope

This Network Standard sets the minimum requirements for design of underground residential subdivisions.

Reference Documents

All work covered in this document shall conform to all relevant Legislation, Standards, Codes of Practice and Network Standards.

Ausgrid Documents

NS001 Glossary of Terms

NS100 Field Recording of Network Assets

NS117 Design and Construction Standards for Kiosk Type Substations

NS119 Public Lighting Design and Construction

NS127 Low Voltage Cable Joints and Terminations

NS129 11kV Joints and Terminations – Paper Insulated Lead Covered Cables

NS130 Laying Underground Cables up to and including 11kV

NS141 Site Selection and Preparation for Kiosk Substations

NS156 Working Near or around Underground Cables

NS161 Specification for Testing of Underground Cables

NS177 11kV Joints (including transition joints) and Terminations – Polymeric Insulated Cables

NS290 Selection of Distribution Substations

Other Standards and Documents

AS/NZS 3008 Electrical installations – Selection of Cables

Service and Installation Rules of New South Wales

Clause	Standard Requirements

1 Distribution substations

1.1 Only kiosk type substations shall be used in underground residential subdivisions. Refer to NS290.

2 Initial load and line length limitations

2.1 The load to be connected to a substation shall be balanced across the distributors of the substation where practicable.

2.2 After Diversity Maximum Demand (ADMD)

2.2.1 The ADMD appropriate for a subdivision shall be provided by Ausgrid.

2.2.2 The designed maximum diversified load for distributors shall not exceed 75% of its nominal 400A rating. Refer to Annexure B for sample calculation.

2.3 Voltage Drop

2.3.1 The designed maximum voltage drop along a low voltage distributor shall not exceed 9V phase-to-earth at the extremities. Refer to Annexure B for sample calculation.

2.3.2 Service mains for the calculation shall not be considered part of the distributor, voltage drop for service mains shall be in accordance with the Service and Installation Rules of NSW.

2.3.3 Where an existing non-compliance is identified, the designer shall inform Ausgrid. The new connection shall not worsen the voltage drop for existing non-complying sites.

2.4 Protection of low voltage underground networks

2.4.1 All LV underground networks shall be protected by current limiting HRC fuses at the distribution substation. The fuse size and type shall be selected in accordance with NS114 or NS117 depending on the substation type.

2.4.2 The maximum rating fuse to be used on the underground network or distributor shall be 400A and all fuses shall have fast operating characteristics.

2.4.3 There are limitations on the length of underground networks for protection reasons. At the extremities of all sections of underground network, the bolted phase to neutral fault current shall be greater than the 10 second fuse current as per Table 1.

Table 1 - Fuse operating fault level

Fuse Size (Amps)	Fault Level (A) for 10s Operating Time	
	Fuse Type	
	J	T
100	350	443
200	800	1000
250	971	1222
315	1152	1533
400	1521	2154

[1] Unless specifically calculated, the fuse 10 second current is to be taken from this table. This represents typical characteristics for fuses used on Ausgrid's network. Site specific fuse characteristics may be used in lieu this table, refer to Ausgrid for specific fuse sizes and fuse time current characteristics.
[2] The cable loop impedance of a LV distributor is defined as the total impedance, measured from a Distribution Centre to the network extremity, of a phase conductor plus the return neutral.
[3] The maximum distributor length requirements for protection reasons does not consider voltage drop.

2.4.4 The bolted phase to neutral fault level at the extremities of the network and compliance with protection criteria shall be calculated using the Fuse Sensitivity Calculator contained in external Annexure A.

2.4.5 Where an existing non-compliance is identified, the designer shall inform Ausgrid. The new connection shall not worsen the protection performance for existing non-complying sites.

3 Low voltage distributors

3.1 Design and arrangement

3.1.1 Low voltage distributor cables in new subdivisions shall be direct buried to achieve the required rating unless a crossing (e.g. driveway, easement, roadway, rail) is required, where cables shall be installed in conduits (ducts).

3.1.2 All LV direct buried cables in the footway shall be installed with 1 spare conduit (in addition to any 11kV spare conduits).

3.1.3 All LV cables in conduits under roadways shall be installed with 1 spare conduit (in addition to any 11kV spare conduits).

3.1.4 Cables shall be looped into and out of distribution pillars. Some typical arrangements used in Ausgrid network area are given in Annexure C.

3.1.5 Alternative supply shall be provided to distributor sections supplying more than 15 services.

3.1.6 Ducted sections normally require at least 300mm^2 aluminium cable. Where there are less than 15 services connectable and there is no alternative configuration (e.g. end of a spur), 240mm^2 aluminium cable is permitted. Refer to Annexure C.

3.1.7 The number of services designed to be connected to any solid section of a distributor (i.e. not switchable by the use of paralleling links) shall not exceed 15. Any section of a distributor containing solid pillars is classified as a solid section.

3.1.8 The first pillar from a substation on each distributor shall be a link pillar to allow for isolation of the distributor. Services shall not be connected to the substation side of the links. Refer to Annexure D.

3.1.9 Each distribution cable shall be terminated into the link module on the side of the module at which the cable enters the pillar, with the pillar in its final position.

3.1.10 Adjacent pillars shall be supplied by the same distributor (except for link pillars used as interconnectors between different distributors).

3.1.11 Distribution pillars at the extremities of a low voltage distributor shall have links installed to allow for paralleling with adjacent distribution centres.

3.1.12 Link pillars rely on the distributor cables to support the link module or link panel, and cannot be used without all distributor cables installed. Link pillars shall not be used at the extremities of a subdivision stage.

3.1.13 Alternative supply to LV distributors shall be provided from adjacent distribution centres where practicable. Each distributor shall have a minimum of 2 alternative points of supply (or 3 in cases where practical).

3.1.14 Every opportunity shall be taken to establish loop feeds where loop roadways exist (i.e. interconnection between distributors from the same distribution centre or between different branches of the same distributor).

3.2 Rail crossings

3.2.1 The cable installation across the railway tracks shall be made by trenchless methods in accordance with the requirements of the Rail Authority.

3.3 Rail crossings shall allow for all ends of the ductlines to be located off the rail property.

3.3.1 Ducts shall be run the full width of the rail corridor, finishing just outside the rail property boundary.

3.4 Cable ratings

3.4.1 Ratings for LV distributors are given in Table 2.

Table 2 - Cable type and ratings

Cross-sectional area (mm²)	Cable Type	Summer Cyclic Cable Rating - Amps	
		Duct laid	Direct buried
240	LV 240 AL4 XQ Z/SAC	355[1]	440
300	LV 300 AL4 XQ Z/SAC	400	495
185	[2]LV 185 CU1 XQ Z / COM# COL (4 cables) LV 185 CU1 XQ Z (4 cables)	420	
240	LV 240 CU4 XQ Z	460	

[1] This cable can only be used if it has been approved for duct installation. Approval does not need to be sought if the cable is being duct laid for the purpose of crossing a driveway, an easement or a road which is less than 20m and supplies no more than 15 services.

[2] This cable is not UV stable and not suitable for outdoor use i.e. UGOH

[3] Cable ratings are based on a soil thermal resistivity of 1.2 Km/W with no other cables in the trench. Refer to NS272.

4 Distribution pillars

4.1 All distribution pillars shall be installed adjacent to lot boundaries and centred 400mm from the street alignment where practicable.

4.2 For residential areas, pillars detailed in NS127 shall be used.

4.3 Double link pillars

4.3.1 The design shall have all three distributor cables to the link panel when the double link pillar is constructed to support the link panel in its position.

4.3.2 A minimum of one direct-buried service shall be connected when the pillar is being constructed to leave sufficient room in the pillar base for three conduit stubs for future services. If installed in a new development where no services (including three phase street light circuits) are initially required, a maximum of three services may be taken from a double link pillar.

4.4 Maximum number of service connections

4.4.1 The maximum number of services shall be in accordance with Table 3.

4.4.2 Only one service active or neutral shall be connected into each hole of the termination blocks. Each streetlight circuit (whether single phase or three phase) shall be regarded as a separate service.

Table 3 - Pillar maximum number of services

Pillar Type	Pillar arrangement as per NS127	Designed number of services to be initially connected	Maximum number of services possible
Two-way solid pillar	LV1-81 LV1-82 CMPBL2EA	4 x 100A or 1 x 200A	6 x 100A or 2 x 200A
Three-way solid pillar	LV1-81 LV1-82 CMPBL3EA	4 x 100A or 1 x 200A	5 x 100A or 1 x 200A
Single link pillar	LV1-37	4 x 100A or 1 x 200A	6 x 100A (3 each side of link) or 2 x 200A (1 each side of link)

Double link pillar	LV1-60	3 x 100A or 1 x 200A to the centre distributor	4 x 100A or 1 x 200A to the centre distributor

5 Service mains

5.1 Services exceeding 200 amperes are not normally supplied from pillars in a residential area. Any proposed services exceeding 200 amperes and up to 400 amperes require approval from Ausgrid. These shall be supplied from distribution pillars by connecting the service mains directly onto either a solid pillar or, as the third cable connected to a double link pillar.

5.2 Services larger than 400 amperes shall be directly supplied from the nearest substation, or a kiosk substation may need to be constructed on site if network capacity is determined to be insufficient.

5.3 Service mains (other than special small services) shall not be connected to decorative street lighting furniture or conventional base, street lighting standards.

5.4 Distribution pillars adjoining residential lots shall have conduit stubs installed as detailed in NS127 to allow easy installation of service mains by customers at a later stage. Service mains to these lots shall only be installed as each customer requires supply.

5.5 For each lot remote from a distribution pillar, a conduit and draw wire from the nearest distribution pillar to the customer's property (located within 1m inside the lot boundary) shall be installed. All services are governed by the Service and Installation Rules of NSW 40mm minimum.

5.6 Multiple battle-axe blocks sharing a common access driveway and similar blocks without a street frontage shall be supplied by common service mains terminating in a common private pillar at the street end of the driveway. Each customer must then install separate consumers mains from the common private pillar to their meter board.

5.7 Service cable roadway crossings shall be in conduits. Conduits shall be laid as close to being perpendicular to the carriageway as practicable, and shall terminate at the road-side edge of Ausgrid's cable allocation. Refer to NS130 for the cable allocation that applies in the relevant area. Minor deviations to align with offset lot boundaries on opposite sides of the road are permitted.

5.8 Service cables

5.8.1 Service cables shall be four-wire three-phase except for single domestic premises, duplexes, special small services and builder's services where a two-wire single-phase service is permissible.

5.8.2 The conductor size shall not be less than 16 mm².

5.8.3 For common service mains supplying multiple premises (e.g. battle-axe blocks) a 50 mm² cable may be used for supplying up to six 100 amp services.

5.8.4 Service cable specifications are according to Table 4.

Table 4 - Service cable ratings

Rating Amps	Cross-sectional area (mm²)	Cable Description
100	16 or 25	Circular, stranded, copper conductor, single-core, two-core or four-core.
200	50 or 70[1]	Circular, stranded, copper conductor, single-core or four-core.
>200A	185	Circular, stranded, copper conductor, single core.
	240 or 300	90 degree sector shaped, solid, aluminium conductor, multicore.

[1]70mm² must be compacted conductor

6 Ownership

6.1 Low voltage and street light reticulation in community title developments other than on dedicated public roads shall be owned and maintained by the owners of the development and does not form part of Ausgrid's network.

6.2 Pillars serving a single customer or battle-axe block developments shall be installed inside the property boundary and constitute the connection point for the customer. These pillars are private pillars and shall be owned and maintained by the customer.

7 Existing HV and subtransmission assets

7.1 Where a new subdivision is proposed near existing high voltage distribution or subtransmission assets, the subdivision layout shall be designed in such a way that access to the existing assets is maintained.

7.1.1 Existing or relocated assets shall not be located in resultant lots.

7.1.2 Access to existing or relocated assets shall not require access via resultant lots.

7.1.3 Where high voltage distribution mains are relocated, they shall be placed underground in future public roadways or footways in accordance with NS130.

7.1.4 Where subtransmission lines are relocated, Ausgrid will determine whether overhead or underground is preferred.

Annexure A: Fuse Sensitivity Calculator

The fuse sensitivity calculator is stored externally to this standard.

Annexure B: Calculation of diversified load and voltage drop

B1 The After Diversity Maximum Demand (ADMD) of a low voltage distributor is a function of the number of dwellings connected to the distributor and the allocated Maximum Demand for each dwelling.

The following formulae shall be used in estimating the maximum demand and voltage drop of a distributor.

N = Number of customers

Formula for maximum demand for distributor loading:

$$MD = 8 * ADMD + 0.72 * ADMD * N + 0.95 * ADMD * \sqrt{N} \text{ kVA}$$

Formula for maximum demand for voltage drop

$$MD_v = 12 * ADMD + 0.97 * ADMD * N + 1.3 * ADMD * \sqrt{N} \text{ kVA}$$

Phase Current = $\frac{MaxDemand * 1000}{3 * V_{start}}$

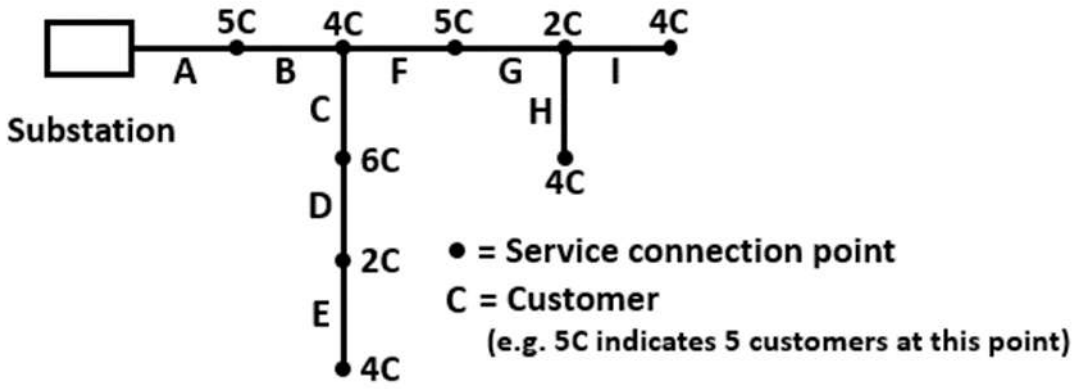
V_{start} is the voltage at the start of the distributor segment where voltage drop is to be calculated.

Voltage Drop = $\frac{(V/A/km) * Length * PhaseCurrent}{1000}$

Where (V/A/km) is voltage drop constant of the cable is accordance with Table A2.

B2 Sample load and voltage drop calculations

B2.1 Calculate the diversified Maximum Demand for the low voltage distributor shown below, and the voltage drop at the extremities of the distributor. The After Diversity Maximum Demand of the subdivision is 5 kVA and the distributor cable is 240mm² AL4 XQ Z/SAC. Length of each section of the distributor cable is 35m.



Distributor Load

Total number of customers connected to section A is 36.

MD = 8 * ADMD + 0.72 * ADMD * N + 0.95 * ADMD * SQRT(N)

= 198.10 kVA

Phase Current = $\frac{MD * 1000}{3 * V_{start}}$ = 287.10A

Voltage Drop Calculations (example shown for section A)

Voltage at the start of the Distributor 230V (at the Substation, beginning of section A)

Voltage drop constants (V/A/km) shall be obtained from Table A2.

MD_v = 12 * ADMD + 0.97 * ADMD * N + 1.3 * ADMD * SQRT(N)

= 273.60 kVA

Phase current = $\frac{MaxDemand * 1000}{3 * V_{start}}$ = 396.52A

Voltage drop (in section A) = $\frac{(V / A / km) * Length * PhaseCurrent}{1000}$ = 2.43V

Voltage drop constant used was 0.175mV/A.m for 415V 240AL4 XQ Z/SAC cable

Table B1 - Calculations result

Section	Length	No. of Customers supplied through section	Maximum Demand (12*ADMD +0.97*ADMD*N +1.3*ADMD* SQRT(N))	Vstart	Phase Current (MD*1000/ (3*Vstart))	Voltage drop (V/A/Km)*length* Phase Current/1000	Voltage drop at the extremities	Percentage Voltage drop
A	35	36	273.60	230.00	396.52	2.43		
B	35	31	246.54	227.57	361.12	2.21		
C	35	12	140.72	225.36	208.14	1.27		
D	35	6	105.02	224.08	156.22	0.96		
E	35	4	92.40	223.13	138.04	0.85	7.72	3.36
F	35	15	157.92	225.36	233.59	1.43		
G	35	10	129.05	223.93	192.11	1.18		
H	35	4	92.40	222.75	138.27	0.85	8.09	3.52
I	35	4	92.40	222.75	138.27	0.85	8.09	3.52

Table B2 - Voltage drop constants for distributor and streetlighting cables

Underground Cable	Voltage Drop Constants for Balanced Loading over Three Phases (mV/amp-metre)	
	Phase / Earth[1]	Phase / Phase
415V 16 CU4 XQ Z	1.472	2.550
415V 240 AL4 XQ Z / SAC	0.175	0.303
415V 300 AL4 XQ Z / SAC	0.145	0.252
415V 240 CU4 XQ Z	0.118	0.205
415V 185 CU1 XQ Z / COM#COL (4 cables) or 415V 185 CU1 XQ Z (4 cables)	0.165	0.285

[1] Use this column for calculation of the designed maximum voltage drop in a low voltage distributor.

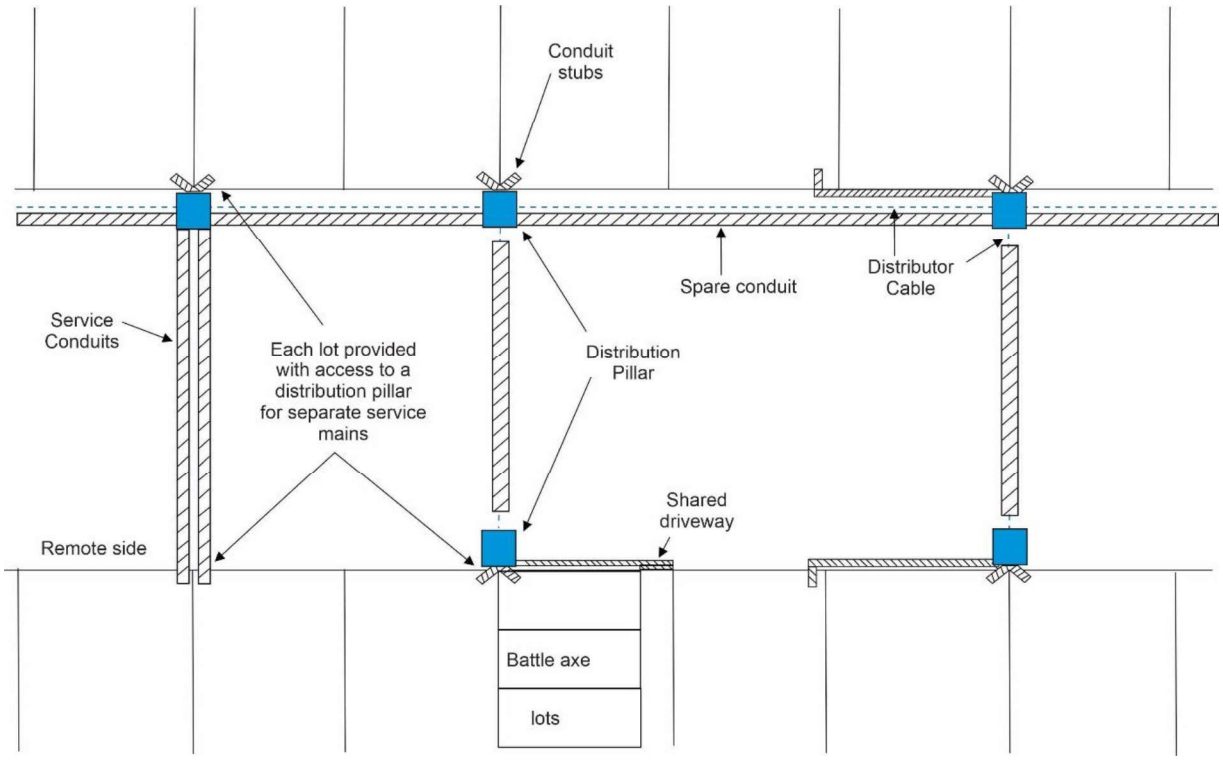
[2] For single-phase distributors, the voltage drop calculated from the phase-to-earth constants in the middle column of the above table must be doubled.

Table B3 - Voltage drop constant for single phase loads

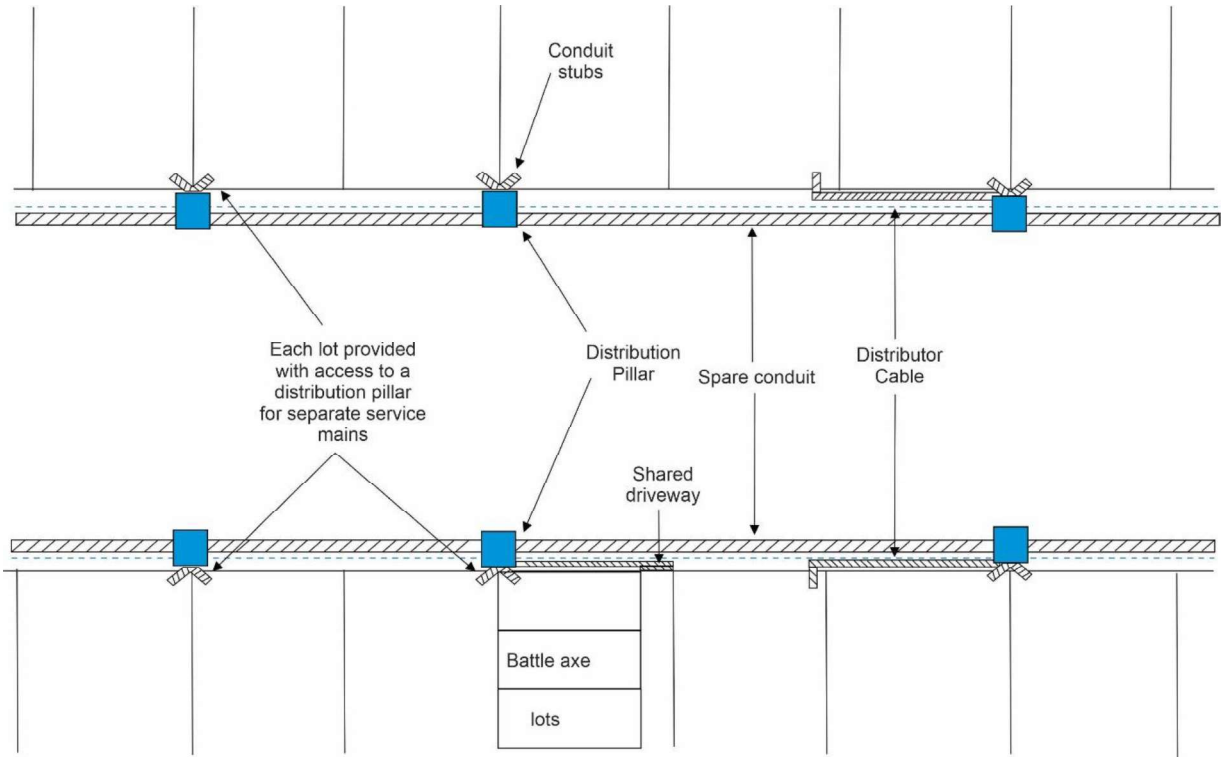
Underground Cable	Voltage Drop Constants for Single-Phase Loads (with Unparalleled Cable Cores) mV/amp-metre
415V 16 CU4 XQ Z	2.945

Annexure C: Typical arrangements of low voltage system

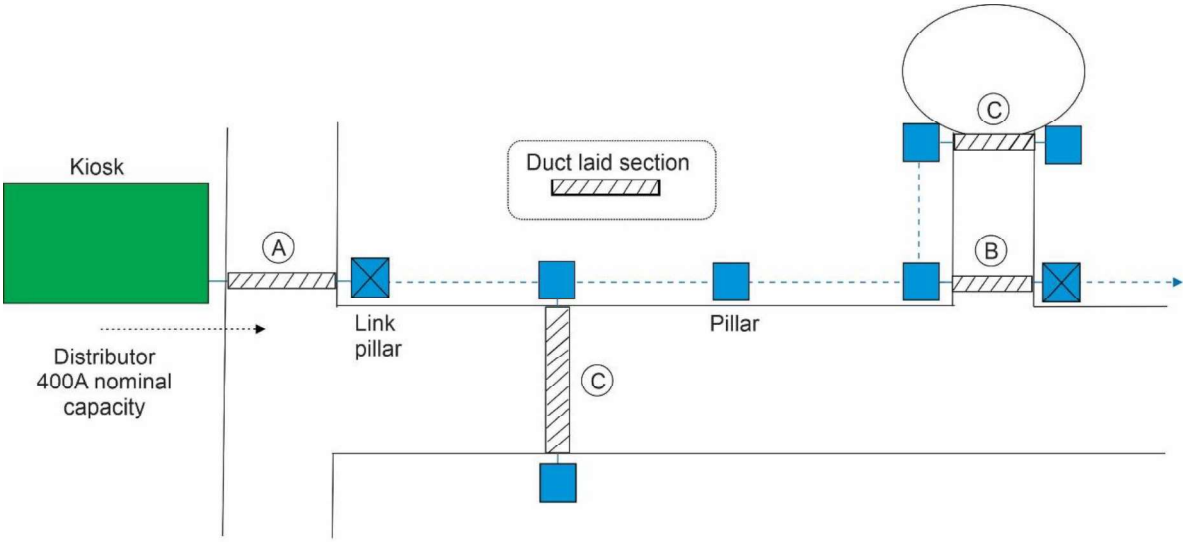
C1 LV distributor on one side of the street



C2 LV distributor on both sides of the street



C3 Duct laid sections of low voltage distributor



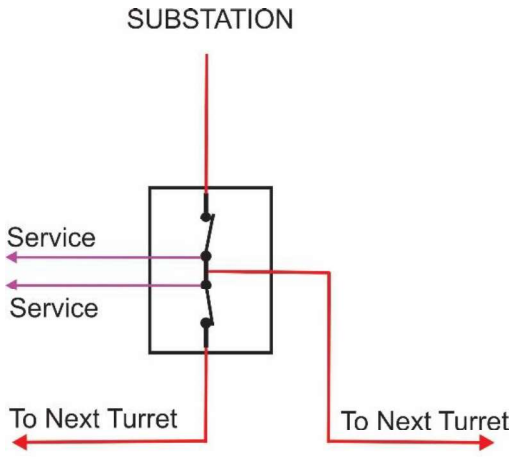
A & B : Duct laid sections forming the main distributor loop require a 400A rating. (Min 300AL)

C: Duct laid sections that supply a maximum 15 services with no alternate supply may utilise 240AL.

Annexure D: Link pillar connection diagrams – first pillar out of substation

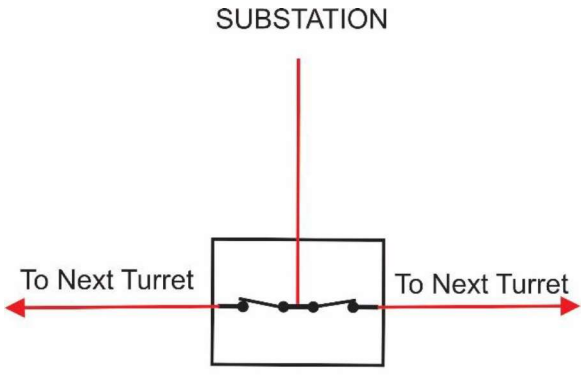
D1 Double link pillars

D1.1 Option for low voltage networks where one leg is to a radial feed



Used where distributor is required to supply two directions AND service connections are required

D1.2 Option for low voltage networks where both legs are connected to ring feed low voltage



Used where distributor is required to supply two directions AND there is no foreseeable need for service connections

D2 Single link pillars

Currently used configuration.