Northpower
Electricity Network

Electricity Reticulation Underground Design Standard

Document summary

This standard defines Northpower's requirements for the design and configuration of underground distribution network and associated ground mounted equipment for voltages up to and including 11kV.

Document approval

Version	3
Document Owner	Shaun BROWN Distribution Engineering Manager
Document Approver	Shaun BROWN Distribution Engineering Manager
Date Published	17/03/2024
Date for Next Review	16/03/2027

Controlled Document

Table of contents

1.0 Introduction

1.1 Purpose

The purpose of this standard is to define standard requirements for the design and construction of underground distribution systems installed within the Northpower Service area. The intent of defining standard requirements is to ensure that installations:

- Comply with industry standards and regulations
- Ensure safety in accordance with EEA's Safety in Design Framework
- Meet Northpower's objectives for network reliability and customer service.
- Are constructed using standard materials and techniques to enhance the long-term maintainability of the network.
- Are optimised to provide lowest lifecycle cost over the life of the asset.
- Provide appropriate flexibility and facility for network growth and extension.
- Cost effective estimating and design processes in which network risk is effectively managed.

1.2 Scope

This standard defines Northpower's requirements for the design and configuration of underground distribution network and associated ground mounted equipment for voltages up to and including 11kV.

Exclusions:

- *Sub-transmission and Transmission Detailed Design guidelines.*
- *Transmission Cables run within Northpower's Zone Substations.*

1.3 Application

This standard applies to the design:

- And configuration of underground cabling and associated equipment intended for use in or connected to Northpower's underground electricity distribution network for voltages up to and including 11kV.
- Minor Guidance on 33kV Cable Route Selection and Standard 33kV Cable Sizes.
- And configuration of alterations or extensions to Northpower's existing underground electricity distribution network.
- Of underground networks and associated equipment owned by other parties that are connected to Northpower's underground electricity distribution network.

Network designers are the audience intended for this standard. It is Northpower's requirement that all designs comply with this standard. Alternative approaches may be considered where sound justification exists based on technical or economic reasons. Any proposed deviation to this standard shall:

- Demonstrate that technical, safety and lifecycle cost outcomes will equal or exceed the standard approaches defined in this document.

- Be appropriately documented with sufficient detail to allow for technical and lifecycle economic evaluation to validate compliance.
- Be approved in writing by Northpower's Distribution Engineer or delegate prior to the commencement of construction works.

The Design of overhead lines shall comply with the requirements of *Overhead Line Design Standard.*

For Volt Drop determination, Fusing, Transformer selection, network diversity factors and general network configuration requirements, refer to *Electricity Reticulation Design Standard*.

2.0 References

Please note hyperlinks have been supplied to the electricity network's latest published controlled content (Northpower access only).

Internal Reference	Details
Working Near Electricity Reticulation	Northpower networks requirements for outside contractors working near electricity reticulation.
Overhead Line Design Standard	Northpower networks requirements for overhead line design on Northpower's Distribution and Sub Transmission Network.
Electricity Reticulation Design Standard	Northpower networks requirements for the design of electricity distribution infrastructure to be connected to Northpower's network.
Zone Substation and Distribution Earthing Design Standard	This standard is to ensure that design of power systems earthing infrastructure is completed in a safe and consistent manner for Northpower staff and members of the public.
Protection of Northpower's Assets against Atmospheric Corrosion	Northpower networks requirements for protection of Northpower's assets against atmospheric corrosion
Electricity Distribution Planning Standard (*under action*)	This standard covers planning principles for electricity distribution connected to Northpower's network
Legal Protection Requirements for Electricity Reticulation	This Standard summarises the legal protections for Northpower's electricity Assets; and details Northpower's requirements for implementing and using those legal protections
Northpower Approved Materials and Suppliers	Northpower's network requirements for equipment that is approved to be used for construction and maintenance of the network.
Archaeological and Accidental Discovery Procedure	Northpower's requirements to ensure that all projects and activities manage the potential environmental impacts relating to the treatment of known archaeological sites and the discovery of new archaeological sites in accordance with best practice and legal requirements.

Other References	Details
Customer Initiated Works	Northpower's standard for managing Customer Initiated Works, where a Customer connection requires works to amend or upgrade the electricity distribution network to enable their connection to the distribution network.

Drawing Reference	Details
Plan 2F250s2	Directly Laid HV and LV Cables with Telecom (based on horizontal separation)
Plan 2F250s4	Ducted HV and LV Cables or Spare Duct with Telecom (based on horizontal separation)
Plan 2F250s1	Directly Laid HV and LV (or Spare Duct) (no Telecom)
Plan 2F250s3	Ducted HV and LV Cables or Spare Duct
Plan 2F250s5	Directly Laid HV Cables With Telecom
Plan 2F250s6	Ducted HV Cables With Telecom
Plan 2F250s16*	Directly Laid HV Cables with Telecom (Alternative Option)
Plan 2F250s17*	Ducted HV Cables with Telecom (Alternative Option)
Plan 2F250s11	Directly laid HV Cables (no Telecom)
Plan 2F250s12	Ducted HV Cables (no Telecom)
Plan 2F250s8	Directly Laid LV cables with Telecom
Plan 2F250s10	Ducted LV Cables with Telecom
Plan 2F250s14*	Directly Laid LV Cables with Telecom (Alternative Option)
Plan 2F250s15*	Ducted LV Cables with Telecom (Alternative Option)
Plan 2F250s7	Directly Laid LV Cables Without Telecom
Plan 2F250s9	Ducted LV Cables (no Telecom)
Plan 2F284s1	Trenching Details to a Typical LV Pillar
Plan 2F173s1	Standard Reticulation Layout for a Residential Subdivision
Plan 2F250s13	General arrangement of power cables and gas pipes.
Plan 2Y138s1	Duct Installation Verification

External References	Details
AS/NZS 3000	Electrical Installations (Wiring Rules)
NZECP 34	New Zealand Electrical Code of Practice for Electrical Safe Distances
www.legislation.govt.nz	Electricity (safety) Regulations 2010
www.legislation.govt.nz	Electricity (Hazards from Trees) Regulation 2003
EEA Guide	EEA Guide to Safety Management of Power Line Waterway Crossings

External References	Details
Electrical Engineers Association	Safety In Design Guide
www.beforeudig.co.nz	visit beforeUdig website or call 0800 248 344 to request plans
www.nzta.govt.nz	National Code of Practice for Utility Operators' Access to Transport Corridors
www.northpower.com	Northpower's website

3.0 Definitions

Terminology	Definition
A	Amperes
ADSS Fibre	All-Dielectric Self-Supporting Fibre
beforeUdig	**beforeUdig** is an online service provider which enables anyone undertaking excavation works to obtain information on the location of cables, pipes and other utility assets in and around any proposed dig site, helping to protect themselves and valuable assets during these works.
CAR	A Corridor Access Request (CAR), formerly known as a Road Opening Notice, is a type of permit required by Road-Controlling Authorities (councils) and NZ Transport Agencies if you intend to perform excavation work, or other non-excavation activities, within a road corridor.
HV (High Voltage)	As defined in SM-EI and means any voltage exceeding 1000 Volts a.c. or 1500 Volts d.c.
kVA	Kilo Volt Amps (Power Unit)
LV (Low Voltage)	As defined in SM-EI and means any voltage exceeding 50 Volts a.c. or 120 Volts ripple free d.c. but not exceeding 1000 Volts a.c. or 1500 Volts d.c.
MEN	Multiple Earthed Neutral
Navigable Waterway	As generally defined in the EEA / Maritime publication Guide to Safety Management of Power Line Waterway Crossings (May 06).
Northpower Network Distribution Engineer (or delegate)	Lead person responsible with providing information, reviewing and approving requests
Field Service Providers	Contractors engaged by Northpower network, including Northpower Contracting
Network Approved Contractor	Contractors approved to undertake specific works – engaged by customers and third parties such as Council
Shall	Indicates that the statement is mandatory.
Should	Indicated a recommendation.
V	Voltage or Volts

4.0 Design Principles

4.1 General

4.1.1 Seismic

Equipment pads, foundations and fixings shall be designed to survive with unimpaired operating ability earthquake induced forces consistent with the relevant seismic zones according to AS/NZS 1170.0 and its related documents as they apply to electricity network equipment. In the absence of such analysis, seismic withstand can generally be achieved by designing distribution class equipment to withstand a horizontal force of 1.0g and vertical force of 1.0g applied to its centre of mass.

4.1.2 Land Instability

Underground cables and associated equipment shall not be located in areas susceptible to ground subsidence, such as due to ground water changes to ice or mining, etc. unless appropriately engineered mitigation measures are applied.

4.1.3 Flooding

All HV equipment such as switchgear, transformers, etc., shall be designed so that their HV terminals will be above the local 10-year storm flow (without ponding) in the roads. As a general rule of thumb, this generally means that designers are required to ensure that the HV terminals are installed at least 300mm above the invert of the nearby kerb and channel. Designers should also avoid areas where double sumps are present as they are the most likely areas to pond in the larger rainfall events.

All LV network equipment installations (such as service pillars, pillar/link boxes, etc.,) shall be designed so that the manufacturers nominated “ground line” mark is at the finished level of the surrounding area. Designers should also ensure that the LV terminals of the equipment are not less than 150mm above the invert of the nearby kerb and channel. Again, designers should avoid areas where double sumps are present as they are the most likely areas to pond in the larger rainfall events.

4.1.4 Cable Support and Protection

Cables in situations where mechanical forces can be imposed such as in cable risers or steep gradients must be secured with appropriate cable clamping arrangements to ensure that stresses in cables, joints and terminations are maintained within manufacturers design limits.

Cable installations above ground shall provide adequate mechanical protection to prevent damage from foreseeable mechanical damage.

4.2 Cable Route Selection

4.2.1 33kV

33kV Cable route selection shall be conducted by Northpower's Engineering and Delivery Team with consideration into cable size, backfill requirements, public safety, trench dimensions and maintenance of the cable and termination structures (if required).

33kV Cable routes may be required to be investigated by a geotechnical engineer to determine soil stability risks.

4.2.2 11kV

The 11kV cable route shall be installed first and foremost in the berm of the road reserve. Where road reserve does not exist, the 11kV cable shall be installed within the berm of a formed road in order to maintain all weather access. 11kV cables shall not be installed directly under the middle of the transport corridor (apart from road crossings) due to significant reinstatement costs and increased risk of the cable being crushed by compaction of the road over time.

Where 11kV Cable is to be installed across paddocks, written approval is required from Northpower Network's Distribution Engineer, or equivalent. Suitable protection shall be designed to protect the public from making accidental contact with the cable (i.e. installing fence posts, gardens, installing Waratahs/Stakes. This can be protecting the cable with depth or adding suitable concrete pavers/capping (see section 6.3 for more information).

Critical 11kV cable routes may be required to be investigated by a geotechnical engineer to determine soil stability risks.

4.2.3 230/400V

The 230/400V cable route shall be installed first and foremost in the berm of the road reserve. Where road reserve does not exist, the 230/400V cable shall be installed within the berm of a formed road in order to maintain all weather access. 230/400V cables shall not be installed directly under the middle of the transport corridor (apart from road crossings) due to significant reinstatement costs and increased risk of the cable being crushed by compaction of the road over time.

Where 230/400V Cable is to be installed across paddocks, written approval is required from Northpower Network's Distribution Engineer, or equivalent. Suitable protection shall be designed to protect the public from making accidental contact with the cable (i.e. installing fence posts, gardens, installing Waratahs/Stakes. This can be protecting the cable with depth or adding suitable concrete pavers/capping (see section 6.3 for more information).

4.3 Easements

All new works which will be owned by Northpower, including upgrading of existing assets beyond that which can reasonably be considered maintenance or like-for like replacement must be located within registered easements allocated to Northpower. Construction work shall not commence on any part of the project until easements have been secured for the project in its entirety.

All easements shall comply with the requirements of Northpower network. Refer to *Legal Protection Requirements for Electricity Reticulation Standard and Electricity and Telecommunications Easements.*

4.4 Historical and Archaeological Sites Discovery

The designer shall make appropriate enquiries or investigations to identify any known archaeological sites that may be affected prior to site works commencing.

In the event of any archaeological sites being identified during planning, or discovered during site works, the works shall be managed according to the requirements of the Northpower Archaeological and Accidental Discovery Procedure.

4.5 Public Safety and Housekeeping

4.5.1 Safety

The designer and service provider shall ensure that the public are protected from hazards associated with trenching operations and open trenches by the erection of suitable fences, barriers and warning lights as required under the Construction Contracts Act and its related codes of practice, and the Health and Safety at Work Act and the relevant Codes of Practice.

4.5.2 Access Ways

Provision shall be made in the design to ensure that private access ways are not obstructed longer than necessary. If obstruction persists for more than one working day, temporary access must be arranged to the satisfaction of the property owners.

4.5.3 Reinstatement

The design shall ensure that upon completion of construction works the land must be reinstated to a condition acceptable to Northpower and the affected landowners. Reinstatement will include the removal of any debris and include the re-sowing of grass and or reinstatement of hard surfaces such as concrete or bitumen as required.

4.5.4 Worksite Housekeeping

Provision shall be made in the design for the construction site (including any area used for storage) to be clearly defined and barricaded, where appropriate to ensure all site hazards to workers and members of the public are minimised.

Further, the design shall made provision for ensuring that:

- The size of the worksite is kept as small as reasonably possible.
- The site is kept tidy at all times.
- Where the worksite is located in roadway, provision has been made for all roadway users, including pedestrians and cyclists.
- Access to properties adjacent to the site is not obstructed.
- Storm water and siltation controls are in place.

- The worksite will comply with the requirements of the OSH publication Guidelines for the Provision and General Safety in the Construction Industry.

4.6 Consents and Notifications

4.6.1 Notifications to Transportation Corridor Managers

The designer shall make provision for the notification for planned underground cables within a transportation corridor (i.e., motorways, state highways, public roads and rail corridors) are given to, and permission obtained from the appropriate Transportation Corridor Manager (i.e., District Council, NZTA and KiwiRail) in accordance with the requirements of The National Code of Practice for Utilities' Access to the Transport Corridors. A copy of this document can be down loaded from www.nzuag.org.nz.

4.6.2 Resource Consent

The designer shall be responsible for obtaining all necessary permits and approvals and providing all required notifications necessary for the execution of the works in accordance with the requirements of The National Code of Practice for Utilities' Access to the Transport Corridors.

The developer shall be responsible for all charges for such permits and approvals.

Design and planning of works shall give due consideration to minimising the impact on factors likely to affect the granting of a resource consent such as historic sites, protected trees, archaeological sites, traffic management and others.

Unless otherwise specified in Service Level Agreement or Works Contract documents, Northpower Network shall be responsible for obtaining all Resource Management Consents and Land Use Consents from Local Authorities.

4.6.3 Railway Crossings

The designer shall be responsible for obtaining permission from the Railway Transportation Corridor Manager for any lines entering into the Railway Transportation Corridor in accordance with the requirements of The National Code of Practice for Utilities' Access to the Transport Corridors. All cables must be installed to meet the requirements of the Railway Transportation Corridor Manager with respect to strength and clearances as per NZECP 34.

4.6.4 Other Utility Notifications

The designer shall make all reasonable enquiries to establish the presence of other services and utilities in the proposed route. The designer shall obtain all necessary approvals and provide necessary notifications prior to works commencing.

4.6.5 Telecommunication Lines

Where line construction or alterations are to be carried out in the vicinity of telecommunication lines, the owner of the telecommunication conductors shall be notified of the proposed work.

Any requirements of the owner shall be complied with or alternative agreed techniques employed. The power circuit shall not induce more than 430 volts on any telecommunication circuit; otherwise, circuit protection is required for the telecommunication circuit. Where these requirements will have significant cost implications, written approval shall be obtained from Northpower's Distribution Engineer. *Refer to Section 6.8.1 for minimum clearances between circuits.*

4.6.6 Cables in the Vicinity of Transmission Voltage Lines

The designer must obtain approval from the transmission line owner where cables are proposed to cross beneath or run in parallel with transmission voltage (66 kV and greater) lines or cables. In the case of transmission voltage lines owned by Transpower, permission shall be obtained.

4.7 Waterway Crossings

4.7.1 General Requirements

Northpower's preferred method for crossing waterways with underground cables is to utilise an above water route using existing road bridge structures wherever this is feasible. Consents shall be obtained from the structure owner, *as per section 4.6.2 Resource Consents.*

Where cables are located on bridge structures, mechanical protection and identification of cables in structure approaches and crossings shall comply with the requirements of AS/NZS 3000.

Where existing bridge structures cannot be used, waterway crossings may be made using, above water structures utilising steel pipe conduits. Steel structures shall be bonded to earth *as per Earthing Design Standard* and shall be protected against corrosion according to requirements to achieve a service life classified as Extra Long Term, in Category C environment, as per AS/NZS 2312:2002.

Designs for cable crossing structures must be approved in writing by Northpower's Operations and Engineering Delivery Manager (or delegate) prior to installation. Any design certificates and consents required for waterway crossing structures shall be submitted to Northpower, with design proposals.

Where overhead waterway crossings cannot be achieved, Northpower's Operations and Engineering Delivery Manager may approve underground crossings. Underground crossings shall comply with all underground cabling requirements expressed in the document

4.7.2 Navigable Waterway Crossings

Lines crossing navigable waterways shall comply with the requirements of EEA Publication Guide to Safety Management of Power Line Waterway Crossings. Notifications shall be made to Maritime Transport.

4.7.3 Other Waterway Crossings

Permission must be obtained from the Northland Regional Council for all lines/cables crossing waterways not considered to be navigable but which require network structures to be constructed within the waterway. Note that resource consent may be required - refer section 4.6.2 Resource Consent.

Underground waterway crossings shall be constructed so that the cable is laid with a minimum of one (1) metre clearance below the stream bed. Northpower approved cable markers shall be installed on the banks of streams to indicate the presence of underground cables at waterway crossings.

4.8 Transformer and Switchgear Site Selection

4.8.1 General Site Selection Considerations

Sites for transformers and switchgear shall be selected to:

- Minimise the risk of damage from third parties. Where suitably protected sites are not available, additional measures shall be taken to provide site equipment with adequate mechanical protection, such as bollards or barriers.
- Be accessible to Northpower at all times for maintenance, operational and equipment replacement purposes.
- Minimise environmental risks such as corrosive atmospheres, ground instability, susceptibility to flooding and erosion of waterways.
- Minimise the impact that any oil leak from transformers would have on nearby waterways, storm water sumps or similar facilities. In particularly environmentally sensitive areas provision shall be made in the design for oil containment facilities to be installed at the site.
- Wherever possible transformer and switchgear sites are to be located in road reserve to avoid the requirement to obtain an easement.

4.8.2 New Residential Subdivisions

The designer shall determine the locations of transformers in consultation with the developer. All transformer and equipment sites shall be designated as road reserve. Surveying and other expenses associated with establishing transformer and equipment sites are the developer's responsibility. The designer shall ensure that adequate space is available for the equipment, cable fitting, and entry and routine maintenance and operator access.

4.9 Commercial and Industrial Substation Sites

4.9.1 General Design Considerations

Where a new substation is required in order to provide for load required by a large commercial or industrial consumer, the consumer shall supply a suitable site, room or structure to locate Northpower equipment. It should be noted that location of Northpower assets in a customer provided site does not imply that these assets are provided for the sole use of the customer.

Minimum requirements for Indoor commercial and industrial substations are provided in Section 11.0 of this document.

4.9.2 Northpower Property Right Requirements

If Northpower owned assets are established on land owned by a Consumer, which are not for sole supply to that customer and they form part of Northpower's distribution network, then an easement in gross to Northpower shall be obtained and registered against the Consumer's land title. The easement in gross shall provide Northpower and its contractors with sufficient legal protection to allow the routine entry onto the Consumer's land in order to establish, operate and maintain its assets. *Refer to Legal Protection Requirements for Electricity Reticulation Standard and Electricity and Telecommunications Easements*

4.9.3 Northpower Clearance Requirements and Easement Areas

To ensure Northpower assets can be operated safely, maintained and upgraded, sufficient clearance is required. Figure 1 to Figure 3 below, shows Northpower required clearances around assets. These include room for a standard gradient earth ring to protect public from touch potential risks.

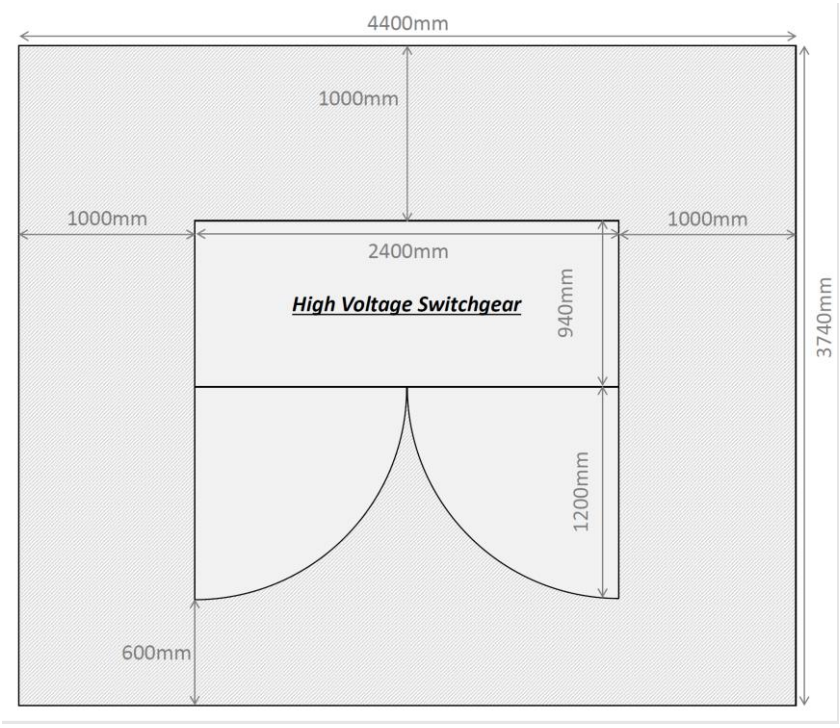

Figure 1: General Clearance and Easement Requirements for Ground Mounted HV Switchgear

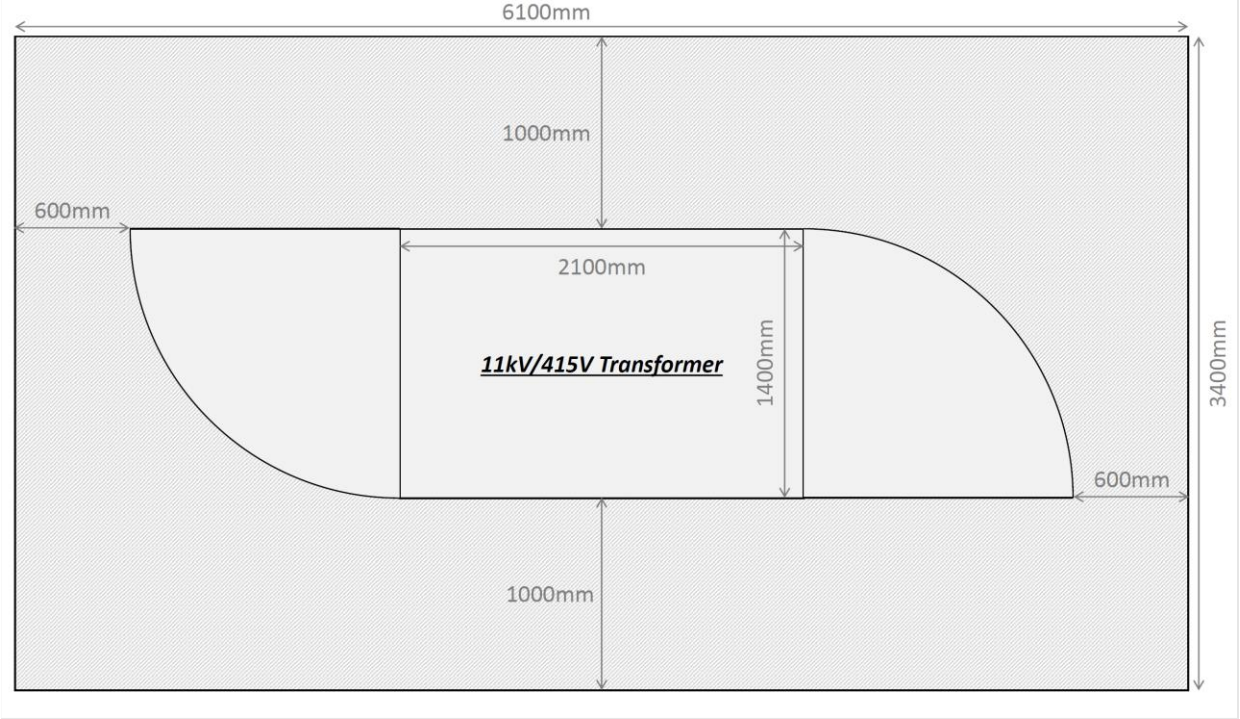

Figure 2: General Clearance and Easement Requirements for Ground Mounted Transformer (Up to 500kVA)

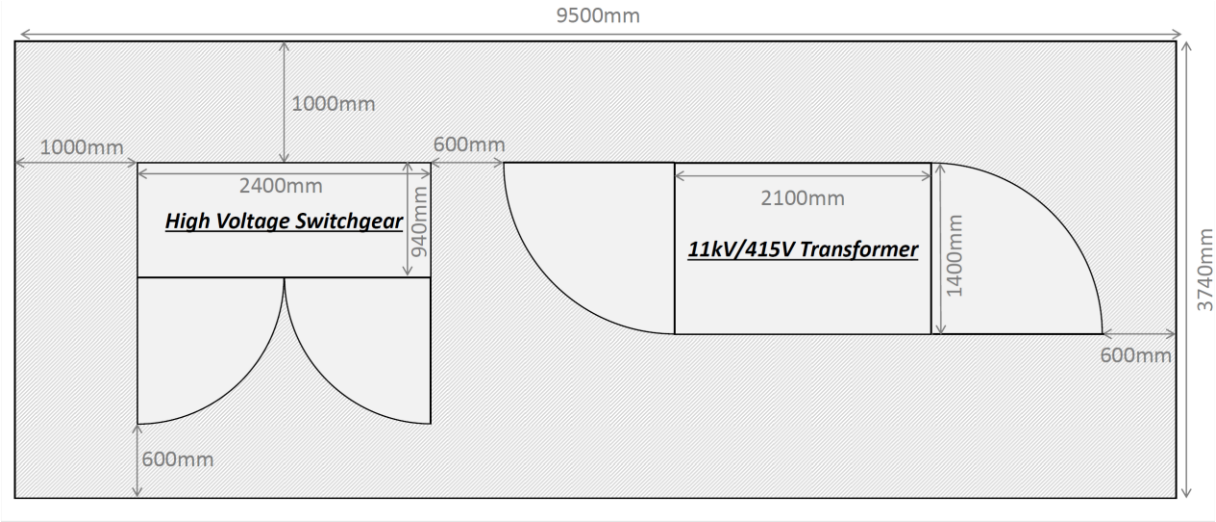

Figure 3: General Clearance and Easement Requirements for Combined Ground Mounted HV Switchgear and Transformer Site

Clearances can be reduced if the touch potential risk is removed. This can be, but not limited to, the installation of a non-conductive fence or the installation of a maintained asphalt road. These reduced clearances are shown below in Figure 4 to Figure 6.

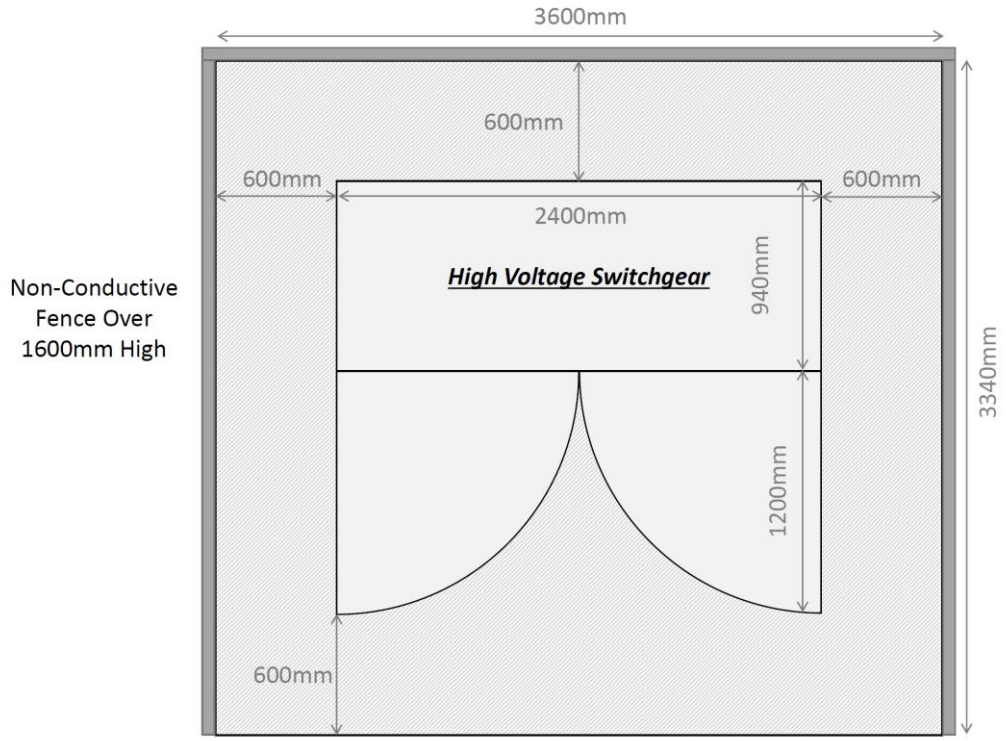

Figure 4: Reduced Clearances and Easement Requirements for Ground Mounted Switchgear

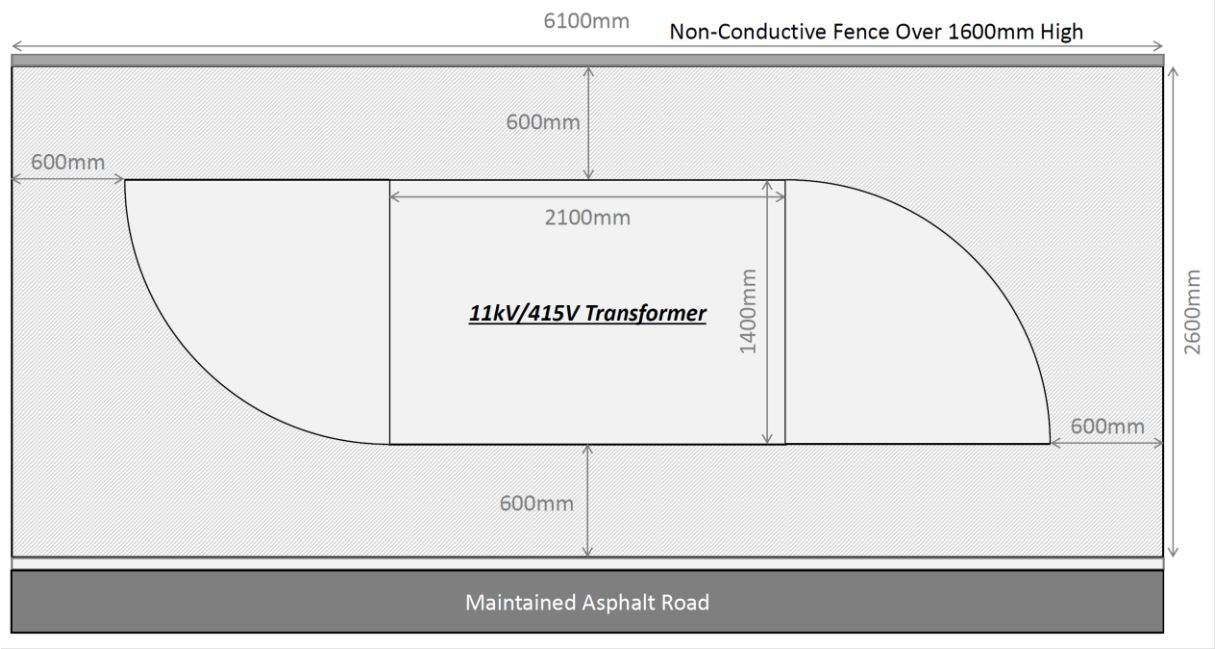

Figure 5: Reduced Clearance and Easement Requirements for Ground Mounted Transformer (up to 500kVA)

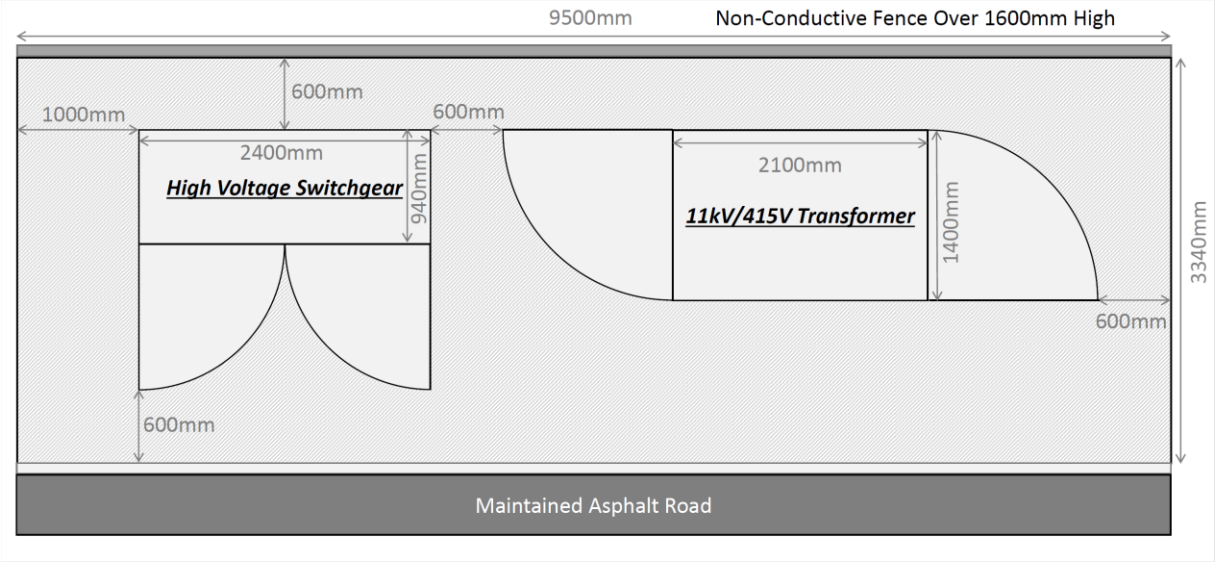

Figure 6: Reduced Clearance Requirements for Combined Ground Mounted HV Switchgear and Transformer Site

5.0 Electrical Design Requirements

5.1 Fusing

The location, size and type of fusing used to protect underground cables and equipment shall be in accordance with *Electricity Reticulation Design Standard and Northpower Approved Materials and Supplier.*

Group fusing shall follow *Electricity Distribution Planning Standard* and be approved by Northpower Networks Distribution Engineer or delegate.

5.2 Surge Protection

Surge arrestors are required on all 33kV and 11kV Cable risers. Surge arrestors shall be mounted directly onto the crucifix. An example is shown below in Figure 7.

Figure 7: Surge Arrestor Crucifix Example

5.3 Ferro-resonance

Ferro-resonance is a non-linear resonance phenomenon that can affect power networks. The abnormal rates of harmonics and transient or steady state over-voltages and over-currents that it causes can damage electrical equipment

Ferro-resonance can occur where lightly loaded transformers (non-linear inductance) are supplied by long overhead lines or cables (capacitance) and single-phase switching (opening or closing) takes place either intentionally or as a result of fuse links operating.

As cables are inherently highly capacitive, instances where transformers are supplied via underground cables are particularly at risk. When the length of cable associated with a particular transformer size approaches or exceeds a certain critical length, precautions need to be taken.

Damage can be avoided by using 3-phase switches or connecting a resistive load to transformer(s).

Table 1 outlines the critical length in cables where Ferro-resonance becomes an issue for 6.35/11 kV Paper Insulated Belted Cable. Table 2 compares critical cable lengths for various cable types. For cable lengths shorter than those indicated, any voltages due to Ferro-resonance should not be of such a level as to cause damage.

Table 1: Critical Cable Lengths for 6.35/11 kV Paper Insulated Belted Cable (Excited Current 0.8%). 6.35/11kV XLPE Screened is shown in brackets for the common sizes

Transformer Rating (kVA)	Cable Size (mm^2)					
	16	25	35	70	95	120
	Cable Length (m)					
100	27	24 (16)	22 (14)	19	16 (10)	14
150	35	32 (21)	32 (21)	28	23 (15)	20
200	53	48 (32)	48 (32)	36	32 (21)	26
300	80	72 (48)	72 (48)	55	45 (30)	40
500	133	120 (80)	120 (80)	90	80 (53)	65
750	199	180 (120)	180 (120)	140	115 (77)	100
1000	265	240 (160)	240 (160)	185	155 (103)	135

Table 2: Comparison of Critical Cable Length for Various Types of Cable

Cable Type	6.35/11kV Paper Belted	11/11kV Paper Belted	6.35/11kV Paper Screened	6.35/11kV XLPE Screened	6.35/11kV EP12 Screened	11/11kV XLPE Screened
Critical Length	100%	155%	56%	67%	44%	104%

Critical Cable lengths are directly proportional to the transformer magnetising current.

A “rule of thumb” formula for calculating the minimum resistive load to control Ferro-resonance for cable lengths up to twice the critical length is:

$$kW\ Load = \frac{kVA\ Magnetising\ Load}{2} - kW\ Core\ Losses$$

		No load loss/ core losses
KVA	**Phases**	**Watts**
15	1	40
30	1	64
50	1	100
15	3	50
30	3	80
50	3	130
75	3	160
100	3	225
150	3	300
200	3	370
300	3	630
500	3	690
750	3	950
1000	3	1125
1500	3	1705

For Cable lengths longer than twice the critical length, the value of the resistive load will need to be increased.

Where a design has the potential for Ferro-resonance to occur, this shall be noted on the appropriate switching plans and a suitable warning placed on the appropriate field location to give warning of the potential Ferro-resonance.

Designs with a potential for Ferro-resonance shall include a suitable means for controlling Ferro-resonance. This could include:

- A suitable three phase switching device
- A suitable amount of customer connected load
- An appropriate dummy load. The designer shall specify the required value of this dummy load.

5.4 Capacitance

The designer shall take into account the capacitance of an underground cable and specify a suitable switching device. Consideration into upstream switching devices shall also be taken into account. As per Northpower Approved Materials and Suppliers Standard.

5.5 Phasing

The phase rotation shall be Red, Yellow/White, Blue. These phase colours shall be identified on the cable cores.

A phase sequence indicator shall be used when determining phase sequences.

The service provider shall identify the phasing of neighbouring networks and shall ensure that the phasing of new works is compliant with circuits in neighbouring sections of networks and is correct at all ring and paralleling points.

Note

When installing a new transformer where an interconnection into the existing LV network is required then it may not be possible to keep the 11kV phase colours, colour true i.e. Red may not be able to connect to “A” on the transformer HV bushing and may need to connect to another phase i.e. “B or C”. In this instance it is OK for the cable colours to not match the transformers bushing letters. Reference Electricity Reticulation Design Standard for guidance.

6.0 Trenching, Cable Protection and Ducting

6.1 Trenching

6.1.1 Trench Dimensions

Trench dimensions are determined by:

a) The type of cable (3 phase, single core and size etc.).
b) Other services in the area, or other services to share the trench, includes spare ducts.
c) Future development of the area which might affect the depth due to changes in the level of cover.
d) Minimum depth requirements are given on Table 1 and AS/NZS 3000:2007. Refer also to ENS 5.9 - Installation of Underground Lead-ins for Telecom (Chorus) Residential Customers when a Telecommunications service is laid in the same trench.
e) The cables minimum bending radius.
f) The standard reticulation layout for residential subdivisions as per Plan 2F173s1 - Standard Reticulation Layout for a Residential Subdivision unless agreement is reached with other utilities.
g) The standard layout for ducts installed to poles and pillars as per plan 2Y138s1 Duct Installation Verification. Ducts should be laid at required depth right up to the pole or pillar. Non Network Approved contractors will require a restriction for excavating near poles from Northpower and Network Approved Contractor may have an exemption given that they can perform engineering calculations. A duct may only be taken into a pillar by a Northpower approved contractor or under Northpower supervision.

6.1.2 Typical Cable Trench Dimensions

Situation	Drawing No.	Depth (mm)	Width (mm)
HV and LV (with Telecom, based on horizontal separation)	2F250s2 2F250s4	1,050	600
HV and LV (no Telecom)	2F250s1 2F250s3	1,050	300
HV (with Telecom)	2F250s5 2F250s6 2F250s16* 2F250s17*	1,050 (1,200 vertical separation with Telecom)	600 (300 vertical separation with Telecom)
HV (no Telecom)	2F250s11 2F250s12	1,050	300
LV (with Telecom)	2F250s8 2F250s10 2F250s14* 2F250s15*	750 (1, 050 vertical separation with Telecom)	450 (300 vertical separation with Telecom)
LV (no Telecom)	2F250s7 2F250s9	750	300

* Alternative option

6.1.3 Cable Bedding and Backfill

The base of the trench and the bedding materials must not include granular materials of greater than 7mm particle size and shall be free of vegetation or rubbish. If the base of the trench or excavated material includes any of the above materials, the cables and ducts are to be bedded in clean granular material of 7mm maximum particle size or clean sand.

If the excavated material is clay or silt, it may be used as bedding material, provided that:

- It is not dry or hard, and
- Soft clay or silt must be of no greater sod size than 150mm and the density of the bedding when compacted must not be less than that of the adjoining soil.

Compaction of bedding must not damage or deform the ducts or impose bending loads on cables.

In some instances, project design specifications may require the use of thermally stabilised backfill material around cables. Any requirements of this type shall be complied with when bedding cables.

6.2 Thrust Boring

Thrust Boring and other alternative methods may be used provided that the Service Provider takes full responsibility in writing for damages to other services. Due care shall be given to cable pulling tension and to the nature of the ground (such as the presence of stones, boulders, etc.), to ensure that the cable is not damaged while being installed.

All thrust or bored holes shall be lined with an orange coloured HD PVC or polyethylene ducting, compliant with AS/NZS 3000. Duct materials shall be compliant with AS/NZS 61386.

6.3 Cable Identification and Protection

Cable Identification and protection shall be in accordance with the requirements of AS/NZS 3000. A summary of standard cable protection systems where open trenching techniques are required are outlines in Table 3 below.

Cable covers shall be placed over the cable after laying; with a minimum of 75mm and a maximum of 150mm of bedding material being placed between the cable and the cable protection slabs/covers. Protection slabs/covers shall overlap the cable system by at least 40mm on each side.

The cable protection may be one of the following types:

- Cable identification and protection shall be in accordance with the requirements of AS/NZS3000.
- Concrete slabs not less than 300 x 200 x 50mm thick and having a classification of not less than grade 15 in accordance with AS 3600. Continuous pour concrete is not acceptable unless specifically approved for a particular installation. A continuous run of orange coloured cable marker tape shall be laid directly over the concrete slabs. Cable marker tape shall comply with AS/NZS 2648.1.

Table 3: Cable Protection Requirements

Type	Protection System Details	Application
Mag Slab	Width – Not less than 250mm. Thickness – as per AS/NZS 3000 requirements	All 3-phase 11,000 volts and 400 volts cables protection applications for all network cables or where trenches exceed 300mm width.
	Width – Not less than 150mm. Thickness – as per AS/NZS 3000 requirements	All 400 volts cable protection applications where trenches do not exceed 300mm width and are for dedicated LV cable applications.
Concrete Slabs	N/A	Purchased to order for specific high load cable protection applications.

Cable risers are required to have mechanical protection to prevent damage to the cable. As a minimum material requirement, ducts or cable covers shall be high impact rated, UV resistant PVC, be suitable for outdoor use and be either white or grey.

Cable risers shall be positioned on poles so as to minimise any risk of physical damage from exposure to their local environment.

Cables can be protected either with;

- Cable cover installed such that the cable is protected over 2.5m above ground
- Ducting installed up to 1 meter below LV arm or HV Crucifix.

All ducts ends are required to have duct end protection to prevent sharp edges of the duct damaging the cable.

6.4 Duct Sizes and Types

Standard ducting sizes and types shall comply with the requirements prescribed in Table 4 below and *Northpower Approved Materials and Suppliers*.

Table 4: Northpower Standard Ducting Sizes and Requirements

Type	Nominal Outside Diameter	Material Type / Colour Required	Properties
Stick Ducts	50 mm for streetlight 100 mm 150 mm Larger duct sizes may be approved for use in specific applications, subject to compliance with cable manufacturers technical instructions and approval by Northpower's Distribution Engineer	• Heavy Duty Orange • uPVC or polyethylene *Street light duct is unclassified so U/G neutral screen cable shall be used.	Dielectric strength 12 to 40 kV/mm Compliant with either: *AS/NZS 61386.21*
PE Continuous Ducts (i.e., Boring applications)	50 mm for streetlight 110 mm 140 mm Larger duct sizes may be approved for use in specific applications, subject to compliance with cable manufacturers technical instructions and approval by Northpower's Distribution Engineer	• Heavy Duty Orange uPVC or polyethylene	Dielectric strength 12 to 40 kV/mm Compliant with either: • *AS/NZS 61386.21* *AS/NZS 4130*

Type	Nominal Outside Diameter	Material Type / Colour Required	Properties
Pole Riser Applications	20 mm 50 mm 65 mm 80 mm	Grey/White coloured High impact Either UV stabilised PVC circular Or UV stabilised polyethylene shaped	Treated for use in direct sunlight (i.e., UV stabilised) Compliant with *AS/NZS 61386.21* Self-extinguishing Dielectric strength 12 to 40 kV/mm
Drain Coil	65mm 110m	Orange Un-punched	

6.5 Duct Diameter for Cable Diameter

Table 5 states the recommended duct sizes for cable diameters as per *Nexans Cable Catalogue 2012*.

Table 5: Duct Diameters for Cable Diameters

HD Ridgid PVC Duct Nominal Size (mm)	Cable Diameter (mm)		
	Single Cable	Three Cables	Four Cables
50	Up to 30	-	-
63	30 to 38	-	-
65	38 to 47	Up to 24	Up to 21
80	47 to 52	24 to 27	21 to 23
100	52 to 69	27 to 35	23 to 31
150	69 to 99	35 to 51	31 to 44
200	99 to 142	51 to 73	44 to 63
250	Above 142	Above 73	Above 63

6.6 Duct sealing

To prevent rocks, debris and water entering ducting, all ducts (both spare and utilised) shall be sealed using Northpower approved duct seals/duct end seals.

Refer to *Northpower Approved Materials and Suppliers* for approved Duct Seals.

6.7 Spare Ducting

Spare or Future provision Ducting is required in the following scenarios:

a) A service pillar is located on one side of a driveway and a connection will be required on the other side of the driveway. Ducting however is not required if more than 10 meters of cable is required to be run in road reserve as per section 8.3.2 of this document. In this case, a new pillar is to be installed.
b) Spare 11kV Ducting is required if there is a potential route to link two 11kV feeders through a subdivision.

6.8 Clearances from other Services

6.8.1 Clearance from Telecom Services

Table 6: Clearance from Telecom Services

Voltage	Power Cable Type	Crossings		Parallel Runs
		With Protection*	Without Protection	
32V – 250V	Armoured or neutral screened cables	50mm	150mm	Refer to Crossings clearances
32V – 250V	Other types	50mm	300mm	300mm
6.6kV and Higher	Single or multicore	150mm	450mm	450mm (run not to exceed 2.3kM)

* Protection shall be 50mm thick concrete slab

6.8.2 Clearance from Gas

Before commencing cable-laying operations for new works, gas utility clearance requirements should be ascertained.

In the absence any other clearance requirements from gas services, the minimum clearances quoted in section 6.8.3 Clearances From Bulk Water and Wastewater Services should apply.

Wherever there is any variance between Northpower's clearance requirements and gas utility requirements, the larger distance should be adopted.

6.8.3 Clearance from Bulk Water and Wastewater Services

Local requirements for clearances between power cables and water services vary between authorities. Before commencing cable-laying operations for new works, local authority clearance requirements should be ascertained.

In the absence of any other clearance requirements, the following minimum clearances from bulk water or wastewater services shall be:

- 33kV – Minimum Clearance distance = 500mm
- 11kV and 400/230V- Minimum Clearance distance = 300mm

Wherever there is any variance between Northpower's clearance standards and local authority requirements, the larger clearance distance should be adopted.

Where it is not possible to achieve clearance requirements between services, such as when making repairs to existing cables, then protective barriers such as concrete slabs or magslabs should be inserted between the affected services

7.0 Cables

7.1 11kV Cable Design

Northpower requires that XLPE-TR cables be utilised for all new 11kV works as per *Northpower Approved Materials and Suppliers.*

All new 11kV Cable shall be installed in a suitably sized duct. This is to allow for any future upgrade, maintenance or replacement. Written approval is required from Northpower's Distribution Engineer, or delegate, if new cables are designed to be direct buried.

Table 7, below, states the 11kV cable size requirements for general network applications. Any variation from this requires written approval from the Northpower Network Distribution Engineer or delegate.

Table 7: 11kV Cables for General Network Applications

11kV TR-XLPE Cables					
Cores	**CSA (mm^2)**	**Commercial**	**Industrial**	**Residential**	**Rural**
1 or 3	300 Al	Approved	Preferable	Approval Required	Approval Required
1 or 3	185 Al	Preferable	Preferable	Preferable	Preferable
3	35 Al	Approved (2)	Approved (2)	Approved (2)	Approved (2)
1	35 Al	Approved (3)	Approved (3)	Approved (3)	Approved (3)

Notes:

1. For the purpose of Table 7 above:

- Approval Required means Northpower standard cable that is authorised, but can only be used with Distribution Engineer approval for network applications;
- Preferable means Northpower standard cable that shall be used, for network applications, unless a dispensation has been approved by the network distribution engineer.
- Approved means this size can be used where appropriate when consideration is given to future load requirements over the life of the cable.

2. See Section 7.1.1 Permitted Use of Small Cables for requirements.
3. Single core cables may be used for short lengths up to a radius of 20m of a pole or switch gear.

7.1.1 Permitted Use of Small Cables

Notwithstanding the requirements of Section 7.1 11kV Cable Design, 35mm^2 cable may be installed in the following situations:

a. The cable must be protected by fusing compliant with *Northpowers Electricity Reticulation Design Standard.*

b. The cable must be supplying an isolated radial load with little likelihood of growth beyond the rating of the cable.

c. The total installed transformer capacity to be supplied by the cable shall not exceed 100kVA.

d. Maximum length of ducted 35mm 3c 100m.

e. A maximum of two 50kVA transformers may be supplied by the cable, with installed capacity being less than the rated capacity of the cable.

f. Where the use of 11kV multicore cables in distribution substations between distribution transformers and their source ring main switchgear is not practicable, then 1-core cables may be used, subject to meeting the following requirements:

i. Be of appropriate load and fault current rated capacities;
ii. Be protected by the fuses in the switchgear;
iii. Be totally contained within the substation site;

All runs of 35mm^2 cables, irrespective of their location shall be laid in an orange HD duct 100mm (minimum) diameter; i.e. a duct size that will accommodate a single 3-core x 185mm^2 11kV cable.

In order to accommodate future load growth, 11kV network cables in Residential, commercial or industrial regions shall have a minimum conductor of 185mm^2 Aluminium. 300mm^2 Aluminium cable shall be considered for heavily loaded commercial and industrial developments.

Consideration shall be given to the use of 300mm^2 Aluminium cable for sections of network cables near zone substations, or wherever the economic loading of 185mm^2 is likely to be exceeded during the life of the cable.

Care shall be taken when running long lengths of two phase single core cables as the capacitive coupling will cause a rise in the measured earth fault current on the upstream protection. This in turn could result in protection discrimination issues. If a three phase system exists, a three phase cable and transformer shall be used. If only a two wire overhead system

exists, the cable length shall be a maximum length of 100 meters or a protection study shall be under taken to determine the consequences of the capacitive coupling.

7.1.2 11kV Cable Sizes

Current carrying capacity of cables shall be calculated based on the site specific conditions of the location. Cable rating calculations shall be performed using manufacturer provided de-rating tables such as the Olex Cable Handbook, or other approved calculation methods such as that described in IEC60287. The standard design assumptions in Table 8 may be applied in determining cable ratings except where noted below:

Cable ratings for approved cable types under standard design conditions are shown in the following table. In the absence of any other specific cable rating data, the ratings in the table below should be used:

Cable Rating Notes:

1) The standard thermal resistivity value in Table 8 assumes normal soil or backfill types with good dry thermal conductivity characteristics. Site specific measurements of dry thermal conductivity shall be made to establish native thermal conductivity for soils of potentially poor thermal resistivity such as beach sand, peat or similar.
2) As soil thermal conductivity is a dominant factor in determining cable current carrying capacity, site specific thermal resistivity measurements shall be taken for cables with a design load of greater than 3 MVA or 80% of cable rating calculated using assumptions listed above.
3) As cable runs generally include significant sections of ducted installation, cable ratings shall be based on ducted installations data to account for these ducted sections of cables.
4) Care shall be taken in specifying the material and compaction requirements of cable bedding in the immediate vicinity of the cable envelope to ensure that such material has a thermal conductivity in the fully dried state of less than 1.5 DegC m/W. The designer shall specify the thermal conductivity, compaction and grade of material required for cable embedment and backfill in the project construction drawings.

7.1.3 11kV Cable Load Rating

Table 8: 11kV Cable Loadings and Characteristics

Nominal Conductor Size	Maximum Overall Diameter	Ω/km	Capacitance µF/km	Rating in Duct	Minimum Bending Radius	
					Installed	During Installation
25mm² Al XLPE 1C (CTS)	19.4mm	1.20	0.215	100A	230mm	350mm
35mm² Al XLPE 1C	22.5mm	1.11	0.23	119A	270mm	410mm
35mm² Al XLPE 3C	43.9mm	1.11	0.24	111A	530mm	800mm
95mm² Al XLPE 3C	54.2mm	0.411	0.33	191A	650mm	980mm
95mm² Al XLPE 1C	27.9mm	0.411	0.33	205A	340mm	510mm
185mm² Al XLPE 1C	32.4mm	0.211	0.42	297A	390mm	590mm
185mm² Al XLPE 3C	64.6mm	0.211	0.42	279A	780mm	1170mm
300mm² Al XLPE 1C	37.0mm	0.130	0.52	392A	450mm	670mm
300mm² Al XLPE 3C	75.0mm	0.130	0.52	370A	900mm	1350mm

Note: The values in this table are for installation conditions of:

- Ambient Air Temperature 30°C
- Soil Temperature 15°C
- Soil Thermal Resistivity 1.2 K.m/W
- Depth of Burial 1.0m
- Screens Bonded at both ends

Data taken from Nexans Cable Catalogue 2012

7.1.4 Short Circuit Rating

11kV cable shall be capable of withstanding 3-phase and 1-phase short circuit faults for a minimum of 2 seconds. In order to satisfy the above requirements, all network cable short circuit rating shall satisfy the following criteria, cable screens shall be rated: -

- 13.1kA or 10kA for 1 second for all network applications in commercial, industrial, urban regions and where cable run is in close proximity to any zone substation, depending on network fault levels.
- 3kA for 1 second screen fault current ratings for applications in remote rural network applications or protected by upstream fuses.
- Screen requirements should be individually calculated for cable applications within zone substations.

7.1.5 11kV Cable Riser Connections to Overhead Lines

Connection Type	Installed Capacity	Single Transformer	Multiple Transformers (individually protected)	Switching Facilities Down Stream
Solid Connection	≥600kVA	✓*	✓	✓
Overhead Load Break Switch	≥600kVA	×	✓	×
Dropout Fuses Only	<600kVA	✓	×	N/A

* Note – Transformer shall be protected via a ground mounted RMU

7.2 Low Voltage Cable Design

7.2.1 General Configuration Requirements for network

Due to LV service loads starting to increase, with more items such as induction hobs, EV's etc. and with more homes being totally reliant on electricity for all their energy needs, the LV network needs to be designed more resilient, allowing for future growth in individual house load.

Low voltage circuits should be run within the road reserve wherever possible along both sides of all streets/roads being reticulated and shall be designed to provide adequate ring/parallel feeds and interconnections.

Ring and parallel points shall be provided in pillars. Suitably sized disconnects, as appropriate for the circuit loading, shall be installed with links for Ring points and without links for open points.

Reticulation scheme designs shall include link pillars at the midpoints of ring circuits.

Neutral leads shall be connected onto common neutral termination bars in pillars. All existing and new rings shall be run in open status; new ring switching points should be configured to be consistent with operating status in adjacent sections of LV network.

In order to allow easier fault finding, cables shall be run in a “looped in, looped out scheme”. Cables can be terminated in pillars in the following ways:

- Cap Joints - heat shrink end cap cover, mastic tape sealing and 2x 25mm^2 Copper service Tails
- Gelports – a minimum provision for 2x main cables and 2x 25mm^2 Copper Service Tails (minimum)
- Breach Joints – to supply Pits
- Lugged into Link or CBD style pillars

Low voltage ring circuits shall be run in the same capacity cable throughout and shall not be reduced down the circuit.

All new Low Voltage cables shall be run in a suitably sized duct. This is to allow for any future upgrade, maintenance or replacement. Written approval is required from Northpower’s Distribution Engineer if new cables are designed to be direct buried.

7.2.2 Requirements for Interconnection

Interconnection of low voltage network circuits shall be provided as described below for network types:

- ***Commercial/Industrial LV networks:***

Wherever network low voltage circuits are installed, interconnection shall be provided between all adjoining network low voltage circuits.

- ***Interconnection of neutral conductors:***

Wherever L.V. networks phase conductors are interconnected between adjoining circuits, their neutral conductors shall also be interconnected and shall be connected to the Neutral bar.

7.2.3 Low Voltage Cable Sizes

Table 9 below, designate those areas where LV cables approved for use on Northpower’s Distribution Network may be used.

Refer to *Northpower Approved Materials and Suppliers* for approved Low Voltage Cable.

Table 9: LV Cables for General Network Applications

Stranded Aluminium Conductor, XLPE/PVC Insulation, Unarmoured Sheath				
Cores	**CSA (mm^2)**	**Commercial**	**Industrial**	**Residential**
1	630	Approved	Approved	Not Approved
4 or 1	300	Preferable	Preferable	Approved

Stranded Aluminium Conductor, XLPE/PVC Insulation, Unarmoured Sheath				
4 or 1	185	Minimum Requirement	Minimum Requirement	Preferable
4 or 1	120	Not Approved	Not Approved	Minimum Requirement 2

Notes:

1. For the purpose of Table 9 above:
   - Minimum Requirement means Northpower standard cable that is authorised for use, but can only be used with Engineering approval for network applications;
   - Preferable means Northpower standard cable that should be used for network applications.
   - Approved means cable that is authorised for network applications
   - Not Approved means cable that is not authorised for network applications

2. 120mm can be used for short cable lengths for example going down a right of way to a one of pillar where no other connections will be connected. Cable must be installed in a 100mm orange HD PVC duct. (No further cable extension will be allowed). Requires Engineering approval for any other network applications.

Often it is practical to reduce standard LV Cables to install in pillars and into LV Panels. Guidance for tailing down Sector into single core copper cables is shown in Table 10 below.

Table 10: Tailing Down Recommended Sizes

Sector Size	Rating (A) (In Duct)	Fused at (A)	Minimum Tailed Down Size (PVC/PVC)	Minimum Tailed Down Size (PVC/XLPE)	Recommended Tailed Down Size
70mm^2	161	120	35 mm^2	25 mm^2	35mm^2 PVC/PVC
95mm^2	194	160	50mm^2	35mm^2	50mm^2 PVC/XLPE
120mm^2	225	200	70mm^2	50mm^2	50mm^2 PVC/XLPE
185mm^2	291	250	-	70mm^2	70mm^2 PVC/XLPE
240mm^2	345	315	-	95mm^2	120mm^2 PVC/XLPE
300mm^2	391	355	120 mm^2	120mm^2	120mm^2 PVC/XLPE
630mm^2	635	500	300mm^2	300mm^2	300mm^2 PVC/XLPE

7.2.4 Low Voltage Cable Load Ratings

Table 11: 400V Cable Loadings and Characteristics

Nominal Conductor Size	Maximum Overall Diameter	Minimum Bending Radius mm (Set/Installing)	Rating in Duct	Volt Drop mV/A.m	
				1 Phase	*3 Phase*
50mm^2 Kutu 1C	16mm		100A (fused)	1.6	1.4
70mm^2 Rango 1C	17mm		125A (fused)	1.2	1
100mm^2 Beetle 1C	19mm		155A (fused)	0.91	0.72
150mm^2 Weta 1C	24mm		200A (fused)	0.73	0.64
25mm^2 PVC/PVC Cu 1C	11.8mm	95/145	110A (117A in Air)	1.78	1.54
*25mm^2 PVC/XLPE Cu 4C	27.7mm	166 (installed)	110A	-	
35mm^2 PVC/PVC Cu 1C	13.0mm	105/160	134A (145A in Air)	1.29	1.12
50mm^2 PVC/XLPE Cu 1C	13.4mm		174A (207A in Air)	1.01	0.872
*50mm^2 PVC/XLPE Cu 4C	33.9mm	203 (installed)	160A	-	
70mm^2 PVC/PVC Cu 1C	16.4mm	135/200	198A (210A in Air)	0.68	0.589
120mm^2 PVC/XLPE Cu 1C	18.6mm		304A (384A in Air)	0.431	0.373
185mm^2 XLPE/PVC Cu 1C	22.8mm	185/275	338A (515A in Air)	0.233	0.202
120mm^2 XLPE/PVC Al 1C	18.5mm	148/225	236A	0.672	0.582

Nominal Conductor Size	Maximum Overall Diameter	Minimum Bending Radius mm (Set/Installing)	Rating in Duct	Volt Drop mV/A.m	
				1 Phase	*3 Phase*
185mm^2 XLPE/PVC Al 1C	22.7mm	185/275	303A	0.455	0.394
300mm^2 XLPE/PVC Al 1C	27.9mm	225/335	412A	0.307	0.266
630 mm^2 XLPE/PVC Al 1C	39.4 mm	1025/685	635A	0.204	0.177
70mm^2 XLPE/PVC Al 4C	32.0mm	385/580	161A	-	0.993
95mm^2 XLPE/PVC Al 4C	36.6mm	440/660	194A	-	0.723
120mm^2 XLPE/PVC Al 4C	39.8mm	480/720	225A	-	0.577
185mm2 XLPE/PVC Al 4C	49.6mm	600/700	291A	-	0.388
240mm^2 XLPE/PVC Al 4C	55.3mm	665/1000	345A	-	0.307
300mm^2 XLPE/PVC Al 4C	60.2mm	725/1085	391A	-	0.258

Note: The values in this table are for installation conditions of:

- Ambient Air Temperature 30°C
- Soil Temperature 15°C
- Soil Thermal Resistivity 1.2 K.m/W
- Depth of Burial 1.0m
- Screens Bonded at both ends

Data taken from Nexans Cable Catalogue 2019

7.3 33kV Cable Design

Northpower requires that XLPE-TR cables be utilised for all new 33kV works as per *Northpower Approved Materials and Suppliers.*

All new 33kV Cable shall be installed in a suitably sized duct. This is to allow for any future upgrade, maintenance or replacement. Written approval is required from Northpower's Distribution Engineer, or delegate, if new cables are designed to be direct buried.

All 33kV cable works shall be specifically designed and is classed as complex work. Design consideration shall include:

- Current rating including de-rating factors
- Screen Voltage and mitigation where required
- Configuration i.e. flat or trefoil
- Lightning protection
- Proximity to other services and protection requirements

Northpower Standard cable sizes are outlined in Section 7.3.1.

7.3.1 33kV Cable Sizes

Nominal Conductor Size	Maximum Overall Diameter	Ω/km	Capacitance µF/km	Rating in Duct	Minimum Bending Radius	
					Installed	During Installation
95mm^2 Al XLPE 1C	36.7mm	0.411	0.17	Specified as part of design	665mm	445mm
240mm^2 Al XLPE 1C	44.0mm	0.161	0.24	Specified as part of design	795mm	530mm
300 mm^2 Al XLPE 1C	45.2mm	0.129	0.26	Specified as part of design	814mm	543mm
630mm^2 Al XLPE 1C	56.7mm	0.0630	0.35	Specified as part of design	1025mm	685mm

Data taken from Nexans Cable Catalogue 2019

7.4 Terminations

7.4.1 11kV Terminations.

Outdoor Termination Lugs

Northpower's standard is to use suitably sized copper droppers onto a crucifix mounted outdoor termination. Because of the potential for dissimilar metals to be introduced, a shear bolt friction welded bi-metallic lug shall be used on all outdoor terminations.

The friction weld of the bi-metallic lug shall be covered with a water sealing mastic and a suitable lug sealing heatshrink.

All outdoor lugs shall be fitted effectively to prevent water ingress and be of a water blocked type.

Refer to *Northpower Approved Materials and Suppliers* for approved Terminations

Switchgear Terminations

Where cables are to be terminated into switchgear, they shall be trifurcated before the cable box to allow single core terminations to be used.

Where the trifurcation is required to be buried, it is required to have mechanical protection to protect it from any form of external impact or damage.

Refer to *Northpower Approved Materials and Suppliers* for approved Trifurcation Kits.

Transformer Terminations

A suitably rated bushing boot is required to cover transformer terminations and bushings.

Refer to *Northpower Approved Materials and Suppliers* for approved bushing boots.

7.4.2 Low Voltage Terminations

Lugs

All low voltage lugs shall be colour coded to the correct phase with heatshrink over the barrel of the lug.

Breakout

Where a four core cable has been used and terminated onto a disconnect or up a pole, each core shall have coloured heatshrink applied over the turret of the breakout boot and over the lug. This is to protect the XLPE from UV damage and cover exposed lugs.

Natural Screened cables shall have water-blocking links on at least the Neutral conductor to prevent any water ingress into the cable. The phase conductor shall have coloured UV stable heatshrink (coloured to correct phase) applied to the entire length of tail. The bare neutral screen shall have black, UV stable, thick wall, glue lined heatshrink applied to the entire length, including the water blocking sleeve, and over the breakout boot turret. Refer to *Northpower Drawing 2F397s1* for further detail.

7.5 Joints and Connectors

7.5.1 11kV Joints

For new work, HV cable runs of less than 250m shall be continuous without joints, wherever possible.

11kV cable joints shall be installed underground where possible in a location with unrestricted access.

Refer to *Northpower Approved Materials and Suppliers* for approved Joints.

7.5.2 400V Joints

Breach Joints

Where breach joints are to be utilised, i.e. a space restricted area where Pits are required, a break point shall be installed every five (5) pits with a tie point to another LV Feeder. This is to minimise customer outages while a breach joint fault is located and repaired.

Refer to *Northpower Approved Materials and Suppliers* for approved Breach Joints.

8.0 Equipment

8.1 Switchgear

8.1.1 11kV Switchgear

General Requirements

A list of Ring Main switchgear approved for use on the distribution network is in *Northpower Approve Materials and Suppliers.* For their purchasing parameters, refer to Northpower's Distribution Engineer. When selecting Ringmain switchgear for supplying larger loads, (such as transformers greater than 600kVA capacities), the designer should ensure that the switchgear is capable of accommodating the larger styles of fuse links required for these loads.

In situations where 11kV distribution network cables are to be linked together at points of network interconnection, they shall be made by the means of approved switchgear.

Switchgear earthing systems shall comply with *Earthing Design Standard.*

Where switchgear is installed in a substation that is located within or in close proximity to any building, the substation shall be designed and constructed to comply with Section 11.0 of this document.

All RMU's shall be fitted with cable gland plates to reduce the amount moisture ingress and vermin around the cable terminations.

Residential Areas

Where there is more than 600kVA of installed transformer capacity in an area supplied by a feeder with an alternative supply available, from another feeder, switchgear shall be installed in order to permit switching and isolation to be carried out quickly, unless written dispensation is granted by Northpower's Distribution Engineer.

11kV switching breaks should be allowed for every 150 network connection points. This is a guide only and significant discretion may be applied for good engineering reasons with the written approval of Northpower's Distribution Engineer or delegate.

Industrial/Commercial Areas

Switchgear shall be installed in the following instances:

a) Irrespective of transformer sizes, three-phase isolation is required for fault clearance in all substations supplying industrial and commercial areas.
~~b)~~ A Northpower approved type of ground mounted switch unit is required to be used if the transformer is 600kVA or greater.

8.1.2 Low Voltage Switchgear

Disconnects/fuses shall be installed and arranged to be as high above floor/ground level as practicable but shall be set so that the disconnect cable connection tags are not less than 150mm above the substation floor level, or pillar ground level. Due consideration shall also be given to LV cable minimum bending radii when setting LV disconnect heights above floor levels.

Approved "U Bus Bars" are to be utilised where disconnects are fitted to pillars to ensure that cables to not exceed their bending radius.

Where individual disconnects and/or fuses are installed, larger sizes of cable may be terminated using the disconnect manufacturers terminal extension kit.

Disconnect/fuse links shall be selected to co-ordinate with the cable rated capacities; appropriate de-rating of disconnectors shall be applied to account for elevated operating ambient temperatures inside cubicles.

Note – Fuse disconnects are not rated to run continuously at their full rating, for this reason the fuse disconnect rating shall be 150% higher than the fuse installed. e.g. 250A disconnect for 160A fuses.

All designs shall ensure that the space allowed between each disconnect/fuse base complies with the manufacturer's installation requirements and shall be subjected to appropriate de-rating criteria to account for multiple units in close proximity and at elevated ambient temperatures.

Refer to *Northpower Approved Materials and Suppliers* for approved Low Voltage Switchgear.

8.2 Transformers

8.2.1 General

For Transformer types and sizes, refer to *Electricity Reticulation Design Standard*.

8.2.2 Requirements for Fusing Dedicated Transformers

In situations where a ground-mounted transformer is dedicated to supplying a single customer, Northpower requires their own LV fusing/overcurrent protection to be installed on or as close as practicable to the transformer.

This is to ensure that protection meets Northpower's standards and offers the ability for Northpower's Field Service Providers to disconnect the supply, for the sakes of maintenance, without getting access to the customers switchboard.

Where a transformer is being replaced under maintenance or under CIW, a suitably sized LV disconnect shall be installed and fused as per *Electricity Reticulation Design Standard*.

8.2.3 Low Voltage Panel

The Low Voltage Panel shall be designed to have the provision to accommodate:

- Up to four (4) three-phase feeder circuit fuse disconnects from 100kVA to 200kVA transformers
- Up to six (6) three-phase feeder circuit fuse disconnects from 300kVA and greater (if not feeding a dedicated customer).

The LV panel shall have a Transformer Isolator Disconnect with fuses installed as per *Electricity Reticulation Design Standard*.

All disconnectors shall be load break rated.

Refer to *Northpower Approved Materials and Suppliers* for approved LV Panels.

Where greater numbers of circuits (outgoing ways) are required, close attention must be given to the space that is required for these extra circuits. Each circuit shall be fused according to the size of conductor used in the circuit.

The LV Panel shall be constructed using standard industry materials and practice and meet the following:

- The Neutral / Earth Bar to be located on the right hand side of the LV cubical in a transformer to allow for more room for LV cables to be terminated.
- The Neutral Bar shall include a minimum of:
  - 7x 5mm holes tapped to 6mm
  - 12x M12 holes
- The neutral bar shall be suitably rated for the application.
- The bus bars shall be suitably rated for the application.
- No conductive connections shall have spring washers or nyloc nuts. A half lock nut is required.

- The Main Isolator shall be located on the left hand side of the panel unless where a split bus is designed in which case the Isolators are to be located centrally each side of the bus coupler.
- The Phasing shall be coloured correctly from left to right, Red-White-Blue.
- Any drillable parts, i.e. service panel etc., shall be clear of live parts to prevent accidental contact while drilling.
- Live parts, including bus bars, shall have sufficient clearance or protection to prevent phase to earth contact by vermin.

Tails from the bushings of the transformer shall be rated to handle the short circuit current of the transformer for 3 Seconds and/or full load current of the transformer. Table 12 summarises the required cable size from the Transformer bushings to the main disconnect. Care shall be taken to not exceed the cable manufacturers recommended bending radii.

Table 12: Northpower recommended Cable Sizes from Transformer to Main Disconnect

Transformer Size	Full Load Current (A)	Recommended Cable Size (Single Core Copper)
50kVA	70	25mm^2
75kVA	105	25mm^2
100kVA	140	35mm^2
150kVA	209	95mm^2
200kVA	279	95mm^2
300kVA	418	185mm^2
500kVA	696	2x 185mm^2
750kVA	1044	2x 240mm^2
1000kVA	1392	3x 240mm^2 or 2x 400mm^2
1250kVA	1740	3x 300mm^2
1500kVA	2087	3x 400mm^2

8.2.4 Control Equipment Owned by Others in Transformer Cubicles

Control, metering or other equipment that is owned by other parties shall not be installed in Northpower's Distribution Transformers or Cabinets.

8.3 Pillars and Pits

8.3.1 General

Table 13 below outlines typical Northpower approved pillars for standard service connections and the number of fuses that can be utilised.

Refer to *Northpower Approved Materials and Suppliers* for approved Pillars and Pits.

Table 13: Typical Northpower Standard Pillars and Pits

Pillar	No. Fuses at 63A	No. Fuses 3 Phase 160A	Notes
Eco Pillar EP2	5	1	Can be used when small footprint required
Eco Pillar EP3	6	2	Preferred Standard Service Pillar
Eco Pillar EP4	10	3	For extra services, disconnects and links Larger neutral bars shall be specified to allow for future connections
Eco Pillar EP6	10	*	As required for multiway cables and disconnects. Can be used as an alternative for Service Cabinets Larger neutral bars shall be specified to allow for future connections
Gyro E2000	6	2	Preferred Standard Service Pillar
Gyro E2300	12	2	For extra services, disconnects and links
Total Underground Distribution System (TUDS) Pit	4-5	-	Dependant on space in pit
U-Pillar 160A	-	1	
U-Pillar Service	6	-	
Promax S1	3	-	
Promax S2	6	-	
Promax S3	9	-	

CBD style Pillars are generally designed for specific applications.

8.3.2 Location of Service Pillars

Service pillars in roadways should be located:

- in the inner berm area of the road reserve,
- as close as practicable to the street frontage of the subdivided site, and
- as close as practicable to the corner between adjacent sections.

Service pillars located in right-of-ways should be:

- set away from potential vehicle movement areas,
- fed from service pillars located the in road reserve, and
- preferably located on, or as close as practicable to the right-of-way frontage of the subdivided site.

Pits shall always be located in concrete (i.e. Footpath or Driveway) to avoid the Pit from being over grown in grass or being backfilled over.

New Subdivisions, Network Extensions Etc.

Where practicable, service pillars in new subdivisions, network extensions, etc. should be located on opposite site boundaries from telecommunication service pillars, to minimise voltage withstand and site congestion issues.

New consumer connections in existing overhead or underground areas (Infill)

Where a new consumer supply underground cable to be run in road berm would exceed 10 metres from an existing pillar (for underground supply) or pole (for overhead supply), then a new service pillar shall be installed at the consumer's boundary, as described in the above paragraphs.

The service pillar shall be located clear of all existing driveways, access ways or other underground services.

8.4 In Ground Cable Markers

8.4.1 Use of Markers

- LV cables - mark every change of direction.
- HV distribution cables - mark every change of direction and at locations where cables cross.
- Subtransmission - mark every change of direction and approximately every 50 metres.
- Spare ducts – at the ends of spare ducts but may be omitted when cable ducts can be located by other means e.g. ducts into substation building.
- Joints - all joints except LV breech joints.
- Only cable or duct owned by, or to be vested to, Northpower shall be marked.
- The marker is to be recovered from spare ducts when the cable is installed unless it is required to mark the cable location or it is impractical to remove.

8.4.2 Type of Markers

Passive radio marker and a single frequency is to be used for all Northpower applications. Refer to *Northpower Approved Materials and Suppliers* for approved Cable Markers.

8.4.3 Placement of Markers

The marker shall be placed as close as practical to the cable or duct end. For multiple cables in the same trench:

- Between the two cables at or just above the cable depth for cables with horizontal separation.
- Just above or beside the shallowest cable where the cables are vertically separated.

8.4.4 Recording

The location of the cable marker shall be recorded in the GIS. The GIS shall denote what cable or duct is being marked.

9.0 Overhead to Underground Network Conversion

When a request is received to convert any section of overhead network to underground, written approval from Northpower Network's Distribution Engineer or delegate is required before commencing site work. Such approval will not be unreasonably withheld; however, the works must comply with all of Northpower's relevant design and construction standards. Sections 9.1 and 9.2 offer initial guidance into requirements, however these requirements may be reduced if network risk is reasonably mitigated under the guidance of Northpower's Distribution Engineer or delegate.

Note: Some 11kV and sub-transmission circuits will not be able to be undergrounded due to limited back feed ability and time taken to restore a cable fault.

9.1 Cables in Road Reserve

Table 14: OHUG Requirements for Cables in Road Reserve

Requirement	400V	11kV	Sub-transmission
Minimum Run	150 Meters	500 Meters	500 Meters
Minimum Cable Size	185mm^2 Al	185mm^2 Al	630mm^2 Al
Spare Duct	Not Required	Spare Low Voltage* and 11kV Duct* Required	Spare Low Voltage* and 11kV Duct Required
Communications Duct	Required if Fibre is located on poles	Required if Fibre is located on poles	Required if Fibre is located on poles

* Required if open trenching

9.2 Cables in Privately Owned Land

Table 15: OHUG Requirements for Cables in Privately Owned Land Designated Urban

Requirement	Designated Urban		
	400V	**11kV**	**Sub-transmission**
Minimum Run	Property Frontage	250 meters, or across property frontage if >250m	500 Meters
Minimum Cable Size	185mm^2 Al	185mm^2 Al	630mm^2 Al
Spare Duct	Not Required	Spare Low Voltage* and 11kV Duct* Required	Spare Low Voltage* and 11kV Duct Required
Communications Duct	Required if Fibre is located on poles	Required if Fibre is located on poles	Required if Fibre is located on poles
Northpower Favour Easement	Required	Required	Required

* Required if open trenching

Table 16:OHUG Requirements for Cables in Privately Owned Land Designated Rural

Requirement	Designated Rural		
	400V	**11kV**	**Sub-transmission**
Minimum Run	150 Meters	500 Meters	500 Meters
Minimum Cable Size	To Suit Application	185mm^2 Al	630mm^2 Al
Spare Duct	Not Required	Spare Low Voltage* and 11kV Duct* Required	Spare Low Voltage* and 11kV Duct Required
Communications Duct	Required if Fibre is located on poles	Required if Fibre is located on poles	Required if Fibre is located on poles
Northpower Favour Easement	Required	Required	Required

* Required if open trenching

10.0 Street Lighting

TBA

11.0 Indoor and Commercial Substation Requirements

TBA

12.0 Document Review History

Version Number	Date	Revision Notes (reason for change)
1.0	24/09/2021	New document release. Replacing documents: • ENS 03.01.070 Distribution Ferroresonance • ENS 03.03.080 Undergrounding of Overhead Lines • ENS 03.03.100 Pillars and Cabinets • ENS 03.03.025 Guidelines for Future Ducting • ENS 03.03.020 Underground Distribution Line Cable and Location Route • ENS 03.03.085 Underground Distribution – Trenching Content split between Overhead Line Design Standard and Underground Design Standard: • ENS 03.01.095 Distribution Conductor and Cable • ENS 03.01.020 Jointing and Termination • ENS 03.01.025 Overhead and Underground Distribution, Surge Protection • ENS 03.03.095 In Ground Cable Markers
2.0	31/05/2023	Document ID code changed to match new taxonomy: • was named AED.S.03.01 Electricity Reticulation Underground Design Standard • now The following sections have been amended: • 6.4 Ducts and Types – amended sizes following feedback from Northern Contracting • 7.2.4 Low Voltage Cable Load Ratings – amended to include tailing down cables • 7.2.3 Low Voltage Cable Sizes – Added table to provide guidance when tailing down sector cable .3 – Added Northpower Standard 33kV Cables and what is requires for design considerations. •
3.0	15/03/2024	The following sections have been amended. • 4.9.3 Easement area around a Tx & RMU for step potential • 5.3 Added No load/ core loss table • 5.4 Added where to find information

Controlled Document

Version Number	Date	Revision Notes (reason for change)
		• 5.5 Note on LV phasing when connecting new network to existing LV network • 6.2 Added HD to duct type • 7.1.1Removed 25mm cable • 7.1.1 Reduce Tx capacity on small cable • 7.2.1 LV Ring circuits • 7.2.2 Connecting Neutral cores to neutral bar only • 7.2.3 Add 630mm cable to approved list table 10 • 7.2.4 Add 630mm cable to approved list table 11 • 7.3.1. 630mm cable to 33kV cable list • 8.1.1 3 phase isolation required for industrial / commercial areas • 8.1.1 GM Tx above 600kVA requires RMU • 8.1.2 LV Switch gear size guidance • 8.2 tells reader where to find Tx types and sizes • 8.2.1 tells reader where to find LV disconnects & fuse sizes