Northpower

Northpower
Electricity Network

Overhead Line Design Standard

Document summary

This standard provides Northpower's requirements for overhead line design on Northpower's Distribution and Sub Transmission Network.

Document approval

Version	2
Document Owner	Shaun BROWN Distribution Engineering Manager
Document Approver	Raj SINGH Operations and Engineering Delivery Manager
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1.0 Introduction

1.1 Purpose

This standard provides Northpower's requirements for overhead line design on Northpower's Distribution and Sub Transmission Network. This standard is to be used in conjunction with AS/NZS 7000 – Overhead Line Design.

1.2 Scope

The scope of this standard details design principles for overhead reticulation before and beyond the Zone Substation and up to the customer's point of connection and includes:

- Design Principles
- Poles and Support Structures
- Foundations
- Hardware and Fittings
- Conductors
- Electrical Requirements
- Clearances

Exclusions: This standard does **not** cover:

- Zone Substation Equipment including outdoor structures, busbars, and droppers.
- Line hardware and equipment under test condition including R & D trials
- Subtransmission Lattice Towers

1.3 Application

This standard applies to all Designers, Engineers, Network Approved Contractors and Field Service Providers working on Northpower's Network or for Northpower Network.

While private lines may be built to this standard Northpower Network it not mandatory to design and built to this standard. However, where private overhead lines are to be connected to the Northpower Network, there must be evidence that the line is safe prior to connecting. For existing private lines that are found to be unsafe Northpower has an obligation to disconnect from the Network until it is safe to re-connect.

Any deviation from this design standard shall require approval from Northpower Network's Distribution Engineer.

2.0 References

Internal Reference	Details
Use of Network Poles by Other Parties	This standard is intended to cover the attachment and operation of telecommunications and electricity lines and equipment, owned by other parties, to poles owned by Northpower.
Guideline for 3rd Party Attachments on Network Assets	This standard details Northpower networks requirements for 3rd party attachments to Northpower Assets, excluding other utilities.
Legal Protection Requirements for Electricity Reticulation Standard	Legal protections for Northpower's networks electricity Assets; and details Northpower's networks requirements for implementing and using those legal protections
Protection of Northpower's Assets against Atmospheric Corrosion	Northpower networks requirements for protection of Northpower's assets against atmospheric corrosion.
Tree and Vegetation Policy	Northpower networks policy and guidelines regarding vegetation management
Electricity Reticulation Underground Design Standard	Northpower's requirements for the design and configuration of underground distribution network and associated ground mounted equipment for voltages up to and including 11kV.
Electricity Reticulation Design Standard	Northpower's requirements for the design of electricity distribution infrastructure to be connected to Northpower's network.
2F309S7	2m Steel Crossarm for 11KV Northpower
2F325s1	Installation for the spiral vibration damper

External Reference	Details
LineTech Report 2015	Conductor Tension and Damping Recommendations (Line Tech Consulting)
Transnet Report ID 151 2015	Aeolian Vibration Analysis for Northpower Northland 11kV Distribution
AS/NZS 7000 2016	Overhead Line Design – Detailed Procedures
HB331: 2012	Handbook Overhead Line Design
AS/NZS 4676	Structural Design Requirements for Utility Services Poles
AS/NZS 1170.2	Structural Design Actions – Part 2: Wind Actions
AS/NZS 1170:5: 2004	Structural Design Actions, Part 5: Earthquake Actions
AS/NZS 4680	Hot Dip Galvanized (Zinc) Coatings On Fabricated Ferrous Articles
AS/NZS 3000	Electrical Installations (Wiring Rules)
NZECP 34	New Zealand Electrical Code of Practice for Electrical Safe Distances
NZECP 46	New Zealand Electrical Code of Practice for High Voltage Live Line Work
www.legislation.govt.nz	Electricity (safety) Regulations 2010
www.legislation.govt.nz	Electricity (Hazards from Trees) Regulation 2003

External Reference	Details
EEA Guide	EEA Guide to Safety Management of Power Line Waterway Crossings
Electrical Engineers Association	Safety In Design Guide
www.beforeudig.co.nz	visit beforeUdig website or call 0800 248 344 to request plans
www.aviation.govt.nz	Civil Aviation Authority for rules
www.nzta.govt.nz	National Code of Practice for Utility Operators' Access to Transport Corridors
www.northpower.com	Northpowers website

3.0 Definitions

Terminology	Definition
Laminar Wind	A steady and consistent wind with little turbulence. Typically a sea breeze close to the coast. Laminar winds are also more common in the winter months due to the absence of thermals
AAAC	All Aluminium Alloy Conductor
ACSR	Aluminium Conductor Steel Reinforced
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.
Clamp	Clamp in this document refers to the method of attaching the conductor to the insulator.
CAA	Civil Aviation Authority of New Zealand
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.
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.
Support point	The point at which the conductor is clamped

Terminology	Definition
SVD	Spiral vibration damper, also known as an impact type damper, is a helically formed damper with a section that grips to the conductor. This type of damper reduces vibration by impacting the conductor.
Stockbridge	Is a type of damper that attaches to the conductor with weights attached though a messenger cable which dissipates vibration through inter-strand friction.
CBL	Conductor breaking load refers to the maximum load at which a conductor breaks at a certain temperature. Often used as a measure for conductor tension and typically referred to as a percentage of CBL.
EWP	Elevated Work Platform aka Bucket Truck
A	Amperes
V	Voltage or Volts
kVA	Kilo Volt Amps (Power Unit)
ULS	The 'Ultimate Limit State' is the design for the safety of a structure and its users by limiting the stress that materials experience
SLS	The 'Serviceability Limit State' represents a level of stress or strain within the building below which there is a high expectation the building can continue to be used as originally intended without repair.

4.0 Design Principles

4.1 General

The determination of design loads and the assessment of pole capacities should be 'Limit State' format, to be consistent and in accordance with *AS/NZS 7000*. That is, the poles and components are designed using reliability base (risk of failure) approach. The selection of load factors (particularly for weather related loads) and component strength is based on an acceptable risk of failure for the loading condition being considered.

Sub-transmission lines should have allowance for 11kV lines to be run underneath, either now or in the future. This requirement also applies to 11kV distribution feeders with the allowance to run 240/400 volt lines underneath.

Sub-transmission lines are to be designed for an individually specified rating. These specified ratings are to be defined by the Network Distribution Engineer. This will include, but not limited to, consideration into the following:

- Voltage Drop
- Temperature Specifications
- Ground Clearances
- Future Load Growth
- Backfeed ability
- Span Length
- Arm Spacing
- Standard Construction
- Pole Specification

Two pole transformer structures are to be replaced with ground-mounted transformers, where practical.

4.2 Limit State Design

The performance of the structural system for different circumstances is called Limit States. *Refer to AS/NZS 7000 Section 2.2 Limit State Design*.

There are two limit states which are applicable for the design of overhead lines:

(a) Ultimate (Strength) Limit State (ULS)

The design capacity of the component is exceeded, or when it cannot maintain equilibrium and becomes unstable.

(b) Serviceability Limit State (SLS)

The performance of the structure or components under commonly occurring loads or conditions will be satisfactory for the intended use. E.g. avoids excessive deformation, cracking, fatigue, vibration or other operational inadequacies.

The limit states are illustrated in Figure 1 below from *AS/NZS 7000.*

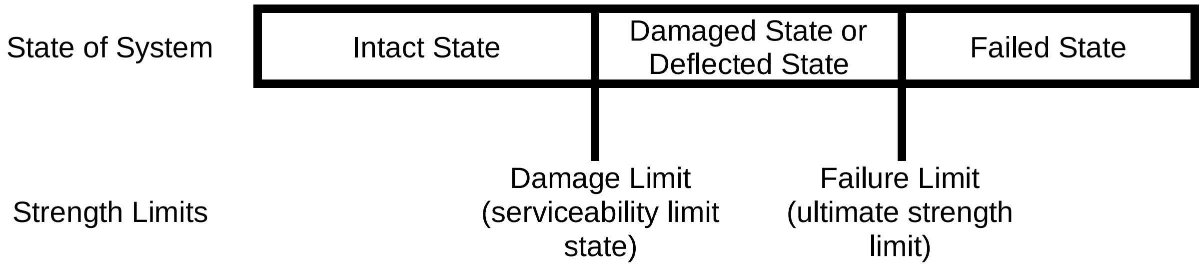

Figure 1: Limit States

All components of an overhead line which carries a structural load irrespective of its primary purpose should be considered a component of the line.

All components shall be designed to satisfy the requirements of both the ultimate and serviceability limit states when subjected to the load combinations defined in this standard. These limit states are summarised in Table 1 below.

Table 1: Ultimate and Serviceability Limit States

Line Component	Normal Design Loadings (Serviceability Limits)	Damage Limit
Structures	Satisfactory performance under commonly occurring loads or conditions including pole deflection	Ultimate strength limit beyond which the structure fails
Conductors (including Earth Wires)	Load beyond which the conductor exhibits permanent deformation	Ultimate strength limit beyond which the conductor fails
Insulators	Load beyond which the insulator is damaged or exceeds the desired deflection limit.	Ultimate load at which the insulator fails

4.3 Design Wind Pressures

Northpower's standard design wind pressures are shown in Table 2 below. These figures are from *AS/NZS 1170.2 – Minimum Design Return Period* for a 50 year design life with a security level III (return period of 200 years) at a height of 10 meters. Where poles or conductors are higher than 10 meters, *refer Table 4.1 in AS/NZS 1170.2.*

For temporary structures or lines, reduced return period can be used (Minimum Design Return Period of 5 years for 6 months design life with a security level of I). These are shown in Table 2. Temporary structures shall be removed or rebuilt to the full design standard in six months.

Terrain Categories are outlined *Section 4.2.1 in AS/NZS 1170.2.*

Refer to AS/NZS 1170.2 Table 3.1 and 4.1 for further information.

For some critical lines, the Northpower Network Distribution Engineer may specify a different design life and security level.

Table 2: Northpower Standard Design Wind Pressures

Terrain Category	Height Multiplier	Full Design Wind Pressure	Temporary Structure Wind Pressure
Urban (Terrain Category 3)	0.83	920 pa.	510 pa.
Rural (Terrain category 2)	1.0	1109 pa.	615 pa.
Costal (Terrain category 1)	1.2	1330 pa.	738 pa.

Drag coefficients for Northpower equipment is shown in Table 3 below. For further information *refer to Appendix E in AS/NZS 1170.2.*

Table 3: Drag Coefficients for Northpower Equipment

Component	Drag Force Coefficient (Cd)
Round Poles	1.2
Busck and Northpower Poles	1.6
Transformers	1.5
Regulators	1.2
Conductors	1.0
Crossarms	1.2
Insulators	1.2
Pole Mounted Switches	1.2

4.4 Line Route Selection

4.4.1 General

Care must be taken into designing line routes. The following should be considered when designing overhead lines:

- Access to poles and equipment for maintenance and replacement.
- Proximity to vegetation including vegetation under the line which can grow into the line and proximity to vegetation at risk for blown debris.
- Clearance to buildings and structures in order to prevent maintenance and cause a public safety risk (*refer to NZECP34*).
- Traffic Management requirements. Consideration into life cycle cost of maintenance of the assets.
- Known future expansion.
- Council Rules and Regulations.
- Health and Safety including public safety and worker safety.

4.4.2 Easements and Designations

All new works which will be owned by Northpower Network, including upgrading of existing assets beyond that which can reasonable considered maintenance or like for like replacement must be located within registered easements allocated to Northpower.

Refer to Legal Protection of Northpower Assets

4.4.3 Airfields, Aerodromes and Airports

Lines sited near licensed Airfields, Aerodromes / Airports are subject to the requirements of the Ministry of Transport, Regional Council, Civil Aviation Authority and the respective airport companies.

4.4.4 Large Aerial Spans

Lines crossing large valleys (i.e., spans greater than 400m) which encroach on airspace (i.e. greater than 45m above the ground) and considered to be within the legitimate domain of aircraft or areas with known aircraft operations (e.g. crop dusting), must obtain the full approval of Ministry of Transport, Regional Council, Civil Aviation Authority).

The Civil Aviation Rules are deemed regulations under the Civil Aviation Act 1990. *Refer to the CAA website* for rules.

- Part 77 of the Rules requires all persons proposing to construct or alter a structure that could constitute a hazard in navigable airspace to notify and obtain the approval of the Director.
- Rule 77.5 Notice of Construct or Alteration of Structure provides additional detail so that a proposed structure can be determined as a hazard or otherwise.
- Rules 77.13 and 77.15 prescribe the Notice requirements

4.4.5 Transport Corridors and Road Safety

When planning for new assets or altering existing assets, where road or transport corridors are affected, *refer to the National Code of Practice for Utility Operators' Access to Transport Corridors* for mandatory requirements and supporting guidance. This Includes Road Corridors (including State Highways), Motorway Corridors and Railway Corridors as defined in that Code.

4.4.6 Waterways and Boat Ramps

The height of conductors over waterways and boat ramps shall comply with the following documents:

- NZECP 34
- EEA Guide to Safety Management of Power Line Waterway Crossings.

Waterway safety signage must be erected where Northpower lines cross waterways as per the following documents:

- EEA Guide to Safety Management of Power Line Waterway Crossings.
- Maritime New Zealand New Zealand's System of Buoys and Beacons.

4.4.7 Vegetation

Pre-existing vegetation needs to be considered and be address where new lines are to be installed as to avoid future vegetation issues that can affect the reliability of the line and impose a significant future maintenance cost. In regard to vegetation growing into the line or at risk of falling into the line *refer to Tree and Vegetation Policy,* which is aligned to the Electricity (Hazards from Trees) Regulation 2003.

4.4.8 Pole Placement

Poles should be located with all-weather vehicle access where possible.

Poles (including stub poles, prop poles and attached stays) should be sited in safe locations so they do not present a potential hazard or more inconvenience than necessary to the public and landowners or present a maintenance liability to Northpower.

Poles being replaced that are in a potentially hazardous location and/or have either been hit by vehicles (particularly if hit more than once) should be moved to a safer location if possible.

Poles in the road corridor should be installed, sited and be painted or have reflectors attached in accordance with district council or NZTA requirements. Note that the installation of a pole within the road corridor, including replacement poles, will require a Corridor Access Request (CAR).

Poles located outside the road corridor should be secured with a suitable easement or be protected by the Electricity Act 1992 unless it for the exclusive use of the property owners.

Poles for high voltage (11 kV to 50 kV) lines should not be installed within 2.2 m from a fence of conductive material. Steel wire fences with steel or concrete fence posts are considered conductive, however, wood fence posts are not considered to be conductive if this cannot be achieved, conductive fence posts shall be replaced with wooden fence posts.

4.5 Wild Life

4.5.1 Possums

Possum Guards shall be fitted to all poles with 11kV Conductors and above.

- Possum guards should be fitted above the web of the pole as to prevent possums getting underneath the possum guard. If this is not possible the possum guard shall be fitted as high as practically possible and moulded to the web to prevent being removed from ground level, preventing vegetation growing above the guard and possums working their way underneath.
- They shall be fitted above pole details i.e. pole markings, warning notices and pole numbers.
- The possum guard shall have a minimum thickness of 0.45mm and minimum width of (height on pole) of 600mm.
- Guywires attached to screw anchors i.e. the stay wire is run to ground level; shall have possum protection, typically a length (1 – 2 metres) of PVC tube, but alternative climbing deterrents can be used.

4.5.2 Birds

Birds can cause issues either by:

1. Striking the conductor, causing the conductor clash
2. Perching on poles structures and making contact between the conductor and fittings attached to the pole or contact between conductors of different phases.

Possible mitigation measures for conductor clash includes using a “delta” conductor configuration and visual markers on the conductor. See Table 17 for Delta Design for areas with high bird strike risk. Possible mitigation for electrical contact on pole structures:

- The use of covered or insulated conductor for jumpers or droppers.
- The use of an appropriate length of cover-up where the conductor is attached to the insulator.
- Mounting bird spikes on the top of the crossarm.

5.0 Poles

5.1 General Requirements

- Northpower's standard poles are concrete poles. In some situations concrete poles may not be practical to install. If this is the case, alternative pole materials can be used with the approval of the Network Distribution Engineer or delegate.
- Poles are to be compliant with *AS/NZS 4676 – Structural Design Requirements for Utility Services Poles*
- The net load capacity of unsupported poles (i.e. no guy) is to be greater than the resultant forces of conductor tension and wind loading, i.e. pole load capacity > conductor static tension + wind loading on pole + wind loading on conductor + wind loading on equipment.
- In cases that involve more than single circuits, consideration for the direction in which the resultant force acts may need to be determined with a vectorial analysis.
- Torsional forces on poles should be avoided. Where these exist consideration must be made in calculating pole strengths

5.2 Load Capacities of Concrete Poles

Table 4, below, shows Northpower poles that are installed in the network.

When two poles are bolted together or are in an "H" Structure configuration, it can be assumed that the transverse and longitudinal strengths can be doubled.

Table 4: Northpower Pole Characteristics

Pole Name	Limit State Transverse top load (kN)	Limit State Longitudinal top load (kN)	Height above ground (m)	Total Length (m)	Weight (tonnes)
24c	2.92	0.95	5.8		
25L	4.00	1.60	6.1	7.6	0.51
25H	6.80	2.70	6.1	7.6	
30L	7.40	3.20	7.6	9.1	0.85
30LA	11.20	3.20	7.6	9.1	0.88
33c	8.00	3.20	8.2	10.0	
33L	8.20	4.00	8.2	10.0	0.88
33LA	14.40	4.00	8.2	10.0	0.89
36L/Tr	14.60	6.20	9.1	11.0	1.23
36LA	20.20	6.20	9.1	11.0	
36LB	18.80	5.20	9.1	11.0	1.34

Pole Name	Limit State Transverse top load (kN)	Limit State Longitudinal top load (kN)	Height above ground (m)	Total Length (m)	Weight (tonnes)
36H	18.94	8.00	9.1	11.0	
36HA	24.46	8.00	9.1	11.0	
40L/Tr	12.80	5.20	10.2	12.2	1.37
40LA	17.70	5.20	10.2	12.2	
40LB	16.60	4.60	10.2	12.2	1.65
40H	16.72	7.10	10.2	12.2	
40HA	19.40	7.10	10.2	12.2	
B7.5	17.00	5.30	5.9	7.5	0.68
B9.5	13.00	4.00	7.9	9.5	0.75
B10	26.00	8.00	8.2	10	1.23
B10.5	10.00	3.00	8.8	10.5	0.79
B11	22.00	8.00	9.2	11.0	1.29
B11.5	26.00	8.00	9.4	11.5	1.53
B12.5	22.00	7.00	10.4	12.5	1.6
B12.4	43.00	11.00	9.2	12.4	2.3
B13.65	38.00	10.00	10.45	13.6	2.5
B14.85	34.00	9.00	11.65	14.8	2.65
B15.5	32.00	8.00	12.3	15.5	2.75
B18.5	32.00	8.00	15.2	18.5	4.1
F14.4	21.00	5.26	12	14.4	2.49

5.3 Foundations

5.3.1 Foundation Design Principles

The level of engineering analysis required for foundation design depends on the importance of the line, public safety, reliability and the loading of the structure in particular termination and angle poles, and the soil conditions at the pole locations.

Table 5: Foundation Design Requirements

Pole Description	Level of design (new line)	Level of design (existing line)
Sub-transmission Line ≤ 66kV	Soil investigation is required where weaker soils are discovered or known. Foundation calculations are required. Standard foundation drawings can be used (i.e. breast and heel blocks).	If line has a history of foundation problems a soil investigation and foundation calculation are required. Standard foundation drawings can be used (i.e. breast and heel blocks).
Distribution Lines – 11kV	Soil investigation is required where weaker soils are discovered or known. Foundation calculations are required. Standard foundation drawings can be used (i.e. breast and heel blocks).	If line has a history of foundation problems a soil investigation and foundation calculation are required. Standard foundation drawings can be used (i.e. breast and heel blocks).
Low Voltage Lines – 400V	Soil investigation is required where weaker soils are discovered or known. Foundation calculations are required. Standard foundation drawings can be used (i.e. breast and heel blocks).	If line has a history of foundation problems a soil investigation and foundation calculation are required. Standard foundation drawings can be used (i.e. breast and heel blocks).

Weak soils are defined as soils a soil class of Very Soft or Soft as shown in Table 6 below.

Table 6: Bearing Strengths of Soils at the Serviceability Limit State

Class	Very Soft	Soft	Firm	Very Firm	Hard
Soil Description	Silty Clays and sands; loose dry sands	Wet clays; silty loams; wet or loose sands	Damp clays; sandy clays; damp clays	Dry clays; clayey sands; coarse sands; compacted sands	Gravels; Dry Clays
Strength – f_b (kPa)	$f_b \leq 60$	$60 < f_b \leq 100$	$100 < f_b \leq 150$	$150 < f_b \leq 240$	$240 < f_b$

5.3.2 Soil Investigation

Where a soil investigation is required the soil along entire route shall be considered, a number of test sites may be required to establish a soil profile for the line route. For new lines it is recommended that at least every fifth pole site should be tested, or at any pole site where deemed necessary. Soil maps can be used to establish suitable test sites.

Persons experienced in field penetrometer tests shall conduct the soil investigations. This may require the services of a professional soil consultant to ensure that the foundation design meets the required standard.

Underground services shall be identified and physically located (refer to Northpowers website, section 'safety below ground' for further information e.g. using Northpower's "Dial-Before-You-Dig" process for electrical cables, underground pipes and gas lines) **before** any penetrometer tests are conducted to prevent risk of contact with underground services.

5.3.3 Soil Mechanic Calculation

The embedment depth formula can be used to determine if the soil will resist the loads induced on the pole to prevent soil displacement and pole deflections. Refer to the following equation. Under most situations the foundations should hold under serviceability limit state and yield under ultimate limit state conditions, aligning with the distribution failure hierarchy.

The embedment depth formula is a function of the depth of the pole in the ground, the effective width of the pole footing and the soil bearing strength.

Many poles have an embedment depth level specified by the manufacturer (especially modern pre-stressed concrete poles) that does not permit burial below the manufacturer's pole embedment depth. Burying beyond or above the manufacturers pole embedment depth of the pole will markedly reduce the strength of the pole. The effective width of the footing can be increased to improve the foundations ability to resist loads and soil displacement. Therefore a trial and error approach may be used and by changing the backfill material the required foundation strength can often be achieved.

Embedment Depth Equation

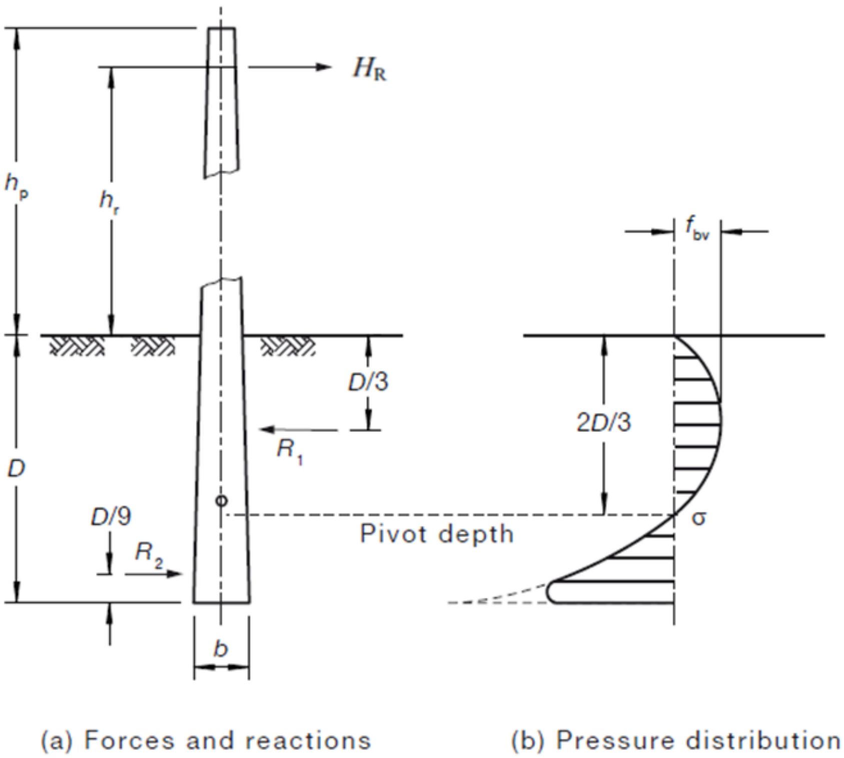

Figure 2: Embedment Depth Diagram

$$D = \frac{3.6H_R + \sqrt{12.96\,{H_R}^2 + 16.2CM}}{2C}$$

where

C = $f_{bu}.b$ for ultimate limit state, or $f_b.b$ for serviceability limit state

- f_b = the nominal maximum bearing strength of the foundation material (kPa)
- f_{bu} = $1.5f_b$
- b = the effective width of the footing, projected on a plane perpendicular to the direction of the resultant horizontal force acting on the pole (m)

M = the overturning moment acting on the pole at ground level (kNm)

= $H_R \times h_r$

- H_R = the resultant of the horizontal forces acting on the pole (kN)
- h_r = the height above ground level at which HR acts (m)

The embedment support is most commonly achieved by boring an oversized hole to the required depth and after installing the pole, backfilling the space between the pole and the perimeter of the hole.

The following are recommended where b is the effective footing width used in the embedment depth formula:-

1. If the backfill is properly prepared concrete, b may be taken as the diameter of the bored hole.

2. If the backfill is AP40 stabilised with cement, b may be taken as the diameter of the bored hole.

3. If the backfill is fully compacted native soil, b may be taken as the average width of the embedded section of the pole.

5.3.4 Minimum Bearing Area Blocks and Footings

Minimum Footing Area Equation

For guyed or stayed poles the minimum plan area (m^2) of the footing required at its lowest point is calculated from the following equation.

where

F_{gt} = the sum of the vertical components of the guy or stay tensions (kN)

F_v = the sum of the vertical forces acting on the pole from loads other than F_{gt} (kN)

f_b = the nominal maximum bearing strength of the foundation material (kPa)

$$A_{fb} = \frac{(F_v + F_{gt})}{f_b}$$

Minimum Blocking Area of Blocks

For termination and angle poles a breast and heel block may be required, the following equation calculates the minimum bearing area of and breast and heel block.

Refer to the Standard Drawings for tables showing standard blocking requirements for various pole configurations.

Blocks need to be fitted to resist the maximum overturning moment (M) as calculated above in all directions.

The minimum footing area calculation above is designed to ensure that coffin shaped poles and guyed poles do not sink into the ground.

Minimum Blocking Area Equation

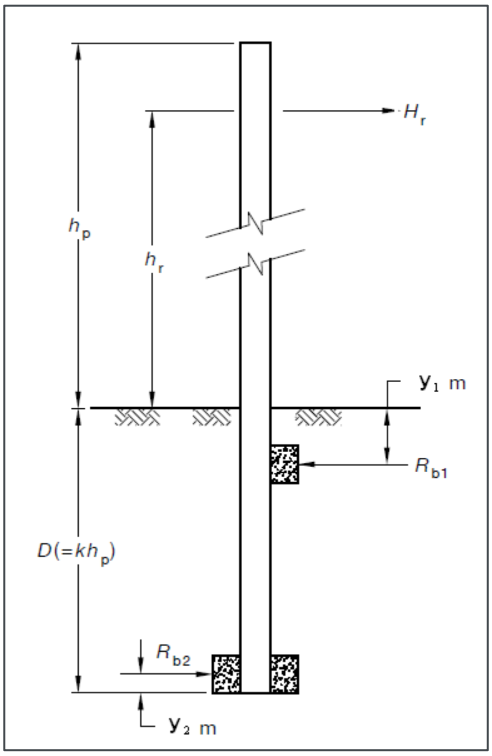

Figure 3: Minimum Blocking Area Diagram

The reaction force (R_{b1}) on the breast block is given by:

$$R_{b1} = H_r \frac{(kh_p + h_r - y_1)}{(kh_p - (y_1 + y_{2)})}$$

The reaction force (R_{b2}) on the heel block is given by:

$$R_{b2} = R_{b1} - H_r$$

The face areas of the breast and heel blocks (A_b) are calculated from

$$A_b = \frac{R_b}{0.85 \, f_{bu}}$$

A separate calculation is required for the breast and heel block.

5.3.5 Pole Donuts

Pole donuts are required to be used on all new poles unless the foundation design specifies a heel block is required. This is to assist in future overhead tap offs and help prevent pole sinkage and prevent poles leaning.

Both concrete and plastic donuts are accepted on the Northpower Network, however, it is recommended that concrete donuts are required for termination and stayed poles due to larger vertical loads acting on the donut. See Northpower's approved equipment list for approved donuts.

5.3.6 Pole Blocks

Pole blocks include both breast blocks, installed on the below the hip of the pole, and heel blocks, installed on the heel of the pole. Breast blocks are required to be installed on angle poles, tap off poles and termination poles as specified by the foundation design. Heel blocks may be required as part of the foundation design.

Both concrete and plastic blocks are accepted on the Northpower Network, however, it is recommended that concrete blocks should be used in termination poles, heavy angle poles and tap off poles due to the flex in the plastic blocks.

Table 7 below, outlines Northpower's standard pole blocks with their dimensions and weights.

Table 7: Northpower Standard Pole Block Dimensions

Pole Block	Length	Width	Depth	Mass
Ecoblock 600 Breast Block	600mm	350mm	100mm	6kg
Ecoblock 900 Breast Block	900mm	350mm	100mm	11kg
Ecoblock 1200 Breast Block	1200mm	350mm	100mm	14kg
Ecoblock 450 Heel Block	450mm	350mm	100mm	5kg
Busck HB460 Heel Block	460mm	350mm	100mm	40kg
Busck BB600 Breast Block	600mm	360mm	100mm	65kg
Busck BB900 Breast Block	900mm	360mm	100mm	81kg
Busck BB1200 Breast Block	1200mm	360mm	100mm	110kg

5.3.7 Shallow Foundation Design

Where a pole cannot be installed at its minimum manufacturers designed depth due to rocks, a standard shallow foundation design has been designed as a lower cost option to rock drilling.

More information is to come, but see Northpower Network's Distribution Engineer for more information.

5.4 Stay Wires and Anchors

Stay wires shall only be used where a pole, including foundation, cannot be designed to take the load cost effectively i.e. Truck/Crane accessibility restrictions, services preventing bigger holes etc. This is to reduce the risk poles failing due to stay wires breaking off and reduce the risk of faults where the stay wire breaks and ends up in the conductors.

During like for like pole replacement where a stay wire is attached, a pole calculation is required to determine whether the stay is still required and a suitable foundation designed.

When stay wires are used, they shall be designed to carry the full pole loading.

5.4.1 Stay Wire Characteristics

Table 8, below, outlines Northpower standard stay wire characteristics.

Table 8: Standard Stay Wire Characteristics

Stay Wire	Light 7/12	Medium 7/10	Heavy 6/19
Limit State Load kN (95% of Breaking Load)	45.1	62.7	104.5
Diameter (mm)	7.5mm	9.45mm	14.0mm

5.4.2 Stay Wire Installation

The angle of the stay wire should be as close to 45 degrees as possible. The angle of the stay can sometimes be reduced for lighter conductors or angles but shall never be less than 30 degrees.

The designer should define for construction purposes:

- The type of stay required
- The stay anchor required
- The location of the anchor and therefore the angle of the stay

When erecting a stay wire ensure that the risk to pedestrians and vehicular traffic is minimised and have adequate visual markings.

All stay wires connected to poles with live conductors shall have at least one suitably rated insulator. The insulators must be located so that a person touching the pole cannot touch below the insulator. This includes linemen. Consideration must also be taken into potential for conductors falling on the guy wire above the insulator.

5.4.3 Screw Anchors

The stay anchor used by Northpower is the 1800mm x 24mm x 200mm helix (51kN axial load max.) and must continue into the ground at the same angle as the down stay wire.

Using soil classifications and strengths and Bowles equations for circular footings (note this excludes the weight of the anchor).

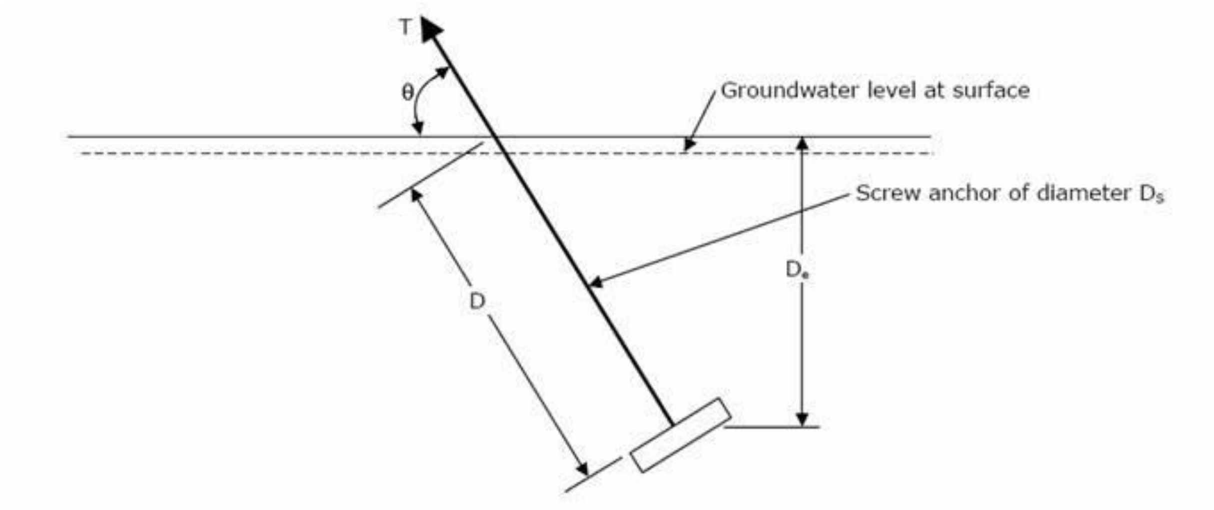

Table 9: Holding Strength of Standard Screw Anchor in Different Soil Classes

Soil Class (ave)	Description	Holding Strength kN 200 mm Single Helix
1	Swamp or Marsh with very soft, deep base	36
2	Soft clay, predominately silty clay	58
3	Firm clay, loose coarse sand. Compact fine sand, sand-gravel mixture, compact sandy loam	71
4	Stiff clay Inorganic material Compacted – silty sand – clean sand – clean gravel	85
5	Very stiff clay Loose gravel Inorganic material Compacted – coarse sand – sandy gravel – clean gravel	89

By design – alternatives to single guy could be two guys separated by 30 degrees but with two eyes together a double helix anchor or dead man.

Where a screw anchor does not provide adequate holding strength, a deadman can be installed.

5.4.4 Prop Poles

Prop poles of adequate strength may be used as an alternative to stay wires.

5.5 Utilisation of Northpower and Chorus Poles

For use of Northpower poles by other parties attachments on Northpower poles and Northpower assets on other parties poles, refer to *Network Poles by Other Parties & Guideline for 3rd Party Attachments on Network Assets.*

6.0 Crossarms

6.1 Approved Crossarm Materials

Traditionally hardwood crossarms have been used and more recently “Purpleheart” as an alternative to hardwood. However, the preferred material is now galvanised steel for HV lines. As galvanised steel cross arms are not available in the full range of sizes wooden crossarms of approved species can still be used for HV lines.

6.1.1 Timber

Table 10, below, are accepted species of timber for crossarms used on the Northpower Network.

Table 10: Northpower Accepted Timber Crossarms

Common Name	Botanical Name	Durability Class (NZ)	Density (kg/m3)
Box, Grey	E. microcarpa, E. moluccana	1	1100-1180
Gum, Spotted	Corymbia maculata	2	1100-1200
Ironbarks, Grey	E. paniculata, E. siderophoia	1	1100-1250
Ironbarks, Red	E. sideroxylon, E. creba, E. fibrosa	1	1100-1250
Purpleheart	Peltogyne pubescens	1	800-1000

6.1.2 Galvanised Steel

Cold formed structural steel rectangular hollow section (RHS) 102 x 76 x 3.5 of grade C350 or greater is permitted to be used for 11kV crossarms. The steel RHS must comply with *AS/NZS 1163:2009.*

The galvanising on all steel crossarms is to comply with *AS/NZS 4680:2006* and have an average coating mass minimum of 600g/m2.

Steel crossarms are not permitted for low voltage due to the possibility of the protection not operating in the event of exposed conductor coming in contact with crossarm.

Refer to Protection of Northpower’s Assets against Atmospheric Corrosion for more information on galvanising requirements on Crossarm Lengths

6.2 Crossarm Lengths

Crossarm lengths shall ensure that conductor clashing does not occur under adverse wind conditions. The crossarm length is based on the number of wires geometry of the wires, line voltage and span length. Northpower standard crossarm length and general configurations are outlined in *section 6.5 Crossarm and Brace Selection* of this document.

6.3 Conductor Spacing

Clearances between conductors of the same circuit are specified in *AS/NZS 7000 Section 3.7*. The procedure for the calculation of mid-span clearances is described in *AS/NZS 7000 Section 3.7.3.2. Refer to AS/NZS 7000* for a detailed explanation of the following simplified description.

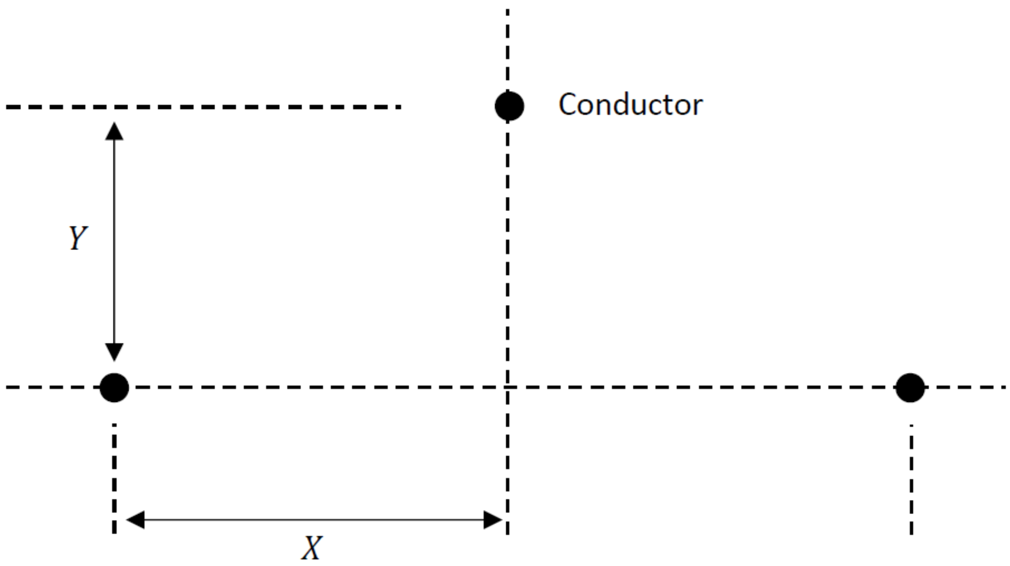

Figure 4: Conductor Spacing Diagram

The following condition must be satisfied:

$$\sqrt{X^2 + (1.2Y)^2} \geq \frac{U}{150} + k\sqrt{D + l_i}$$

Where:

X = Projected horizontal mid-span clearance in metres = average projected horizontal distance at supports on either side of the span.

Y = Projected vertical mid-span clearance in metres = average projected vertical distance at supports on either side of the span.

U = Operating voltage between conductors in kV.

k = Constant (refer to Table 12 below)

D = The greater of the conductor sags in metres at the center of an equivalent level span at 50°C still air.

l = The length in metres of free swing suspension insulator (zero for post or pin insulators).

The minimum mid-span vertical clearances must be as follows:

Table 11: Vertical Conductor Spacing

Operating voltage U	Clearance (m)
≤11kV	0.38
>11kV	0.38+q(U-11)

Where:

q = Constant (refer to Table 12 below)

The values of the constants k and q to be used in the calculation of mid-span clearances are as follows:

Table 12: k and q Constants for Conductor Spacing

Location	k	q
Rural (non-turbulent).	0.4	0.005
Urban & rural where turbulent wind conditions are likely.	0.5	0.0075
All areas with bird-strike risks. Road crossings in urban areas with tall load risks. Rural with areas with bushfire risks - plantations, scrubland etc.	0.6	0.01

6.4 Crossarm Loading

Table 13, below, shows the maximum design working load on Northpower standard crossarms.

Table 13: Maximum Crossarm Working Loads

Crossarm	Maximum Working Load (kN.m)	Crossarm
	Single Arm	Double Arm
Hardwood 100 x 75mm	2.65	5.3
Hardwood 100 x 100mm	3.5	7.0
Steel 102 x 76 x 3.5mm	8.47	16.9*

*Double steel crossarms are not required for strength purposes but may be used for configuration purposes or for insulator transverse loadings.

If double crossarms are used, they shall be connected together near the ends using bolts with suitable spacers (e.g. M16 specific spacer bolts or pipe spacers). Either option must be constructed using washers to protect the timber from damage. Crossarms shall be fitted parallel to each other and suitably braced. Steel crossarms have enough strength to be used as a single arm

When considering the Bending Movement at the pole connection (above) allowance is to be made for the conductor tension with windage added (1/2 span only) for ALL conductors.

6.5 Crossarm and Brace Selection

The following tables, Table 14 to Table 18, provide guidance for selecting braces and crossarm lengths based on the number of conductors, voltage level, and the span length. These guides may be used in general cases without specific design calculations. Where specific design calculations are required *refer to section 6.3 Conductor Spacing* of this document.

6.5.1 Arm Brace Selection

Table 14, below, shows Northpower's standard crossarm braces and generally what size are they are required on. Flat crossarm braces shall only be used as tension only members. Angled crossarm braces can be used for both tension members (if design requires) and compression members (for example side arm construction).

Table 14: Standard Crossarm Braces

Arm Brace	Crossarm Length (m)	Comments
20" (508mm)	1.8	
28" (711mm)	2.0 and 2.1	In rare cases this brace may not fit certain poles to steel crossarms in this instance use a slotted brace
36" (914mm)	2.4 and 2.7	In rare cases this brace may not fit certain poles to steel crossarms in this instance use a slotted brace
42" (1067mm)	3.0 and 3.3	
770mm Slotted	2.0	Can be used on steel crossarm if standard 28" brace does not fit pole hole spacing
950mm Slotted	2.0	Can be used on steel crossarm if standard 36" brace does not fit pole hole spacing
Angled 54" (1370mm)	Where required by design	
Angled 72" (1800mm)	Where required by design	

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6.5.2 400V Crossarm Selection

400V crossarms are to be 100x75mm Hardwood

Table 15: General 400V Crossarm Selection Guide

Span Length (m)	Crossarm Length (m)			
	2 Wire	**3 Wire**	**4 Wire**	**5 and 6 Wire**
Up to 80	1.8	1.8	2.1	2.4
81 to 100	1.8	2.1	2.4	2.7
101 to 120	1.8	2.4	2.7	Not Recommended
121 to 140	1.8	2.7	1.8 at top +2.4 0.9 down	Not Recommended

6.5.3 11kV Crossarm Selection

A general guide to 11kV crossarm lengths are shown below in Table 16. For when there are areas of high bird strike risk, refer to Table 17 below.

11kV Crossarms are generally to be either 100x75mm Hardwood or 102x76x3.5mm RHS Galvanised Steel where specified. A designer should specify a larger crossarm if loads are greater that what a standard arm is design to hold.

Table 16: General 11kV Crossarm Selection Guide

Span Length (m)	Crossarm Length (m)	
	2 Wire	3 Wire
Up to 150	2.0*	2.0*
151 to 200	2.0*	0.6m Pole Top +2.0m* Arm
201 to 220	2.0*	1.2m Pole Top +2.0m* Arm
221 to 280	2.4	1.2m Pole Top +2.4m Arm
281 to 310	2.7	1.2m Pole Top +2.7m Arm

The above calculations are based on a minimum tension of 9% CBL for Fluorine AAAC conductor and an operating temperature of 60°C with k equal to 0.4 i.e. in a rural (non-turbulent) location. Where these parameters are not suitable, *refer to section 6.2 Crossarm Lengths* of this document.

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Table 17: General 11kV Crossarm Selection Guide for Areas of High Bird Strike Risk

Span Length (m)	Delta Arm Configuration
Up to 120	0.6m Pole Top + 2.0*m Arm
121-175	0.6m Pole Top + 2.7m Arm
176-210	1.2m Pole Top + 2.0*m Arm
211-245	1.2m Pole Top + 2.7m Arm

The above calculations are based on a minimum tension of 10% CBL for Fluorine AAAC conductor and an operating temperature of 50°C with k equal to 0.6 i.e. bird strike risk location. Where these parameters are not suitable please *refer to section 6.2 6 Crossarm Lengths* of this document.

* All 2.0m 11kV Crossarms are to be galvanised steel as per drawing 2F309S7

In addition, when replacing existing crossarms for planned work with crossarms recommended in the table above will adversely affect the conductor sag (i.e. angle crossarms); the conductor shall be re-sagged. Any exception to this rule must be approved by the Northpower Network Distribution Engineer. In the instance where the existing construction does not meet *section 6.2* then a new construction must be determined in accordance with *section 6.2 Crossarm Lengths* of this document.

6.5.4 33kV Crossarm Selection

33kV Crossarms are to be 100x100mm Hardwood minimum. Northpower's Standard 33kV arm is 100x125mm.

Table 18: General 33kV Crossarm Selection Guide

Span Length (m)	Crossarm Length (m)	Pole Construction	Arm Brace	
Up to 100	2.7	Single	Flat	36"
101 to 120	3.0	Single	Flat	42"
121 to 140	3.3	Single	Flat	42"
141 to 160	3.6	Single	Angle Iron	54"
161 to 180	3.9	Single	Angle Iron	54"
181 to 200	4.2	Double	Angle Iron	54"
201 to 220	4.5	Double	Angle Iron	54"
221 to 240	4.8	Double	Angle Iron	54"
241 to 260	5.4	Double	Angle Iron	54"
261 to 280	5.6	Double	Angle Iron	54"

7.0 Hardware and Fittings

The bolts attaching the crossarm, insulators and arm braces to the pole shall have a 'lock nut' to avoid the risk of vibration un-doing the nut. Crossarm and crossarm bolts on other lines may also have a 'lock nut'.

The simplest method of 'lock nut' is to fit a second nut to the bolt. Other accepted methods are the use of a second half-sized nut as a lock nut, a galvanised nut with a nylon insert (nyloc nut), using a bolt and galvanised split pin. For the split pin method the bolt must be suitably cold galvanised after drilling the hole for the split pin or a special bolt must be used that has been galvanised after the hole has been drilled.

7.1 Insulators

Insulators shall be used for their designed purpose specified by the manufacturer.

Porcelain clamp-top insulators are not to be used on the Northpower network. If found they are to be replaced with Northpower approved insulators.

Brown 33kV two part pin insulators are to be replaced with Northpower approved insulators if found.

See Northpower's approved equipment list for Northpower's approved insulators.

Insulators shall be designed to accommodate the following loads:

- Vertical loads due to pull down on the arm or uplift (Kline insulator typically used).
- Horizontal loads due to terminations of conductor or guy wire.
- Horizontal loads due to conductor tension (due to changes in line direction and difference in tributary span lengths.

Designers must ensure that the insulator does not fail under the design load.

Where flat conductor configurations are used then the centre phase insulators on 11 kV or 33 kV circuits shall be positioned on opposite sides of alternate poles to maximise mid-span conductor clearances.

7.2 Arm Braces

Arm braces are to be manufactured to Northpower standard drawings and hot dipped galvanised to Northpower Standard *Protection of Northpower's Assets against Atmospheric Corrosion.* Standard length and types of arm braces with their corresponding drawings is shown below in Table 19.

Table 19: Arm Brace Drawings

Arm Brace	Drawing Number
20" (508mm)	TBA
28" (711mm)	TBA
36" (914mm)	TBA
770mm Slotted	2F309s2
950mm Slotted	2F309s2
Angled 54" (1370mm)	TBA
Angled 72" (1800mm)	TBA

Arm braces are required to have a lock nut where the arm brace bolts through the pole to reduce the risk of vibration undoing the nut.

7.3 Nuts, Bolts and Washers

Nuts, bolts, screws, eyebolts and washers are to be metric threaded and hot dipped galvanised to Northpower standard *Protection of Northpower's Assets against Atmospheric Corrosion.*

Stainless Steel hardware - TBA

Clevis Thimble Sets must be used in conjunction with 11 kV and 33 kV preform terminations

8.0 Overhead Conductor

8.1 General Requirements

When a designer is specifying an overhead conductor the following needs to be considered:

- Electrical requirements of the conductor
  - Electrical loading requirements
  - Voltage Drop
- Mechanical requirements of the conductor
  - Mechanical Loading of the conductor
  - Sag and ground clearances due to ambient temperature and loading changes
  - Vibration
- Environmental considerations
  - Proximity to coast
  - Vegetation risks

8.2 Conductor Configuration

Generally, HV conductors are in flat configuration, however, for three wire HV lines “delta” configuration has some advantages in certain situations which could include but not limited to:

- Reducing the risk of conductor clashing from bird strike
- Improving conductor phase clearances while minimising the crossarm size (e.g. smaller easements)
- Improving the clearance to other structures or vegetation
- To avoid aerial trespass

Refer to section 6.2 Crossarm Lengths for how to calculate suitable delta configurations and Table 17 for guidance on delta designs for areas of high risk of bird strikes.

Vertical configuration is generally not used for HV lines due to the additional pole height required with the main exception being angle poles. However for LV it is can be a practical option in certain situations which could include but not limited to:

- Improving conductor phase clearances while minimising the crossarm size
- Improving the clearance to other structures or vegetation
- To avoid aerial trespass

Vertical configuration is permitted for both HV and LV lines.

8.3 Conductor Types

8.3.1 Approved Conductors

Northpower has standardised on AAAC conductors for new HV lines and ABC is preferred for LV where spans allow its use.

Covered LV Conductor shall be used in urban and high public areas where LV is run under HV and does not exceed the rating of the preform deadend. However, for extension to existing lines or repairs, the same conductor as the original line can be used. This applies to both HV and LV lines.

Refer to Table 20 for Northpower's standard conductors.

8.3.2 Conductor Selection

Table 20, below shows Northpower's standard conductors for new work and when they are generally used. For existing conductors and standard conductor ratings, see Table 22 to Table 25 in *Section 8.3.4* of this document.

Table 20: Northpower Standard Conductors

Voltage	System	Conductor
66kV and above	Transmission	No Standard. Generally engineered for the specific application
33kV to 66kV	Sub-transmission	No Standard. Generally engineered for the specific application (Where possible select from 11kV list)
11kV	Spurs (Light Lines)	Fluorine AAAC
	Main Feeder	Iodine AAAC
	Extra Heavy Feeder	Neon AAAC
400V	Service	Owned by Customer, no specification applies
	Spur	35mm^2 Al ABC
	Light Feeder	95mm^2 Al ABC
	Medium Feeder	No Standard. Where possible select from 11kV list.
	Heavy Feeder	No Standard. Where possible select from 11kV list.

General Notes:

- Tension and breaking limits need to be taken into account when choosing a conductor. If the standard list does not cover the required strength limits, refer to Network Distribution Engineer for advice.
- Fault rating should be considered when selecting a conductor.

8.3.3 PVC Covered Conductors and Jumpers

PVC covered conductors are to be used when LV is run underneath 11kV, where ABC cannot be run. Exceptions of this is when the tension of the LV conductors exceeds the preformed deadend rating. This is to offer some protection from a high-low clash.

PVC covered jumpers are to be used when clearances between phases or between phase and earth are reduced. This is to offer some protection against wildlife making contact between phases or a phase and earth.

When a connection is made between two covered conductors or jumpers, the connection needs to be covered in either thick wall heat shrink or a combination of self-amalgamating tape and 33 tape. *Refer to section 8.3.5* of this document, for more information on connections.

Table 21, below, outlines when PVC covered conductor and PVC covered jumpers shall be used, where practical.

Table 21: Approved use of PVC covered conductors and jumpers

Feeder Class	Line Voltage	PVC Covered Jumpers	PVC Covered Conductors
Transmission	66kV and above	Not Allowed	Not Allowed
Sub-transmission	33kV to 66kV	Allowed (Only on Switch Jumpers)	Not Allowed
Distribution	11kV	Allowed	Not Allowed
Distribution	400V	Allowed	Allowed
Services	11kV	Allowed	Not Allowed
Services	400V	Allowed	Allowed

Northpower

8.3.4 Historic Conductors

Table 22 to Table 25 outline Northpower's Conductor characteristics. Current ratings are based on 1.0 m/s wind speed with an ambient temperature of 25°C with a 30°C temperature rise. Maximum "Everyday" tension (at 15°C and no wind) shall not exceed 18% minimum breaking load.

Table 22: Northpower ACSR, AAC and AAAC Conductor Characteristics

Name	Metric Equivalent Cross Section (mm^2)	Stranding Size		Overall Diameter (mm)	Weight (kg/m)	Volt Drop (mV/V.m)		Max Current (A)	Minimum Breaking Load (kN)
		Steel (No./mm)	Aluminium (No./mm)			1 Phase	3 Phase		
Squirrel	21	1/2.11	6/2.11	6.3	0.09	3.4	2.9	105	7.7
Gopher	26	1/2.36	6/2.36	7.1	0.11	2.7	2.3	130	9.6
Poko	31	N/A	7/2.36	7.1	0.08	2.31	2.01	130	5.1
Ferret	42	1/3.00	6/3.00	9.0	0.17	1.78	1.55	175	15.2
Fluorine	49.5	N/A	7/3.00	9.0	0.135	1.59	1.39	190	11.8
Kutu	49.5	N/A	7/3.00	9.0	0.14	1.54	1.35	175	7.9
Mink	63	1/3.66	6/3.66	11.0	0.25	1.28	1.1	220	21.4
Rango	74	N/A	7/3.66	11.0	0.2	1.12	0.97	220	11.1
Helium	77.3	N/A	7/3.75	11.3	0.21	1.11	0.96	220	17.6
Dog	103	7/1.57	6/4.72	14.2	0.39	0.33	0.79	275	32.7
Hare	122.5	1/4.72	6/4.72	14.16				275	44.1
Weke	122	N/A	7/4.72	14.2	0.33	0.80	0.70	275	18.5
Iodine	124	N/A	7/4.75	14.2	0.34	0.82	0.71	275	27.1
Caracal	183	1/3.61	18/3.61	18.1	0.59	0.64	0.55	400	41.0
Jaguar	207	1/3.86	18/3.86	19.3	0.67	0.57	0.48	400	46.0

Name	Metric Equivalent Cross Section (mm^2)	Stranding Size		Overall Diameter (mm)	Weight (kg/m)	Volt Drop (mV/V.m)		Max Current (A)	Minimum Breaking Load (kN)
		Steel (No./mm)	Aluminium (No./mm)			1 Phase	3 Phase		
Neon	210	N/A	19/3.75	18.8	0.58			400	47.8

Table 23: Northpower AAC PVC Conductor Characteristics

Name	Metric Equivalent Cross Section (mm^2)	Stranding Size		Overall Diameter (mm)	Weight (kg/m)	Volt Drop (mV/V.m)		Max Current (A)	Minimum Breaking Load (kN)
		Steel (No./mm)	Aluminium (No./mm)			1 Phase	3 Phase		
Kutu	49.5	N/A	7/3.00	11.5	0.21	1.54	1.35	155	7.98
Rango	74	N/A	7/3.66	13.5	0.29	1.12	0.97	190	11.2
Weke	122	N/A	7/4.72	17.2	0.48	0.80	0.70	250	18.6

Table 24: Northpower Bare Copper Conductor Characteristics

Name	Metric Equivalent Cross Section (mm^2)	Overall Diameter (mm)	Weight (kg/m)	Volt Drop (mV/V.m)		Max Current (A)	Minimum Breaking Load (kN)
				1 Phase	3 Phase		
7/.052" 7/17	10	3.96	0.09	4.5	4.0	85	4.17
7/.064" 7/16	16	4.88	0.13	2.8	2.5	110	6.5
7/.080" 7/14	25	6.1	0.21	1.82	1.58	150	10.1
7/.104"	35	7.92	0.35	1.2	1.1	180	14.1

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Name	Metric Equivalent Cross Section (mm^2)	Overall Diameter (mm)	Weight (kg/m)	Volt Drop (mV/V.m)		Max Current (A)	Minimum Breaking Load (kN)
				1 Phase	3 Phase		
7/12							
19/.064” 19/16	35	8.1	0.36	1.2	1.1	180	14.1
19/083” 19/14	70	10.5	0.59	0.86	0.75	275	26.8

Table 25: Northpower Copper PVC Conductor Characteristics

Name	Metric Equivalent Cross Section (mm^2)	Overall Diameter (mm)	Weight (kg/m)	Volt Drop (mV/V.m)		Max Current (A)	Minimum Breaking Load (kN)
				1 Phase	3 Phase		
7/.064” 7/16	16	6.9	0.164	2.8	2.5	90	5.9
7/.080” 7/14	25	8.4	0.25	1.82	1.58	110	10.4
19/.064” 19/16	35	10.7	0.419	1.2	1.1	150	12.7
19/083” 19/14	70	13.6	0.697	0.86	0.75	240	25

ABC

8.3.5 Conductor Connectors

Table 26, below, shows Northpower approved connections for overhead lines.

Table 26: Northpower Approved Connections for Overhead lines

Conductor	Connection Type	Connector Type	Notes
Bare Overhead Conductor	Full Tension Joint (Mid Span)	Full Tension Compression Sleeve	
	Non Tension Joint	Non Tension Compression Sleeve (Only for Joining the same size and material of conductor) Wedge Type Connector (Al – Al and Cu to Cu only) Wedge Type Connector with gel box (Al – Cu) Split Bolt (Cu – Cu only)	Do not use wedge type connector without gel box when connecting Al – Cu Two split bolts shall be used per connection on HV, Neutrals and Earths
	Tap Off	Wedge Type Connector (Al – Al and Cu to Cu only) Wedge Type Connector with gel box (Al – Cu) Split Bolt (Cu – Cu only)	Do not use wedge type connector without gel box when connection Al – Cu Two split bolts shall be used per connection on HV, Neutrals and Earths
Covered Overhead Conductor	Full Tension Joint (Mid Span)	Full Tension Compression Sleeve	Joint must be covered with glue lined thick wall heatshrink or self-amalgamating tape and 33 tape after installation
	Non Tension Joint	Non Tension Compression Sleeve (Only for Joining the same size and material of conductor) IPC Wedge Type Connector (Al – Al and Cu to Cu only) Wedge Type Connector with gel box (Al – Cu) Split Bolt (Cu – Cu only)	Bare Joints must be covered with glue lined thick wall heatshrink or self-amalgamating tape and 33 tape after installation Do not use wedge type connector without gel box when connection Al – Cu Two split bolts shall be used per connection on HV, Neutrals and Earths

Conductor	Connection Type	Connector Type	Notes
	Tap Off	IPC Wedge Type Connector (Al – Al and Cu to Cu only) Wedge Type Connector with gel box (Al – Cu) Split Bolt (Cu – Cu only)	Bare Joints must be covered with glue lined thick wall heatshrink or self-amalgamating tape and 33 tape after installation Do not use wedge type connector without gel box when connection Al – Cu Two split bolts shall be used per connection on HV, Neutrals and Earths
	Lugged Connection	Compression Lug	Generally used for connecting PVC Covered Conductor onto Overhead Switch terminals
ABC	Full Tension Joint (Mid Span)	Not Accepted	
	Non Tension Joint	IPC	
	Tap Off	IPC	
Bare Conductor to Covered or Insulated Conductor	Full Tension Joint (Mid Span)	Full Tension Compression Sleeve	Only accepted when extending existing PVC with bare. See section 8.6.2 for more detail.
	Non Tension Joint	IPC Non Tension Compression Sleeve (Only for Joining the same size and material of conductor)	IPC only accepted on LV
	Tap Off	IPC Wedge Type Connector (Al – Al and Cu to Cu only) Wedge Type Connector with gel box (Al – Cu) Split Bolt (Cu – Cu only)	IPC only accepted on LV Do not use wedge type connector without gel box when connection Al – Cu Two split bolts shall be used per connection on HV, Neutrals and Earths
Earthing above ground	Joint (Non tension)	Compression Sleeve Split Bolt Brazed or Welded	Two split bolts shall be used per connection on HV, Neutrals and Earths
	Lugged Connection	Compression Lug	

Conductor	Connection Type	Connector Type	Notes
		Quick Lug (bolted lug) Brass Shear Bolt Lug	
	Tap Off	Split Bolt Brazed or Welded	Two split bolts shall be used per connection on HV, Neutrals and Earths

IPC Connections must all be water blocked to ensure water does not ingress into connection.

8.4 Terrain and Clamp Categories

Terrain and clamp categories have been introduced in line design in order to; classify different levels of exposure to laminar winds; and the stresses of different types of clamping/binding of conductor. *AS/NZS 7000* Table Y1 clarifies three terrain categories and three clamp categories, they are summarised as follows.

8.4.1 Terrain Categories

- Type 1 – Flat, no obstacles.
- Type 2 – Rolling terrain with scattered trees.
- Type 3 – Mountain, forest or urban.

Type 1 - Open, flat terrain with no trees or buildings within 500m of conductors. Rolling coastal land exposed to sea breezes with no large trees or buildings within 500m of conductors. Ridges exposed to prevailing winds. Lake and river crossings.

Type 2 - Rolling terrain with scattered trees but no buildings within 500m of conductors. Rolling coastal land exposed to sea breezes with large trees or buildings within 500m of conductors. Flat or rolling terrain covered with low scrub, but away from the coast.

Type 3 - Valleys, steep hills and mountains (except exposed ridges). Forests and native bush. Urban areas, but excluding river crossings and coastal areas.

Type 1 terrain has the highest exposure to laminar winds while Type 3 terrain has the lowest

The terrain categories above are integrated into the Northpower GIS system.

8.4.2 Clamp Categories

Type A – Short trunnion clamp, post or pin insulator with ties (without armour rods).

Type B – Post or pin insulator (clamped or tied) with armour rods, or shaped trunnion clamps with armour rods.

Type C – Helically formed armour grip with elastomer insert or helically formed ties with armour rods.

Clamp type A ideally should not be used for AAAC. Clamp type C provides more support and hence reduces stresses on the conductor. It is therefore preferred to use Type C, helical formed armour grip (i.e. distribution ties, preforms etc.), for all spans for any type of conductor.

8.5 Tensioning and Sagging

The terrain and clamp categories mentioned above are key aspects to consider in line design as they determine the majority of stresses on the conductor which ultimately determines what the maximum tension limit should be. Tension limits have therefore been separated into terrain and clamp type categories for a given conductor. The following tables are based on *AS/NZS 7000* Table Y1 and are in %CBL max everyday tension at 10˚C.

These tensions should not be exceeded.

Table 27: Maximum Tension Limits for Terrain Category Type 1

Conductor Type	Clamp Type A (no dampers)	Clamp Type A (w dampers)	Clamp Type B (no dampers)	Clamp Type B (w dampers)	Clamp Type C (no dampers)	Clamp Type C (w dampers)
Squirrel ACSR	17.0	24.5	18.5	26.0	19.5	27.0
Gopher ACSR	17.0	24.5	18.5	26.0	19.5	27.0
Ferret ACSR	17.0	24.5	18.5	26.0	19.5	27.0
Mink ACSR	17.0	24.5	18.5	26.0	19.5	27.0
Dog ACSR	17.0	24.5	18.5	26.0	19.5	27.0
Caracal ACSR	16.0	22.5	17.5	24.0	18.5	25.0
Jaguar ACSR	16.0	22.5	17.5	24.0	18.5	25.0
Fluorine AAAC	15.0	21.5	16.5	23.0	17.5	24.0
Helium AAAC	15.0	21.5	16.5	23.0	17.5	24.0
Iodine AAAC	15.0	21.5	16.5	23.0	17.5	24.0

Table 28: Maximum Tension Limits for Terrain Category Type 2

Conductor Type	Clamp Type A (no dampers)	Clamp Type A (w dampers)	Clamp Type B (no dampers)	Clamp Type B (w dampers)	Clamp Type C (no dampers)	Clamp Type C (w dampers)
Squirrel ACSR	19.0	26.5	20.5	27.0	21.5	27.0
Gopher ACSR	19.0	26.5	20.5	27.0	21.5	27.0
Ferret ACSR	19.0	26.5	20.5	27.0	21.5	27.0
Mink ACSR	19.0	26.5	20.5	27.0	21.5	27.0
Dog ACSR	19.0	26.5	20.5	27.0	21.5	27.0
Caracal ACSR	18.0	24.5	19.5	25.0	20.5	25.0
Jaguar ACSR	18.0	24.5	19.5	25.0	20.5	25.0
Fluorine AAAC	17.0	23.5	18.5	24.0	19.5	24.0
Helium AAAC	17.0	23.5	18.5	24.0	19.5	24.0
Iodine AAAC	17.0	23.5	18.5	24.0	19.5	24.0
Neon AAAC	17.0	23.5	18.5	24.0	19.5	24.0

Table 29: Maximum Tension Limits for Terrain Category Type 3

Conductor Type	Clamp Type A (no dampers)	Clamp Type A (w dampers)	Clamp Type B (no dampers)	Clamp Type B (w dampers)	Clamp Type C (no dampers)	Clamp Type C (w dampers)
Squirrel ACSR	21.0	27.0	22.5	27.0	23.5	27.0
Gopher ACSR	21.0	27.0	22.5	27.0	23.5	27.0
Ferret ACSR	21.0	27.0	22.5	27.0	23.5	27.0
Mink ACSR	21.0	27.0	22.5	27.0	23.5	27.0
Dog ACSR	21.0	27.0	22.5	27.0	23.5	27.0
Caracal ACSR	20.0	25.0	21.5	25.0	22.5	25.0
Jaguar ACSR	20.0	25.0	21.5	25.0	22.5	25.0

Conductor Type	Clamp Type A (no dampers)	Clamp Type A (w dampers)	Clamp Type B (no dampers)	Clamp Type B (w dampers)	Clamp Type C (no dampers)	Clamp Type C (w dampers)
Fluorine AAAC	19.0	24.0	20.5	24.0	21.5	24.0
Helium AAAC	19.0	24.0	20.5	24.0	21.5	24.0
Iodine AAAC	19.0	24.0	20.5	24.0	21.5	24.0
Neon AAAC	19.0	24.0	20.5	24.0	21.5	24.0

Please note that for long spans the above no dampers tension limits may require dampers due to the increased length of conductor exposed to the wind. This is summarised in Section 8.7 below.

8.6 Binding and Terminating

8.6.1 Binder Wire

Binder wire shall have a tensile strength of greater than 20% of the conductor strength and be made from the same material as the conductor and armour rod. Table 30 below outlines binder wire for conductor types.

Conductors shall be “top-bound” at poles in a straight line; conductors shall be “side-bound” at angles or deviations.

Table 30: Binder Wire for Conductor Types

Conductor Type	Binder Wire
Bare Copper < $35mm^2$	Bare Copper 2.03mm
PVC Copper < $35mm^2$	PVC Copper 2.03mm
Bare Copper ≥ $35mm^2$	**2x** Bare Copper 2.03mm
PVC Copper ≥ $35mm^2$	**2x** PVC Copper 2.03mm
PVC Aluminium	PVC Aluminium 3.2mm
Bare Aluminium LV & 11kV	Bare Aluminium 4.1mm
Bare Aluminium 33kV – 66kV	Bare Aluminium 5.2mm

8.6.2 Preformed Deadends

Single piece preformed deadend are required on all termination poles with AAC, AAAC and Copper conductors. In some applications ACSR conductors can be terminated in single piece preform deadend if the designed conductor load is less than the preform deadend's designed strength.

Two piece preform deadends are required on ACSR conductors where the designed load is more than a single piece deadend. When two piece preform deadends are used, care must be taken to remove all the grease from the steel strand before applying the preform deadend. An alternative is to use a compression deadend. *Refer to section 8.6.3 Compression Deadends* of this document, for more information.

All preformed deadends, with the exception of those for use on PVC insulated conductors, must be capable of withstanding at least 85% of the conductor ultimate tensile strength.

PVC Deadends shall be used within manufacturer's specified ratings. PVC preformed deadends rely on continuous PVC over the length of the conductor run (termination to termination). Where conductors need to be extended, full tension sleeves connecting to bare conductor with a bare preform shall be used. The corresponding end of the PVC run will then need to be stripped back and a bare preform applied. See Table 26 for jointing requirements.

8.6.3 Compression Deadends

Compressions deadends can be used as an alternative to preformed deadends for ACSR conductors.

Compression deadends must be able to hold 100% of the conductor ultimate tensile strength.

8.6.4 Armour Rods

Armour rods are designed to protect the conductor from over bending, insulator chafing and flashover burn.

Armour Rods shall be installed on all AAC, AAAC and ACSR conductors operating at 11kV and above when bound in using binder wire or Kline clamp top insulators. They shall be made of aluminium and not aluminium clad steel.

Armour Rods are not required on copper conductors.

8.6.5 Preformed Insulator Ties

Preformed insulator ties are another method of binding conductors to insulators between 11kV and 33kV with the added benefit of reducing the effects of vibration on conductors.

Preformed insulator ties are required to be all aluminium alloy – aluminium coated steel is not accepted. They shall be installed as per manufacturer's guidelines over top of armour rods without an elastomer insert.

Table 31, below, shows the different preformed insulator tie for different situations.

Table 31: Preformed Insulator Tie Types

Insulator Configuration	Type of Bind	Preformed Insulator Tie Type
Single Post Insulator	Top Bind	Tie Top
Single Post Insulator	Side Bind	Side Tie
Double Post Insulator	Top Bind	Double Tie Top
Double Post Insulator	Side Bind	Double Side Tie

8.6.6 ABC Fittings

Suitable ABC fittings shall be used on all ABC conductors. Refer to Northpower's approved equipment list for approved fittings.

8.7 Vibration Control

8.7.1 Wind Induced Vibration

Wind induced vibration occurs when laminar wind flows across a conductor causing oscillation. This oscillation causes fatigue at support points which can lead to complete failure of conductor. Two ways of counteracting this vibration are to strengthen the support points of the conductor and to dampen the oscillations. It is important to note that both ways mentioned solve the problem in different ways; strengthening the support points does not reduce the vibration but makes the conductor less prone to fatigue; damping the vibration reduces the stresses on the support point by minimising the oscillations. Both the above methods should be used in conjunction.

Refer to Section 8.4 Terrain and Clamp Categories of this document, for further information on support strengthening.

Different types of conductor are more prone than others to fatigue and even from vibration so various conductor types should be treated differently. Specifically AAAC is more prone to both fatigue and vibration than ACSR conductor.

For more information on the effects and identification of vibration, please *refer to the LineTech report (2015).*

8.7.2 Types of Vibration Control

There are two types of vibration dampers recommended for use on Northpower's network. The impact (spiral) type damper and the stockbridge type damper. The impact damper is more suitable to conductors under the diameter of 14mm while the stockbridge damper is more efficient on larger conductors.

For more information on dampers please *refer to the LineTech report (2015).*

Table 32: Recommended Damper Type for Conductor Types

Conductor	Recommended Damper Type
Squirrel ACSR	Impact
Gopher ACSR	Impact
Ferret ACSR	Impact
Mink ACSR	Impact or Stockbridge*
Dog ACSR	Impact or Stockbridge*
Caracal ACSR	Stockbridge
Jaguar ACSR	Stockbridge
Fluorine AAAC	Impact
Helium AAAC	Impact or Stockbridge*
Iodine AAAC	Impact or Stockbridge*
Neon AAAC	Stockbridge

*Impact type dampers can produce noise so in the instance of Mink, Dog and Iodine stockbridge dampers should be used when located close to housing.

Vibration dampers can vary between manufacturers' so it is important to install each damper according to the manufacturer's instructions. *Refer to drawing 2F325s1* for a typical spiral vibration damper installation.

A spiral vibration damper trial has been conducted in Taiharuru, an area which is known to have issues with vibration. The results of this trial can be found in *external reference Transnet Report ID 151.*

8.7.3 Recommended Vibration Dampers

The following tables are summarised from the LineTech report (2015) and the Taiharuru trial and recommend the quantity of dampers and type for a given conductor for a range of span lengths. These tables assume the (no damper) tension in *Section 8.5 Tensioning and Sagging of this document*, is not exceeded. Please note that clamp type has not been included in this section as it does not affect the vibration the conductor experiences.

Table 33: Damper Quantities per Span for Terrain Category 1

Conductor Type	Damper Type	Span Length		
		201m to 300m	301m to 550m	551m to 1000m
Squirrel ACSR	Impact	0	6	12
Gopher ACSR	Impact	0	6	12
Ferret ACSR	Impact	0	6	12

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Conductor Type	Damper Type	Span Length		
		201m to 300m	301m to 550m	551m to 1000m
Mink ACSR	Impact	0	6	12
Mink ACSR	Stockbridge	0	3	6
Dog ACSR	Impact	0	6	12
Dog ACSR	Stockbridge	0	3	6
Caracal ACSR	Stockbridge	0	3	6
Jaguar ACSR	Stockbridge	0	3	6
Fluorine AAAC	Impact	6	12	18
Helium AAAC	Impact	6	12	18
Iodine AAAC	Impact	6	12	18
Iodine AAAC	Stockbridge	3	6	9
Neon AAAC	Stockbridge	TBC	TBC	TBC

Table 34: Damper Quantities per Span for Terrain Category 2 and 3

Conductor Type	Damper Type	Span Length	
		301m to 550m	551m to 1000m
Squirrel ACSR	Impact	0	6
Gopher ACSR	Impact	0	6
Ferret ACSR	Impact	0	6
Mink ACSR	Impact	0	6
Mink ACSR	Stockbridge	0	3
Dog ACSR	Impact	0	6
Dog ACSR	Stockbridge	0	3
Caracal ACSR	Stockbridge	0	3
Jaguar ACSR	Stockbridge	0	3
Fluorine AAAC	Impact	6	12
Helium AAAC	Impact	6	12
Iodine AAAC	Impact	6	12
Iodine AAAC	Stockbridge	3	6
Neon AAAC	Stockbridge	TBC	TBC

8.7.4 Recommended Vibration Dampers for Over Tensioned Line

The following tables are summarised from the LineTech report (2015) and the Taiharuru trial and recommend the quantity of dampers and type for a given conductor for a range of span lengths. These tables assume the (w damper) tension in *section 8.5 Tensioning and Sagging* of this document, if not exceeded. Please note that clamp type has not been included in this section as it does not affect the vibration the conductor experiences.

Table 35: Damper Quantities per Over Tensioned Span for Terrain Category 1

Conductor Type	Damper Type	70 to 150	151 to 350	351 to 550	551 to 1000
Squirrel ACSR	Impact	2	4	6	8
Gopher ACSR	Impact	2	4	6	8
Ferret ACSR	Impact	2	4	6	8
Mink ACSR	Impact	2	4	6	8
Mink ACSR	Stockbridge	1	2	3	4
Dog ACSR	Impact	2	4	6	8
Dog ACSR	Stockbridge	1	2	3	4
Caracal ACSR	Stockbridge	1	2	3	4
Jaguar ACSR	Stockbridge	1	2	3	4
Fluorine AAAC	Impact	2	4	6	8
Helium AAAC	Impact	2	4	6	8
Iodine AAAC	Impact	2	4	6	8
Iodine AAAC	Stockbridge	1	2	3	4
Neon AAAC	Stockbridge	TBC	TBC	TBC	TBC

Table 36: Damper Quantities per Over Tensioned Span for Terrain Category 2 and 3

Conductor Type	Damper Type	150 to 250	251 to 550	551 to 1000
Squirrel ACSR	Impact	2	4	6
Gopher ACSR	Impact	2	4	6
Ferret ACSR	Impact	2	4	6
Mink ACSR	Impact	2	4	6
Mink ACSR	Stockbridge	1	2	3
Dog ACSR	Impact	2	4	6
Dog ACSR	Stockbridge	1	2	3
Caracal ACSR	Stockbridge	1	2	3
Jaguar ACSR	Stockbridge	1	2	3
Fluorine AAAC	Impact	2	4	6

Conductor Type	Damper Type	150 to 250	251 to 550	551 to 1000
Helium AAAC	Impact	2	4	6
Iodine AAAC	Impact	2	4	6
Iodine AAAC	Stockbridge	1	2	3
Neon AAAC	Stockbridge	TBC	TBC	TBC

9.0 Pole Mounted Plant

9.1 Transformers

All pole-mounted transformers shall be located where all weather vehicle access is available. This is to ensure that the transformer can be replaced safely all year round.

When selecting a site, the following shall be considered:

- Identify the location of significant electrical loads.
- Economic considerations, e.g. cost of LV extension versus separate transformer.
- Accessibility, including the location of fusing equipment i.e. safe to operate from the ground.
- Space available for earth mat
- Risk, physical protection, i.e. susceptible to damage from cars hitting the pole
- Risk to the public, property or environment, i.e. does the equipment pose a risk to others
- Compliance with district scheme and building code
- Legal access, e.g. easements
- Pole loading

Standard pole-mounted transformers are shown in *Electricity Reticulation Design Standard.*

150kVA pole mounted transformers are only to be used in special cases, i.e. no room to ground mount or ground mount poses risk to public or asset. A risk assessment shall be completed and written approval given from Northpower Network's Distribution Engineer or equivalent. The risk assessment shall include, but is not limited to:

- Increased risk for working at heights
- Probability and consequence of vehicle damage
- Proximity to driveways and fall risk
- Worker safety, e.g. ladder position and complexity of construction
- Ground and access conditions, e.g. flood risk etc.

1kVA single phase transformers are typically used for automation of pole mounted switchgear where there is not LV Supply. Where there is LV supply from a transformer supplying other loads, a 240V/240V isolation transformer shall be used. 1kVA transformers may be used for streetlight supply where there is no other economic way to supply them. 1kVA transformers are typically internally fused. To isolate the transformer from the main line, solid linked drop out fuse can be used.

Figure 5 outlines the standard structures for overhead transformers.

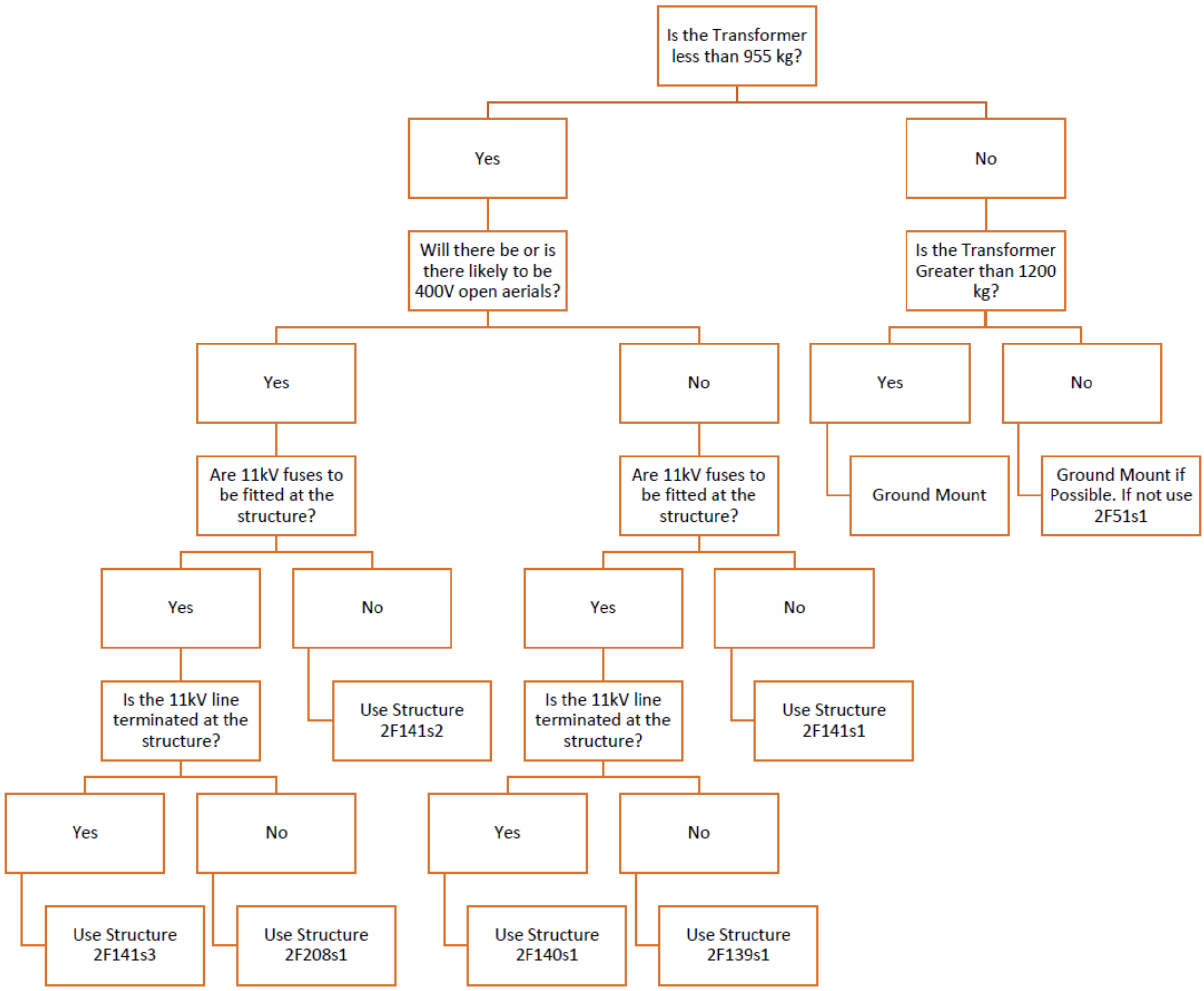

Figure 5: Standard Overhead Transformer Structure Selection

9.2 Regulators

Regulator positions are specified by the Network Planning Engineer to mitigate future voltage constraints on the network under normal and back-feed conditions.

Regulator sites shall have all weather access where vehicles are able to pull off a live lane to perform maintenance or switching.

Manual bypass switches are required to be installed at regulator sites with a set of suitably rated links supplying each regulator tank in order to isolate the regulator.

Regulators can be either installed as ground mounted units or pole mounted units depending on the surrounding environment as risks associated with the site.

There are two standard designs for new regulator sites on the Northpower network; three phase regulation using three regulators or three phase regulation using two regulators (Open Delta Connection).

Three phase regulation using three regulators are used when bidirectional regulation is required. Figure 6 below shows a standard three phase regulated system using three regulators.

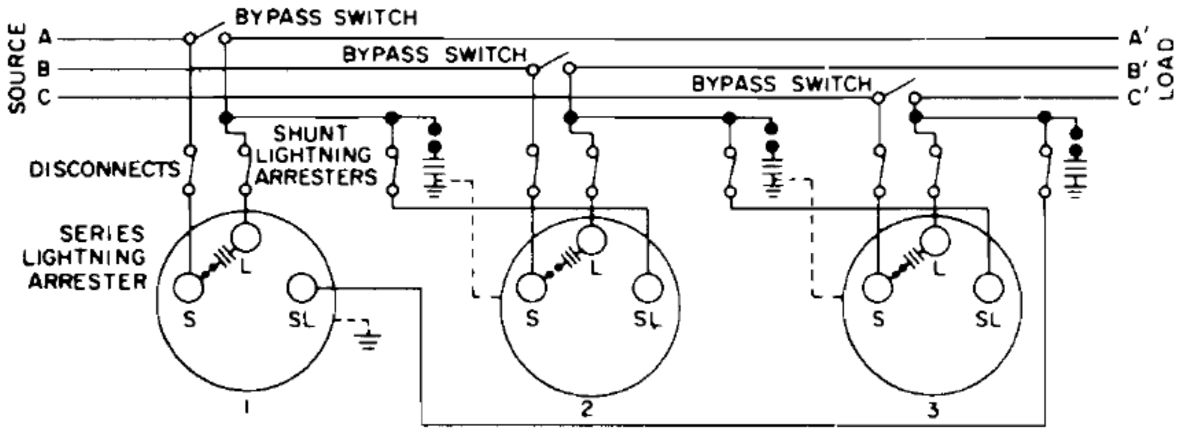

Figure 6: Regulating a Three Phase System with Three Regulators

Three phase regulation using two regulators in an open delta configuration is used when regulation only required in one direction, i.e. when a regulator supplies a spur. Figure 7 below shows a standard open delta connection of two regulators regulating three phases.

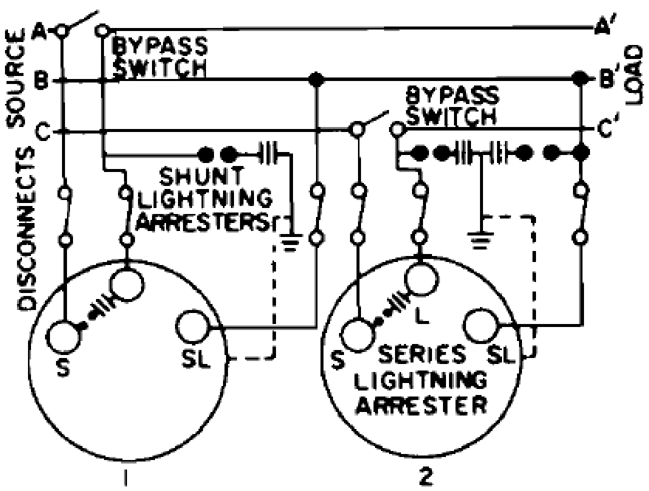

Figure 7: Regulating a Three Phase System with Two Regulators

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9.3 Reclosers

Approximate positioning of reclosers are specified by the Network Asset Planning Team. Refer to planning standards. Site selection should take in to consideration the following:

- All weather access to allow switching, inspection, testing and maintenance of the recloser.
- Far enough off the road as to not require traffic management to operate the recloser or associated components.
- The position does not risk the recloser and associated components being damaged, i.e. Vehicles, trees and high loads.

The recloser control box shall face a direction in which it does not put the operator at a higher risk of harm. The control box shall be mounted over three meters high to prevent any malicious damage to the asset or require special earthing requirements.

All reclosers shall be fitted with at least one set of appropriately rated links as a form of isolation due to reclosers having a micro gap across their contacts.

A bypass switch shall be fitted to a recloser supplying a spur or where a recloser is unable to be reliably back feed.

9.4 Sectionalisers

TBA

9.5 Load Break Switches

Northpower utilise both manually operated switches and remote controlled switches. *Refer to Electricity Distribution Planning Standard* for switch positioning. Site selection should take in to consideration the following:

- Remote controlled switches shall be located where it is practical to allow switching, inspection, testing and maintenance of the switch.
- Manually operated switches shall be located within walking distance from a safe vehicle parking position.
- Far enough off the road as to not require traffic management to operate the switch or associated components.
- The position does not risk the switch and associated components being damaged, i.e. Vehicles, trees and high loads.
- Switches near State Highways shall be far enough away from a live lane so that traffic management is not required to operate the switch.

Remote controlled switch control boxes shall face a direction in which it does not put the operator at a higher risk of harm. The control box shall be mounted over three meters high to prevent any malicious damage to the asset or require special earthing requirements.

Both manual and remote control switches shall be orientated such that the operator is in a safe position during switching.

Where there are low voltage lines are present, a load break switch shall be located at an LV open point between two transformers. If this is not possible, a suitability rated low voltage cut out fitted with solid links is needed to be fitted on the same pole as the switch. This is to ensure the LV can be energised at the same point as the 11kV.

9.6 Links

Northpower utilise three forms of links; Drop Out Fuse Links, Solid Links and Knife Links.

Links shall be located where they are easily accessible for operation and earthing.

Links controlling spurs shall be located one span away from the tap off or in a location that is easily accessible for switching to reduce shutdown areas.

9.6.1 Drop Out Fuse Links

Drop out fuse links are to be installed at all pole mounted transformers or single or group fused ground mount transformers unless protected by a RMU fuse or circuit breaker.

Transformer drop out fuse links shall be located on transformer structure due to ease of use for Field Service Providers. However, if practical, links can be located a maximum of three spans away.

Drop out fuse links are generally not installed on tap off points feeding spurs in order to prevent single phasing of three phase motors. However, they can be installed where there are common tree issues or bird strike issues but should be replaced with solid links when tree and bird strike issues are corrected.

9.6.2 Solid Links

Solid Links are to be installed on spur lines of over one kilometre of line to aid with fault finding and maintenance isolation. The solid links installed shall be suitably rated for load.

If the installed capacity is over 800kVA in a rural environment or 500kVA in the urban environment, solid links shall be replaced with a three-phase load break switch.

9.6.3 Knife Links

Knife links are to be installed as an isolation point where a quick disconnection from the network is required. Knife links are required where the load is greater than that of a solid linked drop out. A Knife link can only be used as an isolation point and should not be used as a switching point.

9.7 400V Cut Outs

400V cut outs are to be installed on all overhead transformer structures with the appropriate fuse installed. Refer to *Electricity Reticulation Design Standard.*

400V cut outs can be installed on overhead LV open points, normally open or closed LV cable risers if they are a common LV tie point or required for quick isolation for fault finding and on the same pole as an 11kV load break switch.. They shall be suitably rated for the load and used with suitably rated solid links.

They shall be mounted in such that the operator can easily and safely operate them from the ground with the use of a line stick.

10.0 Dissimilar Materials

Connection and configuration of conductor of dissimilar material needs specific design and installation techniques to avoid corrosions issues. Because of the Northland geography and climate corrosion to a significant issue for overhead lines, including assets and equipment attached to poles. Northpower's overhead network has both copper and aluminium conductors, which require specific requirements when connecting.

Dissimilar metal corrosion, also known as galvanic corrosion, is the process by which the materials in contact with each other either oxidises or corrodes. Three conditions must exist for dissimilar metal corrosion to occur:

1. Two electrochemically dissimilar metals are present
2. An electrically conductive path exists between two metals
3. A conductive path for the metal ions to move from the more anodic metal to the cathodic metal is present.

If any one of these three conditions do not exist, dissimilar metal corrosion will not occur.

Table 37, below, offers guidance into risk associated with connecting metals.

Table 37: Dissimilar Metals Corrosion Chart

	Zinc	Galvanised Steel	Aluminium	Cast Iron	Lead	Mild Steel	Tin	Copper	Stainless Steel
Zinc	None	Low	Medium	High	High	High	High	High	High
Galvanised Steel	Low	None	Medium	Medium	Medium	High	High	High	High
Aluminium	Medium	Medium	None	Medium	Medium	Medium	Medium	High	High
Cast Iron	High	Medium	Medium	None	Low	Low	Low	Medium	Medium
Lead	High	Medium	Medium	Low	None	Low	Low	Medium	Medium
Mild Steel	High	High	Medium	Low	Low	None	Low	Medium	Medium
Tin	High	High	Medium	Low	Low	Low	None	Medium	Medium
Copper	High	High	High	Medium	Medium	Medium	Medium	None	Low
Stainless Steel	High	High	High	Medium	Medium	Medium	Medium	Low	None

11.0 Electrical Requirements

Overhead lines need to be rated for the electrical designed load and fault current withstand included rapid reclosing. For the purpose of fault withstand the fault duration of 3 seconds should be allowed for unless the line is protected by fuses then 0.5 second fault duration can be used in determining the fault withstand current. In addition lines that are likely to be controlled by a recloser or feeder circuit breaker configured for reclosing then there may be up to 3 consecutive recloses in 60 seconds. The fault withstand current may be increased if the protection the protection has a “hi set” or in the case of the recloser a “Hi set” that blocks the reclose operation.

For further details on electrical protection and voltage drop guidelines refer to *Electricity Reticulation Design Standard*.

With an LV network capable of being connected to another LV network the neutral are generally connected through. While this helps to ensure as low as practical the MEN impedance it does create risks when carrying out de-energised work on the LV network as there is now an in-service conductor with the isolator work area.

11.1 Surge Protection

In regard to lightning protection the normal practice is to install the surge protection close to or on the equipment requiring surge protection e.g. HV cable, transformer, recloser etc. It would only in special cases that a line needs to be shielded from potential lightning strike. In this case the shield conductor would be specifically engineered.

Overhead surge protection is required to be used in the following areas:

- On the 11kV side of distribution transformers
- On both sides of reclosers
- On both sides of regulators

When using a refurbished transformer 50kVA and above, mount surge arrestors on transformer where practical. If it is not practical to mount surge arrestors on the transformer, it is not necessary to install an arrester at all.

Where a transformer is being replaced with a new transformer 50kVA and above mount the surge arrestors on the tank where practical. If it is not practical to mount surge arrestors on the transformer then mount the surge arrestors on the crossarm as per standard.

Refer to drawing 2F141s1 for a typical pole mounted transformer arrangement with surge arrestors mounted on the transformer.

If replacing a transformer during fault conditions, of capacity 50kVA and above and surge arresters are on arm, raise an opportunistic replacement corrective task to install surge arresters on tank if practical.

Figure 8, below, outlines the selection process for surge protection.

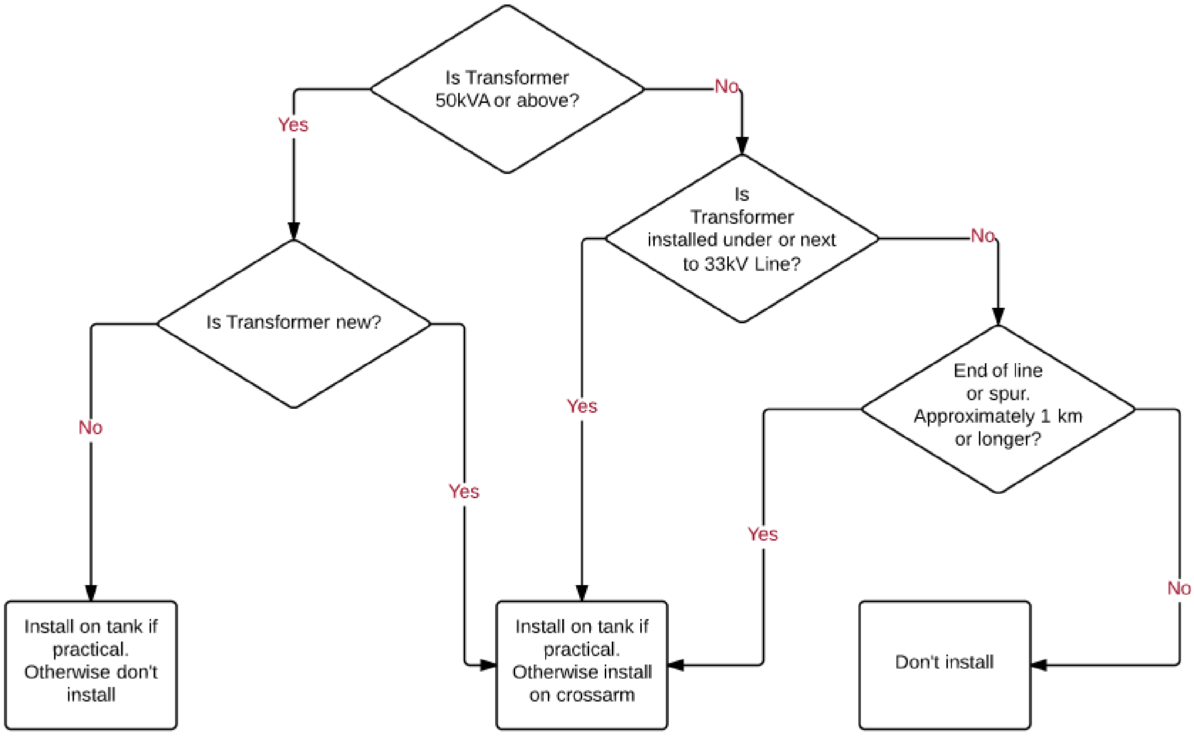

Figure 8: Surge Protection Selection

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12.0 Clearances and Excavations

12.1 General Requirements

Northpower follows NZECP 34 in regard clearances and excitations around structures. NZECP 34 covers:

- Conductor to ground clearances
- Clearances over railway lines
- Conductor to building and other structures clearance
- Clearances between conductors of different circuits
- Clearance to conductive telecommunication lines
- Clearances to stay wires
- Distance from boat ramps
- Excavation around poles

In regard to discrepancies between clearance in *NZECP 34* and *AS/NZS 7000*, *NZECP 34* shall take presentence.

Refer to *section 13.7 Clearances* of this document, for Northpower specific clearance requirements.

When designing and construction lines, the designed and installed clearance needs to consider the operating temperature of the conductor blow out from wind or fault current. In addition a margin above the minimum clearance needs to be allowed for as conductors may sag further over time due pole movement and conductor creep. In addition ground levels may change e.g. road works can raise the road height or from general landscaping activities.

12.2 ADSS Fibre

The Electricity (safety) Regulations recognises that ADSS fibre as a special case as this cable is specifically designed to be installed with electrical conductors at higher Voltage than Northpower operates. Northpower guidelines for ADSS fibre on electricity poles is:

- Not to be any lower than minimum height as defined in *NZECP 34.* The main reason is that the lower the cable the more risk of impact from a high load and because of the mechanical strength of the dielectric supporting core it has the capability to break the supporting poles
- When run with LV conductors to be at or as close as practical to the LV conductors (mainly for ascetic reasons)
- The cable may be attached to the pole or cross arm
- The cable may run with the HV conductor, but this will pose logistical issues for those installing the cable
- Pole calculations are required when running long spans of ADSS Fibre in the rural area to ensure that the addition of the fibre is not going to damage the existing poles

13.0 Northpower Specific Requirements

13.1 Maximum Section Lengths

In order to allow for easier fault finding, minimising effects of cascade failures and reducing the amount of sleeves in the line when new conductor is installed, a back-to-back termination shall be located approximately either every 1000m or every 10 spans, whichever is greatest. The back to back termination should be in a position, where possible, for vehicle access to allow live line breaks to be installed or temporary switches.

13.2 Phasing Identification

Labels, phase markers or phase indicating tubing shall be fitted to ensure that all phasing is clearly identifiable at the following points on overhead lines:

- Connection points outside of substations;
- All tap off points. Phasing Markers shall be installed on poles either side of the tap off.
- Underground cable risers
- Service connections
- Each side on an LV open point
- Pole Mounted transformers to indicate what phases are connected.

Phasing Labels, Markers and tubing shall all be suitably UV rated to ensure they remain identifiable.

13.3 Phasing

In order to keep the networks phases balanced, all single phase transformers and two phase 11kV tap offs shall be installed on alternating phases to balance the network. This shall be identified as per *section 13.2 Phasing Identification* of this document.

All LV and HV open points must be able to phase out.

13.4 Corrosion Zones

This section will include specific material requirements for different corrosion zones.

TBA

13.5 Back to Back Termination at Tap off Poles

Where there is tap off on the 11kV or LV network, the next pole shall be a back to back termination with the span run to the tap off pole installed at reduced tension. The pole and foundation shall be designed to handle the change in tensions. This is to reduce stresses on the tap off pole, allows for breaks to be cut or temporary switches to be installed and creates a terminal point for mean equivalent span calculation.

13.6 LV Fusing Points and Service Poles

Overhead service fusing shall be located at the pole closest to the customer boundary. This is to create a testing point to restrict the number of houses that need to be accessed to perform pre and post testing.

If a service pole is located in a customer's property and it can be moved, a new pole shall be installed on the boundary. This shall be done in conjunction with other works on site and fuses installed on this pole. These poles shall be designed to allow the customers main to be cut away without the need to support the pole i.e. blocked on edge for the road crossing.

13.7 Clearances

13.7.1 Conductor Clearances to Ground

Conductor clearances above ground shall exceed those stated in *NZECP34* by at least 300mm for spans up to 125m and 500mm for spans over 125m. An exemption to this is over roadways, as stated in *section 13.8 Road Crossing Spans for Over-height Loads* of this document.

13.7.2 Conductor Clearances between Attached Circuits

Northpower specifies greater clearances between attached circuits to that stated in *NZECP34* in order to make installation, maintenance and operation safer and easier. Clearances have allowed for a standard EPV to manoeuvre between circuits with enough clearance to allow live work.

Clearances between circuits of different voltages at attached points are shown in Table 38, below.

These clearances may be reduced to those specified in *NZECP34* with permission of Northpower Network's Distribution Engineer. They can be further reduced with a detailed engineering study of over voltages and conductor movement submitted to Northpower Network's Distribution Engineer with written approval.

Note: Some lines are designed to higher temperatures so therefore have larger clearances between circuits.

Table 38: Northpower Specific Requirements for Conductor Clearances between Attached Circuits

Lower Circuit \ Higher Circuit	Low Voltage	11kV	33kV	66kV (inc. 50kV)
Low Voltage	200mm	1500mm	1500mm 3150mm*	1500mm 5150mm*
11kV	Not Accepted	500mm	1650mm	2200mm 3650mm*
33kV	Not Accepted	Not Accepted	Preference for Armless Angle	2200mm
66kV	Not Accepted	Not Accepted	Not Accepted	Preference for Armless Angle

* Distances required when there is a possibility of additional circuits being added.

13.7.3 Conductor and Cable Support Heights

Bushing heights of transformers and cable risers shall comply with *Section 7.1* of *ECP34.*

Under new construction, transformers and cable risers shall be constructed as per Northpower Standard drawings and, where the differ, shall be signed off by the Northpower Network Distribution Engineer.

13.8 Road Crossing Spans for Over-height Loads

Northpower's preference is for all road crossings to be installed underground, however, if under grounding is not feasible, refer to Table 39.

In regards to road crossings, the following terms shall have these meanings:

- A "road" shall have the same meaning as a "transport corridor" as defined in the Utilities Access Act.
- A "road crossing span" means any wire or wires that cross over a road (i.e., a transport corridor) and shall include any of the following situations:
    - All 11 kV, 33 kV, 50kV and 66 kV connected to or forming part of Northpower's electricity distribution networks that cross over a road
    - All Low Voltage distribution systems connected to or forming part of Northpower's electricity distribution networks that cross over a road
    - All stay (guy) wires that cross over a road
    - All Northpower Network owned communication systems (including UFB) that cross over a road
    - All third party wires (including but not limited to) Fibre Optic Cables that are attached to a Northpower owned pole (e.g., UFB and Chorus) that cross over a road.
- The height that the span wires are above the road shall be measured from the lowest point on the sag of the span and the surface of the road carriageway.
- "Significantly altered" means the road crossing span is being upgraded - e.g., the span is being reconductored or replaced.

Table 39: Required Line Heights for New Road Crossings

Road Type	Required Height		
	230/400V	11kV ≤ 33kV	33kV ≤ 66kV
Motorway	Underground		
State Highway	Underground		7.5m
Other	Underground	7.0m	

Northpower Network's Distribution Engineer can allow lower clearances to be used on a case by case basis provided that the road crossing poles are not likely to move throughout their lifetime, the road is unlikely to be resurfaced, and after accounting for creep, the clearance never falls below minimum heights as per NZECP34.

The application of *section 13.8 Road Crossing Spans for Over-height Loads* rule is not retrospective for existing road crossing spans unless one of the following change of circumstance situations occurs, provided they meet the requirements in Table 40:

1. The road crossing span is being upgraded - e.g., the span is being reconductored or replaced.
2. One or both, of the existing road crossing span support poles are being replaced.

Table 40: Required Line Heights for Altered Existing Road Crossings

Road Type	Required Height	
	230/400V	11kV ≤ 33kV
Motorway	Underground	
State Highway	6.0m	7.0m
Other		

Note the stated clearances heights shall be applied when measured at the location during still air conditions and at 20 degrees Celsius.

14.0 Standard Construction Drawings

Table 41 to Table 46, below, outline Network approved standard construction drawings. Where a design does not fit these standard designs, the designer shall prepare a drawing in a Northpower standard format and approved by the Network Distribution Engineer or equivalent.

14.1 General Overhead Construction

Table 41: General Overhead Construction Drawings

Drawing	Description
TBA	Standard 33kV – 11kV – 400V Separation
TBA	Foundation - Standard
TBA	Foundation – Downline Load
TBA	Foundation – Crossline Load
TBA	Stay Wire – Stub Pole
TBA	Stay Wire – Screw Anchor and Deadman
TBA	Stay Wire – Double Stay Separated by 30 Degrees
TBA	Stay Wire – Cattle Protection
2F325s1	Installation for the Spiral Vibration Damper
2F390s7	2.0m Steel Cross Arm
2F389s3	Steel Delta Bracket

14.2 400V Construction

Table 42: General Overhead 400V Construction Drawings

Drawing	Description
TBA	Single Arm Pin
TBA	Double Arm Pin
TBA	Back to Back Termination
TBA	Double Arm Termination
TBA	Service Arm
TBA	Single Floating Arm
TBA	Double Floating Arm
TBA	Single Arm with 90 Degree Tap off
TBA	Double Arm Post with 90 Degree Tap off
TBA	Back to Back Termination with 90 Degree Tap off
TBA	Double Arm Termination with 90 Degree Tap off
TBA	Single Arm with Double Tap off
TBA	Double Arm Post with Double Tap off
TBA	Back to Back Termination with Double Tap off
TBA	Double Arm Termination with Double Tap off
TBA	Single Side Arm
TBA	Double Side Arm
2F359s1	Typical LV Riser Cable Arrangement using Cable Clamp Method
2F359s3	Typical LV Riser Cable Arrangement using Goose Neck Method
2F359s4	Typical LV Riser Cable Arrangement using Saddle Method
2F259s5	Open Wire Overhead Service
2F259s6	Single Neutral Screen Overhead Service
2F259s8	Multiple Neutral Screen Overhead Service

14.3 11kV Construction

Table 43: General Overhead 11kV Construction Drawings

Drawing	Description
2F380s1	Single Arm Post
2F380s2	Double Arm Post
2F380s3	Back to Back Termination
2F380s4	Double Arm Termination
2F380s5	Single Arm with 90 Degree Tap off

Drawing	Description
2F380s6	Double Arm Post with 90 Degree Tap off
2F380s7	Back to Back Termination with 90 Degree Tap off
2F380s8	Double Arm Termination with 90 Degree Tap off
2F380s9	Single Side Arm
2F380s10	Double Side Arm
2F380s11	Single Arm with Double Tap off
2F380s12	Double Arm Post with Double Tap off
2F380s13	Back to Back Termination with Double Tap off
2F380s14	Double Arm Termination with Double Tap off
2F380s15	Single Arm Delta Configuration
TBA	Double Arm Delta Configuration
TBA	Back to Back Termination Delta Configuration
TBA	Double Arm Termination Delta Configuration
TBA	Inline Cable Termination
TBA	End of Line Cable Termination
TBA	K Line Uplift
TBA	H Structure Single Arm Post
TBA	H Structure Double Arm Post
TBA	H Structure Back to Back Termination
TBA	H Structure Double Arm Termination

14.4 33kV Construction

Table 44: General Overhead 33kV Construction Drawings

Drawing	Description
TBA	Single Arm Post
TBA	Double Arm Post
TBA	Back to Back Termination
TBA	Double Arm Termination
TBA	H Structure Single Arm Post
TBA	H Structure Double Arm Post
TBA	H Structure Back to Back Termination
TBA	H Structure Double Arm Termination
TBA	Single Arm Delta Configuration
TBA	Double Arm Delta Configuration

Drawing	Description
TBA	Back to Back Termination Delta Configuration
TBA	Double Arm Termination Delta Configuration

14.5 Pole Mounted Equipment

14.5.1 Transformers

Table 45: General Overhead Pole Mounted Transformer Drawings

Drawing	Description
2F198s17	Pole Mount Transformer – ABC Bridal
TBA	Pole Mount Transformer - Inline with Drop Out Fuses and LV Arm
TBA	Pole Mount Transformer – Inline with Drop Out Fuses
TBA	Pole Mount Transformer – End of Line with LV Arm
TBA	Pole Mount Transformer – End of Line

14.5.2 Pole Mounted Switches

Table 46: General Overhead Pole Mounted Switch Drawings

Drawing	Description
2F256s1	ABB Sectos NXB – Mounting Options
2F256s2	Automated Sectos Switch with 1kVA 11kV Transformer
TBA	Joongwon Pole Mounted Switch Mounting Options
TBA	Joongwon Pole Mounted Switch Automated with 1kVA 11kV Transformer
2F256s8	Joongwon Pole Mounted Switch Automated with Isolating Transformer
2F247s4	CPS NOVA Recloser without By Pass Switch
2F247s5	CPS NOVA Recloser with By Pass Switch

15.0 Document Review History

Version Number	Date	Revision Notes (reason for change)
1.0	2/03/2021	New Document Release. Replaces documents: • ENS 03.02.050 Overhead Distribution - Poles • ENS 03.02.010 Overhead Line Design • ENS 03.02.060 Guidelines for Overhead Line Vibration Damping • ENS 03.02.025 Crossarms
2.0	31/05/2021	Amended sections: • 5.4.1 – Stay wire diameters and strengths following Northpower Contracting feedback • 13.9 – Road Crossings as per Northpower Contracting Feedback Added Section: • 13.7.3 – Transformer Bushing and Cable Riser Heights after a height was requested after Northpower Contracting Feedback 02/09/2021 – Document Controller removed any references to network document identifier short codes and unpublished documents.