Network Standard

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NW000-S0092 NS220 OVERHEAD DESIGN MANUAL

ISSUE

For issue to all Ausgrid and Accredited Service Providers' staff involved with the design of overhead lines, and is for reference by field, technical and engineering staff.

Ausgrid maintains a copy of this and other Network Standards together with updates and amendments on www.ausgrid.com.au.

Where this Standard is issued as a controlled document replacing an earlier edition, remove and destroy the superseded document.

DISCLAIMER

As Ausgrid's Standards are subject to ongoing review, the information contained in this document may be amended by Ausgrid at any time. It is possible that conflict may exist between Standard documents. In this event, the most recent Standard shall prevail.

This document has been developed using information available from field and other sources and is suitable for most situations encountered in Ausgrid. Particular conditions, projects or localities may require special or different practices. It is the responsibility of the local manager, supervisor, assured quality contractor, accredited service provider and the individuals involved to make sure that a safe system of work is employed and that statutory requirements are met.

Ausgrid disclaims any and all liability to any person or persons for any procedure, process or any other thing done or not done, as a result of this Standard.

All design work, and the associated supply of materials and equipment, must be undertaken in accordance with and consideration of relevant legislative and regulatory requirements, latest revision of Ausgrid's Network Standards and specifications and Australian Standards. Designs submitted shall be declared as fit for purpose. Where the designer wishes to include a variation to a Network Standard or an alternative material or equipment to that currently approved the designer must obtain authorisation from the Network Standard owner before incorporating the variation to a Network Standard or alternative material into a design.

All designers including external designers authorised as Accredited Service Providers will seek approval through the approved process as outlined in NS181 Approval of Materials and Equipment and Network Standard Variations. Seeking approval will ensure Network Standards are appropriately updated and that a consistent interpretation of the legislative framework is employed.

Notes: 1. Compliance with this Network Standard does not automatically satisfy the requirements of a Designer Safety Report. The designer must comply with the provisions of the Work Health and Safety Regulation 2017 (NSW - Part 6.2 Duties of designer of structure and person who commissions construction work) which requires the designer to provide a written safety report to the person who commissioned the design. This report must be provided to Ausgrid in all instances, including where the design was commissioned by or on behalf of a person who proposes to connect premises to Ausgrid's network, and will form part of the Designer Safety Report which must also be presented to Ausgrid. Further information is provided in Network Standard (NS) 212 Integrated Support Requirements for Ausgrid Network Assets.

2. Where the procedural requirements of this document conflict with contestable project procedures, the contestable project procedures shall take precedent for the whole project or part thereof which is classified as contestable. Any external contact with Ausgrid for contestable works projects is to be made via the Ausgrid officer responsible for facilitating the contestable project. The Contestable Ausgrid officer will liaise with Ausgrid internal departments and specialists as necessary to fulfil the requirements of this Standard. All other technical aspects of this document which are not procedural in nature shall apply to contestable works projects.

INTERPRETATION

In the event that any user of this Standard considers that any of its provisions is uncertain, ambiguous or otherwise in need of interpretation, the user should request Ausgrid to clarify the provision. Ausgrid's interpretation shall then apply as though it was included in the Standard, and is final and binding. No correspondence will be entered into with any person disputing the meaning of the provision published in the Standard or the accuracy of Ausgrid's interpretation.

KEYPOINTS

This Standard has a summary of content labelled "KEYPOINTS FOR THIS STANDARD". The inclusion or omission of items in this summary does not signify any specific importance or criticality to the items described. It is meant to simply provide the reader with a quick assessment of some of the major issues addressed by the Standard. To fully appreciate the content and the requirements of the standard it must be read in its entirety.

AMENDMENTS TO THIS STANDARD

Where there are changes to this Standard from the previously approved version, any previous shading is removed and the newly affected paragraphs are shaded with a grey background. Where the document changes exceed 25% of the document content, any grey background in the document is to be removed and the following words should be shown below the title block on the right hand side of the page in bold and italic, for example, Supersedes – document details (for example, "Supersedes Document Type (Category) Document No. Amendment No.").

KEY POINTS OF THIS STANDARD

Scope and Risks Addressed

This standard supports the overhead line design process. It assists line designers in the use and understanding of design standards and AS/NZS7000. It covers the following:

- ☐ Design of new and replacement of existing assets.
- ☐ Mechanical and electrical design criteria.
- ☐ Loading and rating information.
- ☐ Selection and use of appropriate software.

Where to for more information?

Section 1, 2

Design Summary and Design Process

These sections identify/summarise major design requirements that include:

- ☐ Ensuring mechanical load forces do not exceed the strength of structures
- ☐ Adequate clearances exist between elements of the network – conductors, ground, other structures, etc.
- ☐ Iterative nature of the design process.
- ☐ Design factors such as wind loading, line temperatures, structural strengths, clearances etc.
- ☐ Overview of the design process including step-by-step notes.
- ☐ Design documentation

Where to for more information?

Section 3, 4

Tools and Forms

Too many to list

Design Components

The design requirements of specific parts of a project design are outlined. These include:

- ☐ Conductors and cables
- ☐ Conductor stringing
- ☐ Poles
- ☐ Stays
- ☐ Pole-top constructions

Where to for more information?

Section 5 - 9

Tools and Forms

Too many to list

Reference Data

A large amount of reference material is provided to assist with design data and assessment of designs. This includes:

- ☐ Clearance data
- ☐ Crossings design information – for railways, waterways, roads, under crossings, etc
- ☐ Software package requirements

Where to for more information?

Section 10 - 11

Tools and Forms

Too many to list

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Contents

1.0 PURPOSE

This document has been produced to support designers of Ausgrid's overhead network, both internal staff and Accredited Service Providers (ASPs), as well as those checking and auditing design work. It is intended to interpret high level national standards such as AS/NZS7000 (and associated Handbook HB331) and other Ausgrid Network Standards, to enable design checking to be carried out quickly at a simple level.

2.0 SCOPE

This document should be interpreted in conjunction with the current versions of Ausgrid Network Standards including NS125, NS126, NS128, NS135 and the associated Standard Construction drawings, as well as other current Ausgrid Network Standards listed in Clause 13.0. Where differences exist, precedence shall be granted to the more specific Ausgrid Network Standard except where appropriate written authorisation is obtained to do otherwise. (Refer to NS109)

All overhead line designs must use an Overhead Line Design software package approved by Ausgrid which has the correct configuration and setting of parameters.

3.0 DESIGN SUMMARY

3.1 General design approach

The design process is iterative. The Designer initially assumes certain pole positions, pole lengths, pole top constructions and conductor stringing tensions. The design is then analysed and adjusted, sometimes several times over, until an optimum design arrangement is obtained. The final design shall be one that:

- best fits the project need with due regard for all-of-life hazards including construction, commissioning, operations, maintenance, decommissioning and demolition/removal into the future as required as an integral part of safety-in-design
- the whole-of-life costs must be assessed to determine the overall least cost option for implementation
- meets all applicable technical and regulatory standards (e.g. voltage drop, electrical current capacity, adequate clearances, not mechanically overloaded)
- uses approved materials (products that are already on the AML or that are approved in accordance with the NS181 process)
- complies with this and other network standards or has variations approved in accordance with the NS181 process
- meets all safety and environmental standards
- is resistant to impacts from vegetation, wildlife, salt and industrial pollution levels
- is practical to construct, maintain and operate
- has adequate reliability for the intended purpose
- minimising impacts on the environment (e.g. flora and fauna, aesthetics)

The Designer must be able to demonstrate they have considered the factors above when doing a design.

3.2 Design considerations and load cases

The two main technical aspects related to the structural design of overhead distribution lines are ensuring that:

- the mechanical load forces do not exceed the strength of the structures or other components;

- there are adequate clearances between the conductors and the ground or from other objects in the vicinity of the line, as well as between the various phase conductors and circuits themselves.

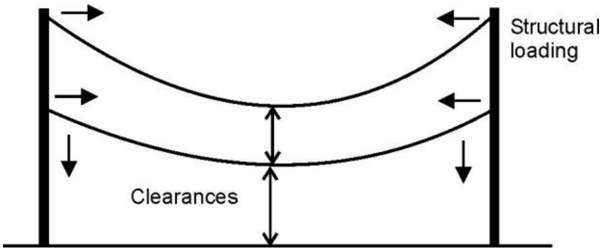


Figure 1 - Structural loading and clearances

The line must comply with these requirements over the full design range of weather and load conditions that could be reasonably encountered; that is, when the line is cold and conductor sag is at its minimum, when the line is at its maximum design temperature and conductor sag is at its maximum, and under maximum wind conditions. As a minimum, the load conditions to be considered for Ausgrid lines are Ultimate Strength Limit – Maximum Wind Load, Serviceability Limit (Sustained Load), Failure Containment (unbalanced support loading) and Maintenance / Construction Loading. The load criteria are set out in the following sections.

3.3 Limit states

For structural integrity to be maintained, the structural strength must always exceed the applied mechanical load, otherwise the line passes beyond the limit of its *intact* state to a *damaged* state or *failed* state. Beyond these limits, the line no longer satisfies the design performance requirements.

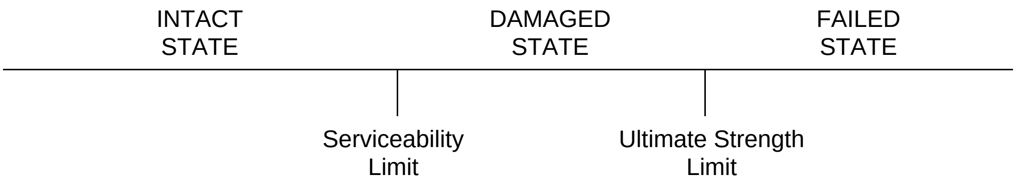


Figure 2 - Mechanical State Scale

This may be expressed by the following general limit state equation:

φR_n > effect of loads $(\gamma_x W_n + \Sigma \gamma_x X)$ (i.e. strength > applied loading)

where:

φ = the strength factor, which takes into account variability of the material, workmanship etc (Refer Table 7);
R_n = the nominal strength of the component;
γ_x = the load factor, taking into account the variability of the load, importance of structure, dynamics etc;
W_n = wind load;
X = the applied loads pertinent to each loading condition.

3.3.1 Ultimate Strength Limit – Maximum Wind Load Condition

The Ultimate Strength Limit equation used within Ausgrid, which pertains to loading under short-term wind gusts, with the appropriate load factors applied from Clause 3.5, is expressed as follows:

$\varphi R_n > W_{n\,(ultimate)} + 1.1\ G_s + 1.25\ G_c + 1.25\ F_t$

where:

W_n = effect of transverse wind load on structure
G_s = vertical downloads due to the self-weight of the structure and fittings
G_c = vertical downloads due to conductors
F_t = conductor loads (under maximum wind conditions)

Note that the limit state equation is not a simple arithmetic equation. The loads include various vector components - vertical, horizontal longitudinal and horizontal transverse. However, for simple distribution lines, downloads are often relatively minor and are not a significant contribution to an overturning moment on the pole, so are often ignored. Note that the structure components have different strengths in different directions and under different actions, for example, compression, tension, shear or torsion.

3.3.2 Serviceability Limit – Sustained Load

Ausgrid also requires checking of the Serviceability Limit, which addresses the effect of sustained loading, primarily due to conductor everyday tension, with a typical wind load. This is appropriate for timber components, which may deflect or deform under a sustained load.

This limit state is described by the following equation:

$$\varphi R_n > W_{n\ (sustained)} + 1.1\ G_s + 1.1\ G_c + 1.0\ F_t$$

where:

F_t = conductor loads (under everyday conditions)

This limit state approach to overhead design has been used widely in Australia since 1999. It is a rationalisation of the earlier working stress method, which applied a general factor of safety, but uses higher, more realistic wind loads (aligned with AS1170 wind code), and material strength factors more closely aligned with reliability of performance. It takes a reliability-based (acceptable risk of failure) approach.

3.3.3 Failure Containment

Ausgrid also requires checking for the Failure Containment, or broken wire condition which is where an unbalanced load occurs on the structure due to a broken conductor situation. This limit state is described by the following equation:

$$\varphi Rn > Wn_{\ (failure\ containment)} + 1.1\ G_s + 1.25\ G_c + 1.1\ F_t + 1.25\ F_b$$

where:

F_b = Unbalanced tension resulting from the broken conductor condition

For the failure containment condition, supports shall be designed for the equivalent longitudinal loads resulting from conductors on the structure being broken in accordance with the following rationale:

- Suspension or intermediate supports;

  For a single circuit support, the number of conductors to be considered is one phase (with allowance for bundles) or the earth wire, whatever configuration has the worst effect on the structure. For a double circuit support, the number of conductors to be considered is the worst loading combination of either any two phases in the same span on opposite sides of the structure, or any phase and the earth wire.

- Tension Supports;

  Tension supports shall be designed to withstand equivalent longitudinal load displacement of one earth wire together with one phase per circuit, the combination of which has to be the worst case loading effect on the structure.

- Distribution System

  In distribution systems using pin or post insulators with wire ties or equivalent fixing and relatively flexible structures and foundations, it is not necessary to design supports for the Residual Static Load (RSL). For tension and terminal distribution pole supports consideration shall be given for the RSL.

- Stayed Structures

  Stayed structures have the additional requirement that the pole and foundation shall be capable of withstanding the Failure Containment Load with the stay wire removed (note: the

Failure Containment Load shall be applied with all phase conductors assumed to be intact instead of one third broken). This policy ensures that the pole will not collapse in the event of stay component failure in moderate weather conditions (note" structures with multiple stay arrangements shall have only one stay component removed for the above load check condition).

Where a critical crossing has been identified, failure containment is required in the form of cascading fail prevention of conductors through the use of termination structures or collapsible/bendable gain bases or alternatives.

A critical crossing is to be identified through risk assessment on a case by case basis, examples include but are not limited to crossings of major roads and highways.

3.3.4 Maintenance and Construction Loading

Ausgrid also requires checking for loadings that may be experienced during the construction or maintenance of overhead lines. This limit state is described by the following equation:

$$\varphi R_n > W_{n\,(maintenance/construction)} + 1.1\,G_s + 1.5\,G_c + 1.5F_t + 2.0Q$$

where:

F_t = Load on the pole due to intact conductor tension loads for the maintenance conditions.

This condition provides the maximum conductor tension which can be reasonably expected during construction or maintenance activities. This tension is calculated based on transverse wind pressure of 100 Pa. Consideration shall also be given for tension increase under minimum temperature conditions.

Q = Construction/maintenance loads

The supports shall be able to withstand all construction and maintenance loads, Q, which are likely to be imposed on them with an appropriate load factor, taking into account safe working procedures, conductor stringing methodology, construction staging and the need for temporary slinging or staying, lifting arrangements, etc. Overstressing of the support shall be prevented by specification of allowable procedures and/or load capacities. The Designer needs to consider all potential aspects that may arise from maintenance practices affecting G_c.

Through consultation, it is the responsibility the Designer and the constructor to communicate, understand and allow for any alternative loads present during the construction of the power line. Any alteration or temporary rearrangement of loading on the pole or its components must satisfy the construction/maintenance load case criteria.

Clauses 3.5, 3.6 and 3.7 present design wind loads, load factors, design temperatures and strength factors to be used for various situations and load cases.

3.4 Design security levels

AS/NZS 7000 Security Levels shall be applied to the design of new Ausgrid overhead mains. A summary of the Security Levels combined with the respective line and Ausgrid's design lives to give the minimum design wind return periods is shown in Table 1. Joint-use / underbuilt lines should be designed according to the line with the highest required Security Level.

Table 1 - Ausgrid Overhead Mains Design Security Levels

AS/NZS 7000 Security Level	Line / load type	Design working life	Maximum design wind return period
I	• LV pole lines • HV pole lines	50 years	50 years
II	• 33kV pole lines • 66kV pole lines	50 years	100 years
III	• 132kV pole lines	50 years	200 years
	• Steel tower transmission and sub-transmission lines	100 years	400 years

3.4.1 Exemptions

All requests regarding variations from the application of Security Levels are to be managed via the NS181 Network Standard Variations process.

3.5 Load case conditions

The following tables provide the wind pressure, ambient temperature and load factors to be used in designing overhead lines.

Table 2 - Load Case Conditions

Load Case	Application	Conditions		Load Factors				
		Design Wind Pressure	Temp.	Non-Conductor Dead Load (G_s)	Conductor Dead Load (G_c)	Conductor Tension (F_t)	Live Load (Q) (see note 4)	Broken Conductor Out of Balance Load (F_b)
Maximum Wind (Ultimate Strength)	Structural capacity checks against ultimate. Structure and foundation	Refer to Note 1	15°C	1.1	1.25	1.25	-	-
Serviceability (Sustained) Loads	Structural capacity checks against sustained. Concrete Pole Cracking Checks, Advanced Foundation Checks	144 Pa	5°C	1.1	1.1	1.0	-	-
Maintenance/ Construction (see note 3)	Structure capacity checks against ultimate	100 Pa	15°C	1.1	1.5	1.5	2.0	-
Failure Containment (Broken Wire see note 2)	Structure failure containment checks against ultimate	0.25 Max Wind	15°C	1.1	1.25	1.25	-	1.25

Notes:

1. Design wind pressure will depend on terrain category, line security level and microburst considerations, see Table 3.
2. Failure containment case shall allow for phase and OHEW conductors to be broken in accordance with Clause 3.3.3, causing a worst case out-of-balance load on both termination and intermediate structures. Additionally, for stayed structures, a failure containment load case is required for all conductors attached and the stay wire removed.

   In distribution systems using pin or post insulators with wire ties or equivalent fixing, and relatively flexible structures and foundations, it is not necessary to design supports for the RSL. For tension and terminal distribution pole supports consideration shall be given for the RSL
3. Designers are to add notes to their design drawings indicating, where required, the need for temporary construction stays. Consideration for conductor stringing and construction staging is required when developing supports for this load case.
4. 'Q' refers to dynamic loads due to personnel and equipment that may be applied to the pole or pole top hardware during construction/maintenance, see AS/NZS7000.
5. For other load cases, e.g. snow and ice, seismic, torsional loading, and maximum wind uplift, see AS/NZS7000.

Table 3 - Maximum Wind Pressures for Design

Line Security	Apply to Type Description	Design Wind Pressure (see Note 1)
Level I	Conductor Design Pressure	1090 Pa
	Timber & Concrete Pole Design Pressure	1110 Pa
	Steel Pole Design Pressure	1200 Pa
Level II	Conductor Design Pressure	1180 Pa
	Timber & Concrete Pole Design Pressure	1220 Pa
	Steel Pole Design Pressure	1320 Pa
Level III	Conductor Design Pressure	1260 Pa
	Timber & Concrete Pole Design Pressure	1320 Pa
	Steel Pole Design Pressure	1430 Pa

Notes:

1. Terrain categories 1 and 4 (as per AS/NZS 1170) are not generally applicable to Ausgrid's network. If there is a relevant situation, a specific wind pressure calculation shall be undertaken.
2. Given that the Rural, Urban and High-density design pressures are practically the same when downdraft effects are included as per AS/NZS 7000, the nominated design pressures are given in Table 3.
3. Line Security Level I, II & III Design Life and Return Period as per Table 1.
4. This document does not cover the wind pressure values for steel tower sub-transmission lines (100 year design life, 400 year return period). The Designer shall use PLS-CADD and the automated wind load calculations built into the PLS-CADD software.
5. These wind pressures are calculated with the input parameters from Table 4. Wind pressures shall be recalculated if the assumptions in Table 4 do not apply.

Table 4 - Wind pressure input parameters

Assumption Criteria		Line Security I Rural	Line Security I Urban	Line Security II Rural	Line Security II Urban	Line Security III Rural	Line Security III Urban
Span Length (m)	Wind	125	50	125	50	125	100
	Tension	1000	500	1000	500	1000	500
Wind Region		A2	A2	A2	A2	A2	A2
Design Life (Years)		50	50	50	50	50	50
Regional Wind Speed (m/s)		39.27	39.27	41.13	41.13	42.86	42.86
Terrain Category		2	3	2	3	2	3
Structure Effective Height (m)		10	10	15	15	20	20
Terrain Height Multiplier	Synoptic	1	0.83	1.05	0.89	1.08	0.94
	Downdraft	1	1	1	1	1	1
Wind Direction Multiplier		1	1	1	1	1	1
Topographical Multiplier		1	1	1	1	1	1
Shielding Multiplier		1	1	1	1	1	1
Aerodynamic Shape Factor for Conductors		1.18	1.18	1.16	1.17	1.14	1.15
Dynamic Shape Factor for wood and concrete poles		1.2	1.2	1.2	1.2	1.2	1.2
Aerodynamic Shape Factor for steel poles		1.3	1.3	1.3	1.3	1.3	1.3

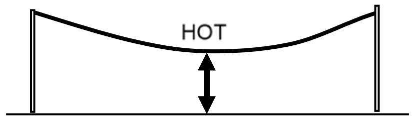
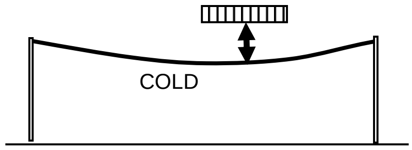
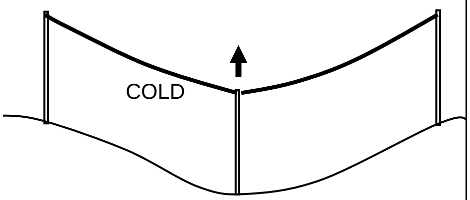
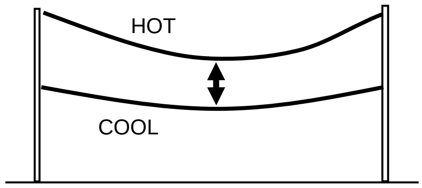
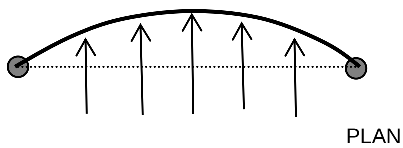
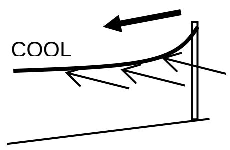
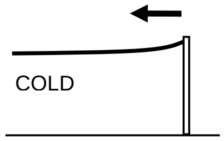
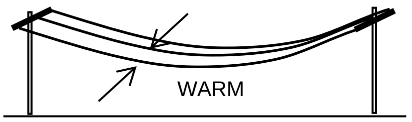
Notes:

1. Wind pressures shall be recalculated if the assumptions in Table 4 do not apply.
2. The design wind pressures are based on assumptions that are critical to the accuracy of the design pressure for any given location. In general, the topographic factor is the only one that tends to increase the design wind pressures significantly. Hence, where there may be significant topographical effects on the wind pressure like the pole being on the top or sides of steep slopes, gorges or significant hills, a check for the appropriate topographic factor from AS/NZS 1170.2 shall be completed and applied to the design pressures. In general, it is expected that the design wind loads stated will be suitably conservative for most designs.

3.6 Line temperature cases

The following table provides the line temperature cases to be set when designing and checking circuit operation.

Table 5 - Line temperature cases

Situation	Line Temperature	When used	
Min. Design Temp. (Hot)	Refer to Table 6	Checking clearance from ground or objects below the line.	
Min. Temp. (Cold)	5°C	Checking clearance from objects above the line	
Uplift	5°C No wind 15 °C Max. wind	Checking for uplift forces, especially on intermediate structures under no wind condition. Uplift shall also be checked under max wind conditions.	
Subcircuit	15°C	Checking intercircuit clearance - Higher conductor at maximum design temperature. Lower conductor at 15 degrees.	
Blowout	40°C	Checking horizontal line displacement (sideways ‘sag’) under 500Pa wind force	
Max. Wind Condition	15°C	Calculating mechanical forces under maximum wind	
Sustained Load Condition	5°C	Calculating sustained mechanical forces and reference temperature for conductor stringing	
Midspan Conductor Clearances	50°C	Checking interphase conductor spacing to avoid clashing	

The following table provides the maximum design operating temperatures for different conductor types and voltages.

Table 6 - Maximum design temperatures for all voltages

Voltage	Conductor	Max Temperature
132kV	ACSR	120°C
132kV	AAC or AAAC	100°C
66kV	ACSR	120°C, if new (see Note 1)
66kV	AAC or AAAC	100°C, if new (see Note 1)
33kV	ACSR	120°C, if new (see Note 1)
33kV	AAC or AAAC	100°C, if new (see Note 1)
11kV	AAC, AAAC or ACSR	75°C
11kV	CCT	80°C
LV	AAC, AAAC or ACSR	75°C (see Note 2)
LV	ABC	80°C
-	OPGW & OHEW	30°C (Design)
-	ADSS	40°C (Design)

Notes:

1. Some existing sub-transmission feeders are rated to 85°C. For existing sub-transmission mains, submit a request for rating to Ratings@ausgrid.com.au. It may be preferred to maintain the existing rating to avoid bulk replacement of structures.
2. In some municipalities the rating of existing bare mains has been 50°C. Submit a request for rating to Ratings@ausgrid.com.au.

3.7 Strength factors for various components

The following table provides strength reduction factors to be applied when designing overhead lines.

Table 7 - Component strength factors

Part of Overhead Line	Component	Limit State	Strength Reduction Factor Φ
Timber pole structures	Pole	Strength	0.60
Timber pole structures	Pole	Serviceability	0.34
Timber crossarm not preserved by full length treatment	Crossarm	Strength	0.85
Timber crossarm not preserved by full length treatment	Crossarm	Serviceability	0.48
Fibre-cement pole structures	Pole	Strength	0.9
Fibre-cement pole structures	Pole	Serviceability	0.9
Fibreglass Composite Structures (design based primarily on testing)	Pole or crossarm	Strength	0.75 (see Note 1)
Fibreglass Composite Structures (design based primarily on testing)	Pole or crossarm	Serviceability	0.3 (see Note 1)
Concrete structures	Pole	Strength	0.9
Concrete structures	Pole	Serviceability	0.3 (see Note 2)
Steel structures	Pole or crossarm	Strength	0.9
Stays	Cable members	Strength	0.80
Stays	Anchors	Strength	0.40
Conductors		Strength	0.70
Conductors		Serviceability	0.50
Fittings and pins - forged or fabricated		Strength	0.80
Fittings – cast		Strength	0.70
Fasteners	Bolts, nuts, washers	Strength	0.90
Porcelain or glass insulators		Strength	0.80
Synthetic composite suspension or strain insulators		Strength	0.70
Synthetic composite suspension or strain insulators		Serviceability	0.40
Synthetic composite line post insulators		Strength	0.9 (max. design cantilever load)
Synthetic composite line post insulators		Serviceability	0.4
Foundations relying on strength of soil - conventional soil testing (see Note 3)		Strength	0.9 (see Note 6)
Foundations relying on strength of soil - empirical assessment of soil (see Note 4)		Strength	0.8 (see Note 6)
Foundations designed to yield before structure failure (see Note 5)		Strength	1.0 (see Note 6)

Notes:

1. Alternative ϕ-factors may be nominated by component manufacturers based on testing or construction methods as defined in the EUROCOMP Design Code. Ausgrid must approve this alternative ϕ-factor, otherwise the values in Table 7 shall apply.
2. Reinforced and prestressed concrete poles must exhibit a no-crack criteria for serviceability/sustained loads in line with the manufacturer's load/deflection pole performance

3. See AS/NZS7000 Clause 9.1. Testing methods may be Cone Penetration Test (CPT), trial pits or other standardised tests.
4. Soil information from Ausgrid's GIS would be considered suitable to meet criteria.
5. For designs up to and including 11kV, only intermediate structure footings may be designed to this criterion. The ϕ-factor of 1.0 must not be used for deviation angle structures (greater than 10°) or termination structures as pole footing yield would be considered unacceptable at these locations.
6. The Strength Reduction Factor (ϕ) is equivalent to the Geotechnical Reduction Factor.

4.0 DESIGN PROCESS

4.1 Design brief

In most cases a Design Brief will be prepared by Ausgrid for each new section of line construction. For Ausgrid initiated projects, the Design Brief may include the following information:

- project scope and description
- proposed route or end points
- required completion date, if applicable to satisfy system loading requirements
- operating voltage
- fault levels
- design life of the transmission line
- line capacity (or in some cases, conductor size and material type for phase conductors)
- the maximum design operating temperature of the conductors
- the maximum design temperature under wind loading conditions
- the minimum design operating temperature of the conductors
- permissible pole material, (e.g. concrete, wood, steel, composite)
- permissible construction type, (e.g. H-pole, standoff insulators)
- allowance for additional circuits, if applicable
- conductor size and material type for overhead earth wire, where required
- whether the overhead earth wire is not required for the full length of line
- whether an OPGW (optical ground wire) is required
- required earthing of structures including maximum pole earth resistance and allowable earthing construction (for contestable projects the Client is generally responsible for the earthing study)
- secondary system protection requirements, where relevant to the scope of works
- list of reference drawings or reference materials not specified in this standard
- any project specific design or construction constraints
- who shall be responsible for obtaining all necessary licences or consents (for contestable projects the Client is generally responsible)
- who shall be responsible for negotiating any easements and rights-of-way, and who shall negotiate access to work sites and onto private property, where relevant (for contestable projects the Client is generally responsible)
- the extent to which the Client shall manage the environmental assessment process and requirements for any additional environmental safety and risk management plans
- any special conditions or arrangements already made for easements, right(s)-of-way and access to private land
- any special conditions or arrangements already made with the local council or roads authority for lines on public roads
- any special conditions or arrangements already made with other authorities.

4.2 Flowchart of generalised overhead design process

Typical steps in an overhead distribution line design are shown below. Note that the precise steps and their sequence will depend upon the project and the context in which the design is performed.

The process is iterative, with the Designer making some initial assumptions, for example, as to pole height and size, which may later need to be adjusted as the design is checked and gradually refined. The optimum arrangement that meets all constraints is required as the final outcome.

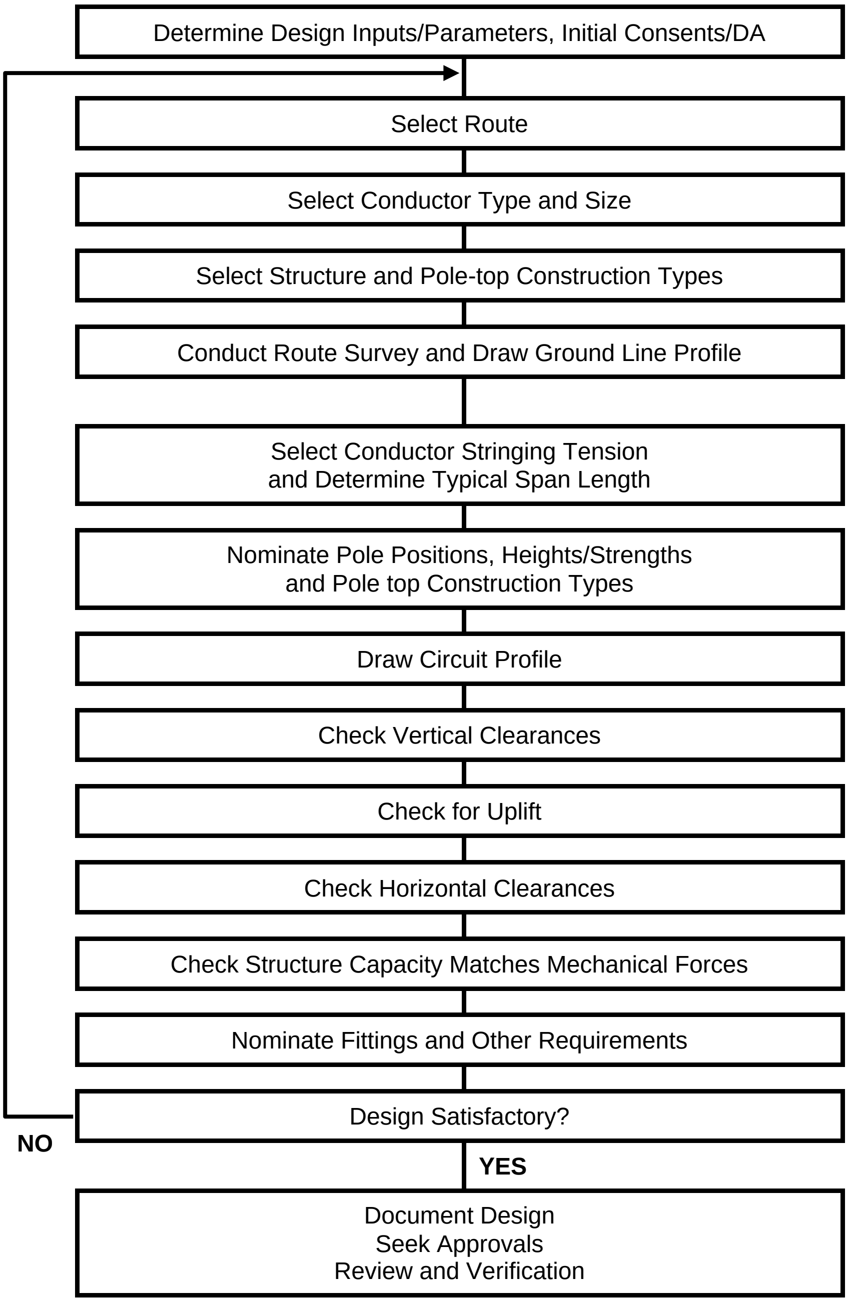


Figure 3 **- Overhead design process flowchart**

4.3 Step by step guide

Typical steps in an overhead line design are shown below. Note that the precise steps and their sequence will depend upon the project and the context in which the design is performed.

4.3.1 Determine design inputs/parameters

Prior to commencing design, it is important to collect and document all relevant design inputs. This may include:

- a planning report, concept, specification or customer request for supply initiating the project
- load details
- any special requirements of customers or stakeholders
- planning requirements from other authorities
- possible future stages or adjacent developments, road widening or resumptions
- relevant applicable standards or statutory authority requirements
- coordination with other utilities — 'designated underground asset information provider' results
- coordination with road lighting design
- survey plans or base maps
- environmental assessments, ecosystem maps
- site or regional constraints.

The design shall be 'traceable' back to a set of design inputs. Persons other than the original Designer shall be able to review the design and see why it was done a certain way.

4.3.2 Select route

The line route should be as short and straight as possible to minimise costs, minimise stays and have a tidy appearance. However, numerous other factors need to be considered, such as:

- property issues, ease of acquisition of Ausgrid property rights over private lands
- ease of obtaining approvals from statutory authorities
- safety
- community acceptance
- minimising impacts on flora and fauna, heritage, aesthetics, protected areas and waterways/wetlands.
- minimising EMF exposure where it can be done at low cost and without undue inconvenience
- access for construction, maintenance and operations
- ease of servicing
- compatibility with future development
- suitable ground for excavation and pole foundations
- minimising termination constructions.

4.3.3 Select conductor size and type

Preferred conductor types are presented in Clause 5.1, with a guide to conductor selection in Clause 5.2.

4.3.4 Select overall structure and pole top construction types

Standard pole sizes are presented in Clause 7.4. Designers shall make allowance for any future circuits likely to be required when sizing poles, as well as any streetlighting brackets to be attached.

Ausgrid's standard construction arrangements for overhead mains are shown in the drawings listed in network standards NS125, NS126 and NS135 for LV, HV and sub-transmission lines respectively. Drawings can be found on the Ausgrid website under the relevant network standard.

Clause 9.1 provides guidance on the performance of various types of pole-top construction, e.g. horizontal vs vertical.

Clause 9.4 presents requirements for siting pole-mounted plant.

4.3.5 Conduct route survey and create profile

A line survey shall be carried out prior to any design work commencing. The survey shall be conducted by a suitably qualified person with experience in power line surveying.

Prior to finalisation of the survey, a search shall be conducted for all services along the proposed route which are in the vicinity of proposed pole locations.

The survey is to record all items essential to the proper design and construction of the line.

Examples are:

- A centre line ground profile of the proposed route of the line
- The position and height of all existing overhead poles and conductors from which safety clearances must be maintained
- The position and height of all structures and ground contours which may come within safety clearances of the new lines when allowing for conductor sag and blow out
- The position and height of all significant trees which need to be accommodated in the line design because of environmental issues
- Location and description of all major below ground installations including other utility mains and services, pits, stormwater drains, etc. which are near proposed pole locations.
- Property boundaries for properties traversed by, or near the site of the proposed route
- For over-crossing and undercrossing design, maximum and minimum sag is to be obtained from the other line owner. Where this is not available, or where it is necessary to check for changed field conditions; the ambient temperature and approximate wind speed, time and date of survey of existing lines shall be recorded to allow loading to be determined and appropriate sag increases extrapolated. The feeder numbers and relevant structure/pole numbers defining the span are to be recorded.

4.3.6 Select conductor stringing tension and determine typical span length

Clause 6.0 discusses guidelines for the selection of a suitable stringing tension which matches the requirements along the route.

In urban areas, the positioning of poles on alternate lot boundaries along the roadway tends to keep spans relatively short and eliminates line encroachments. Insulated/covered cables have lesser spanning capability than bare conductors.

The spacing between ridges in undulating terrain can also be a factor in determining suitable span lengths.

4.3.7 Nominate pole positions

Clause 7.6 provides guidance on preferred locations as well as locations to be avoided.

Firstly, position poles along the route at any key or constrained locations, e.g. end points, bend points, positions required for supporting street lighting or on alternate property boundaries in urban areas to facilitate service mains to each lot without encroaching on property boundaries.

Next determine the maximum span length that can be achieved over flat ground given the attachment heights on poles, the sag at the nominated stringing tension and the required ground clearance. Position poles along the route so that this spacing is not exceeded. If there are gullies between poles, the spacing can be increased; if there are ‘humps’ mid-span, reduce span lengths.

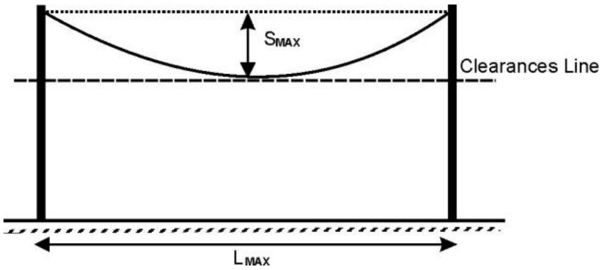


Figure 4 - Maximum length vs sag

4.3.8 Nominate termination points, pole details and poletop constructions

The Designer must determine the location of through-termination structures for the line. They shall be used:

- to keep very short spans or very long spans mechanically separate, such that all spans in a termination section are of similar length (no span less than half or more than double the ruling span length, and on tight-strung lines, the longest span not more than double the shortest span). Failure to limit span variance can cause excess sagging in longest span at higher design temperature loadings.
- to physically isolate critical spans, for example, spans over a river, major highway, railway line, or transmission undercrossing, to help facilitate repairs or maintenance.
- on line deviation angles too great for intermediate constructions, e.g. crossarms with pin insulators.
- at locations where there are uplift forces on poles.
- at intervals of approximately 10 spans or so. It is helpful if this length corresponds with the output of a conductor stringing work crew for a day. Termination constructions can also limit the length of line affected in the event of wires brought down in a storm. Also, the length of conductor on a drum may be a consideration.

Keep the span lengths within the termination section reasonably similar, if possible. Also, keep the type of pole and pole top construction used reasonably consistent, as this gives the line a tidy appearance.

The Designer will need to nominate pole strengths and foundation types/sinking depths as a first pass, knowing that these may need to be amended later once tip loads are checked. Higher strength poles will be used at terminations and on large deviation angles. Pole sinking depths can be determined in accordance with Clause 7.5.

The Designer will need to nominate suitable poletop constructions for intermediate poles with adequate capacity for the deviation angle at each site.

4.3.9 Draw circuit profile and check vertical clearances

The line profile is typically generated with software. The purpose is to verify that vertical clearances are adequate. Ground clearance can be checked by ensuring that the ‘hot’ curve does not fall below the clearance line offset from the ground line.

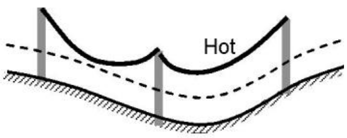


Figure 5 - Sag profile

If there is insufficient ground clearance, the Designer may need to:

- reduce span length
- increase stringing tension
- increase pole height
- adjust pole positions to try to fit in better with the terrain

Where there are long spans with a supercircuit and a subcircuit, intercircuit clearance shall be checked; refer to Clause 10.3.5. The supercircuit will be sagged at the 'hot' maximum design temperature and the subcircuit sagged at the 'cool' temperature, 15°C; refer to Figure 6.

If there is insufficient intercircuit clearance, the Designer may need to:

- reduce span length
- increase stringing tension on the supercircuit
- reduce stringing tension on the subcircuit, provided there is adequate ground clearance
- increase the spacing between the supercircuit and subcircuit at the supporting poles

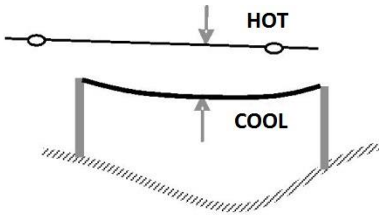


Figure 6 - Super circuit and subcircuit

For checking clearances from an object above the line, the line temperature shall be 5°C.

4.3.10 Check uplift condition

Poles at the bottom of a hill or in a gully are prone to uplift. Under cold conditions, the conductors heading up the slope will become tight and pull upward on structures, causing damage; refer to Figure 7. The 5°C curve is used for this check.

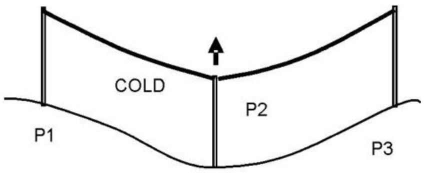


Figure 7 - Uplift at Pole P2

Uplift is generally not a problem if it is on one side of the structure only and offset on the opposite side by a downward force, as may occur with a line with successive spans running down a steep slope. However, if uplift occurs on both sides of an intermediate structure, such as a suspension or pin construction, it can be addressed by:

- changing the poletop construction to a through-termination or uplift-type construction
- moving the pole to a different location
- reducing stringing tension
- increasing pole height
- reducing heights of adjacent poles, subject to adequate ground clearance being available

Uplift is calculated / displayed in different ways in each line design software package. It is important to verify how to conduct this important check in the software package being used.

4.3.11 Check horizontal clearances

The Designer shall check that there are adequate horizontal clearances between the line and any nearby structures (for example, flag poles, buildings, bridge columns, streetlight columns) or embankments. (Refer Clause 10.1 Dimension 'F or G' for allowable clearances.) These clearances shall be checked for both – (a) the no wind condition and (b) the blowout conditions.

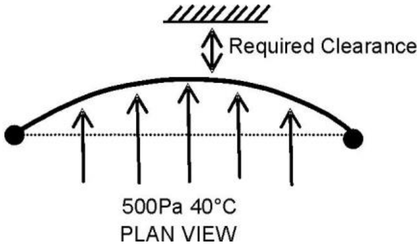


Figure 8 - Conductor under blowout conditions

Ways of addressing horizontal clearance problems include:

- increasing conductor stringing tension
- reducing span length
- relocating poles to a different alignment
- using different poletop constructions, e.g. vertical construction
- using insulated cables rather than bare conductors
- relocating objects affected, where feasible, e.g. streetlights
- increasing line height to skip over the object, where feasible

4.3.12 Check structure capacity matches applied mechanical forces

Tip load and component calculations shall be undertaken for each of the poles in the line. Conductors attached significantly below the tip have their applied force scaled down proportionately. Forces are added as vectors, not scalar quantities unless in the same direction.

The applied tip load is then compared with the capacity of the pole, as detailed in Clause 7.4.

Where the pole has more than adequate strength, the Designer may investigate whether it is feasible to use a lower strength pole, for example, an 8kN (working strength) pole instead of a 12kN (working strength) pole. This may require an adjustment to embedment depth which will affect the profile marginally.

Where the pole has insufficient strength, the Designer shall consider increasing pole strength, or else fitting a stay if space permits. Details of stay types, sizing and positioning are given in Clause 8.0. Where space for a stay is restricted or a pole is unsuitable for staying, the Designer may reduce stringing tensions, or even use a short, slack span, then stay the next pole along, as shown below.

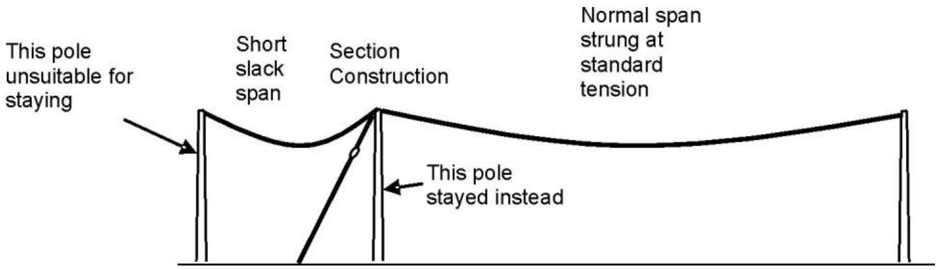


Figure 9 - Use of a slack span

The decision to use a stay shall be a last resort, especially in high traffic, livestock movement or arable cropping land areas.

4.3.13 Nominate fittings and other requirements

The Designer will need to provide additional details concerning:

- fitment of vibration dampers (for example, type, spacing, number of)
- wildlife proofing
- details of clamps, lugs, connectors, sleeves, bridging (as per Standard Construction Drawings and Ausgrid's AML)
- details of pole-mounted plant (refer to Clause 9.4), fusing and settings

- earthing
- lightning and surge protection
- LV services
- phasing
- vegetation clearing requirements (refer to Clause 10.9 and NS179)
- special foundations (refer to Clause 7.5)
- access tracks
- Ausgrid property rights

4.3.14 Modify design until compliant and optimal

The design process is iterative. The initial first-pass design is modified until it complies with all regulations and stakeholder requirements and is optimal in terms of cost, reliability and practicality for construction, maintenance and operations.

4.3.15 Document design

A project design plan shall be prepared in accordance with NS104.

The design shall be thoroughly checked prior to issue. The Designer shall ensure that all aspects have been addressed. Verification and approval of designs shall be performed by a suitably qualified person.

4.4 Design documentation requirements

The Design Documentation Requirements for auditable substantiation are listed in NS104.

These deliverable design outputs shall be provided to Ausgrid by ASP/3's, as applicable.

Ausgrid Designers shall ensure that comparable information is readily accessible in project files.

This Design Documentation is also important for facilitating future Design Information for redesign and for emergency restoration repairs to the line assets during their service life.

- **Pole Strength Summary Check Sheet** – To facilitate design auditing regardless of the design software used, a pole strength check sheet shall be provided. All design checks and calculations supporting the summary sheet are to be provided.
- **Line Schedule** – A list of all structures shall be provided, showing structure number, construction types for each voltage, pole type, pole size and mechanical rating, span lengths, phase and OHEW conductor, equivalent span length and tension within each tension section, design temperatures and minimum design clearances, structure earthing impedance and any comments such as access details and non-standard features of the structure. Pole line designs shall include standard design tables and schedules in the format contained in the NET CAD External design template for external designers or as otherwise approved for Ausgrid work groups.
- **Property Schedule** - Where easements are to be acquired or lands are to be purchased, a property schedule shall be prepared. The schedule will include details of:
  a. Lot and DP numbers of all properties affected;
  b. name;
  c. postal address;
  d. contact phone number of property owners;
  e. comments on the nature of the interest to be obtained;
  f. any agreements made with the property owner such as access conditions, disposal of vegetation removed during line construction etc.
- **Route Plan** – A route plan shall be provided showing the route of the line, with all structures shown in their required location. Each structure shall have the structure number marked beside it. The route plan shall be provided in electronic form compatible with Ausgrid's Geographic Information System. The route plan shall also show the start and end points of the proposed line, the underlying cadastral information (must be survey accurate), and any access routes.

- **Line Profile** – A profile of the line along its whole route shall be provided. The profile shall show the ground profile including any significant changes in levels, obstacles, locations of road carriageways, all line structures, intermediate structures or obstacles, and conductor curves. The conductor curves shall show all conductors and a clearance line at maximum operating temperature, and an uplift line at minimum operating temperature.
- **Overhead Design Electronic Files –** Relevant overhead design files (from the overhead line design software package used), and digital terrain survey file must be submitted along with the drawings and other information discussed above.
- **Environmental Documentation** – Project specific documentation including EIAs, approvals, licences and permits, issue specific management plans, and construction environmental management plans (CEMPs).
- **Earthing design –** documentation in accordance with NS260
- **Blowout plan** – A blowout plan view must be provided in the documentation showing the position of the power line centreline and position of the outermost conductors with respect to any easements, property boundaries and structures. The conductors must be shown as per the blowout load case in clause 4.3.11.
- **Foundation designs** – Pole foundation designs documentation shall be provided in electronic form for all poles being replaced or being modified.

Where the section of line is short, or is wholly on public roads, or on a single property, Ausgrid may vary some of the above requirements. The Design Brief will indicate if any of these requirements have been varied.

4.5 Design basics

4.5.1 Public safety

The design is to ensure that step and touch potential rises around structures do not exceed values specified in AS/NZS 7000 and HB 331 and that the design also complies with AS/NZS 7000 and HB 331 in all other respects.

Where construction is in the vicinity of a major substation, installations shall also comply with the ENA EG-0 Power System Earthing Guide Part 1: Management Principles and ENA EG1 Substation Earthing Guide.

4.5.2 Underbuilt/multiple circuits

4.5.2.1 Underbuilt circuits

Use of a single pole line for more than one Ausgrid circuit is generally acceptable. Shared circuits with low voltage construction will normally be permitted in all locations, other than for multi-pole structures (i.e. long spans). Shared 11kV or 22kV circuits (but not SWER lines) will also normally be acceptable, subject to clearances being maintained between circuits in accordance with NS220.

The type of construction used for lower voltages shall be in accordance with Ausgrid's relevant Network Standards (NS125 and NS126). Where conductive poles are used, the insulation rating of insulators used on lower voltage lines attached to the poles shall be determined from the results of the earthing study. For example, where pole earth potential rise is calculated to be 8kV, LV ABC conductors shall be secured to the pole using 11kV insulators (refer to drawing 565720).

Structure sharing may be undertaken by either running the lower voltage circuit below the higher voltage circuit or by having the two circuits side by side.

Any proposed use of construction types not specified in Network Standards, are to be managed via the NS181 Network Standard Variations process.

4.5.2.2 Multiple circuits

Where multiple circuits are to be constructed on the same structures, the construction shall be in accordance with Ausgrid drawings.

Two sub-transmission circuits of the same voltage will not normally be permitted on the same line of structures. Approval may be granted for a shared line in rural areas or areas where congestion restricts the number of available routes, provided the two lines do not supply the same load area. Ausgrid advice shall be sought in such cases as to whether allowance is required for climbing of live structures.

Where circuits are to be placed side by side, the design shall consider the need to replace insulators or other maintenance on one circuit while the other circuit is energised.

Double circuit lines are permitted on tower lines or where other structures have been designed as substantial structures which permit maintenance work to be carried out on one circuit while the second circuit remains energised.

4.5.2.3 Privately owned circuits

Any proposed use of a single pole line for underbuilt or multiple circuits, where one or more of the circuits will be privately owned or owned by an authority other than Ausgrid, are to be managed via the NS181 Network Standard Variations process. If approval is given, the approval may contain conditions additional to those specified in this Network Standard, including additional clearances, access and maintenance requirements.

4.5.3 Installation of Pole Substations on Transmission Poles

Pole substations shall not be installed on 132kV or 66kV poles. Pole substations on 33kV poles may be installed if it will fit on a standard size transmission pole as used by Ausgrid and it is confirmed there are no Earth Potential Rise (EPR) issues.

4.5.4 Installation of 11kV or LV UGOHs on transmission poles

Refer to Ausgrid Network Standard NS260 on limitations on erection of 11kV and low voltage UGOHs on transmission poles.

An 11kV or low voltage UGOH shall not be constructed on a conductive pole which also carries sub-transmission mains. This is to mitigate the risks associated with transferred voltage and earth potential rise hazards associated with faults on the sub-transmission network. Refer to NS260 for requirements associated with non-conductive poles.

4.5.5 Insulation co-ordination

Ausgrid’s overhead line designs and standards are based on co-ordinated levels of insulation withstand voltages for the various line configurations and equipment types, together with the correct application of surge arresters. Performance of the installation is adversely affected by departures from construction standards affecting clearances or configuration. Compliance with Ausgrid’s requirements will be achieved by using the standard structures as shown in the Ausgrid drawings. Use of construction types not specified in the Design Brief and unapproved network standard variations will be assessed as a “non-compliance” and rectification works will be required to be completed as per the approved design brief and NS181 processes prior to connection to the Ausgrid network.

- The basic insulation levels applying to the standard designs are in accordance with IEC60071 and NS264.
- The following table provides basic insulation levels for 33kV – 132kV overhead lines.

Table 8 - Basic Insulation Levels

Lines	Basic Insulation Level
33kV lines	200kV
66kV lines	325kV
132kV lines	650kV

5.0 CONDUCTORS AND CABLES

5.1 Conductor Materials

5.1.1 Aluminium conductors

All Aluminium Conductor (AAC) is used for most bare distribution mains within Ausgrid. The metal used is known as *Alloy 1350*, which is 99.5% pure aluminium.

All Aluminium Alloy Conductor (AAAC) is used in sections of the Ausgrid network. The metal is *Alloy 1120*. AAAC has greater strength than AAC and is suitable for higher tension stringing on long spans. AAAC can provide a useful alternative to ACSR for coastal areas where corrosion due to salt pollution is a problem. Note however, that the conductivity of AAAC is slightly less than AAC.

Aluminium has good resistance to corrosion in most environments, the one exception being alkaline industrial pollution.

5.1.2 Aluminium Conductor Steel Reinforced (ACSR)

These conductors have properties that lie between those of aluminium and those of steel, and therefore have moderate conductivity and moderate strength. They are particularly suited to rural areas where span lengths are long and electrical loading is light. Various ratios of steel to aluminium are used depending upon the application.

5.1.3 Hard-Drawn Copper (HDCu) conductors

In the early days of electrification, HDCu conductors were used widely. Although copper has excellent conductivity, it is expensive and very heavy. Forces exerted upon supporting structures are very high.

HDCu conductors shall only be used for repairs or minor modifications to existing mains.

5.1.4 Galvanised Steel (SC/GZ) conductors

Although a very strong material, steel has poor conductivity compared with copper and aluminium. Thus, steel is mainly used as a reinforcing material (see ACSR) or with an aluminium coating on SWER lines. Steel conductor is prone to corrosion in polluted or coastal environments as the galvanizing layer is eventually consumed.

Galvanised Steel conductor (SC/GZ) shall only be used with Ausgrid approval (send a request to PlanningInvestigations@ausgrid.com.au) on a like-for-like replacement basis. SC/GZ 3/2.75 shall be the minimum conductor size to reduce the risk of conductor failure if struck directly by lightning.

5.1.5 Insulated/covered cables

ABC (Aerial Bundled Cable) and CCT (Covered Conductor - Thick) are used to improve network reliability caused by vegetation or wildlife.

CCT used within Ausgrid has an insulation thickness of approximately 3.4mm. However, as CCT has no earthed screen, it shall be treated as if it were a bare conductor for operational purposes.

Due to the additional weight and wind loading of the insulation on ABC and CCT, these conductors are heavier than bare conductors of equivalent capacity and consequently have reduced spanning capability (shorter spans). Covered and insulated conductors are generally more expensive to purchase, but the total cost of construction may be less, especially for LV ABC in urban areas.

5.1.6 Overhead earth wires (OHEW)

AAC, AAAC and ACSR conductors may be used for overhead earth wires above sub-transmission lines for intercepting direct lightning strikes. OHEW conductor is selected to match the required lightning performance, fault level and fault clearing time. The outer layer strand size should not be less than 3mm diameter to reduce the risk of lightning strikes severing conductor strands.

Optical ground wires (OPGW) are designed for use as overhead earth wires whilst incorporating optical fibres for communication and protection purposes, refer to NS135.

5.2 Conductor Selection

The selection of conductor is based on a number of factors, namely:

- Required electrical current rating (including future requirements);
- Required fault current capacity;
- Environmental conditions - for example, coastal, rural, heavily polluted, urban;
- Budget - for example, cost of conductor, time and cost of fitting line parts, cost and storage requirements for maintenance stocks);
- Span lengths, required conductor tensions and sag limitations;
- Conductor weight and resulting structural requirements - particularly important for reconductoring a feeder using existing structures;
- Compatibility with existing adjacent electrical infrastructure.

The tables on the following pages provide a summary of Ausgrid's preferred conductors including conductor types and typical applications, current ratings and mechanical properties.

5.2.1 Bare conductor

Table 9 - Bare conductor selection

TYPE	APPLICATION	NOMINAL SIZES	TYPICAL APPLICATION
AAC **A**ll **A**luminium **C**onductor (AAC/1350)	• For LV lines where LV ABC is unsuitable (for example long spans) • Refer NS109 and NS125 regarding criteria for use of bare LV conductor or LV ABC • Standard conductor for new HV mains, except for sites where use of CCT is warranted • Has good conductivity and low weight Limitations: • AAC's lower strength means that it is not suitable for very long rural spans (ACSR may be preferable)	MERCURY (7/4.50)	Normal line segments
		PLUTO (19/3.75)	For LV or 11kV, used as the main feeder 'trunk' from a substation, or to supply large loads (>320A)
		TRITON (37/3.75)	Generally used at 33kV and above
		URANUS (61/3.25)	
AAAC **A**ll **A**luminium **A**lloy **C**onductor (AAAC/1120)	Rarely used, but may be required for long HV spans in coastal areas (where ACSR would suffer from corrosion)	CHLORINE (7/2.50)	Spur lines, rural areas with light loading
		HYDROGEN (7/4.50)	Normal feeder segments
		KRYPTON (19/3.25)	Main feeder 'trunk' from a substation
ACSR **A**luminium **C**onductor Galvanised **S**teel **R**einforced (ACSR/GZ/1350)	• Good for long, tightly-strung spans in rural areas where electrical loads are light • Has greater strength than AAC, but inferior conductivity • Corrosion of steel strands can be a problem for lines close to the coast, particularly on smaller size conductors (AAAC may be preferable) • Conductors such as RAISIN (3/4/2.50) may be unsuitable in the vicinity of a zone substation due to the high fault levels on the network	APPLE (6/1/3.00)	Spur lines, rural areas with light loading
		CHERRY (6/4.75 + 7/1.60)	Normal feeder segments
		LEMON (30/7/3.00)	Generally used at 33kV and above
		OLIVE (54/7/3.50)	
HDCu (**H**ard-**D**rawn **C**opper)	Obsolete — use only for repairs or minor modifications to existing mains		
SC/GZ (**S**teel **C**onductor –**G**alvanised)	Obsolete — Refer clause 5.1.4. SC/GZ 3/2.75 shall be the minimum conductor size to reduce the risk of conductor failure if struck directly by lightning.		

5.2.2 Insulated/covered conductor

Table 10 - Insulated/covered conductor selection

TYPE	APPLICATION	NOMINAL SIZES	TYPICAL APPLICATION
LV ABC **LV A**erial **B**undled **C**onductor (Hard Drawn Aluminium)	LV Distribution • Refer NS109 and NS125 regarding criteria for use of bare LV conductor or LV ABC Limitations: • Unsuitable for long spans—not suitable for tight stringing	95mm^2	Normal single dwelling residential areas
		150mm^2	Commercial/industrial areas with loads in range 200A – 280A.
		2 x 95mm^2	Where loads are likely to exceed 280A. Parallel at 100m (max.) intervals
CCT **C**overed **C**onductor – **T**hick (AAAC 1120)	HV Distribution • Refer to NS126 regarding criteria for use of bare HV conductor or CCT Limitations • Shall only be used where shielded (such as by vegetation) • CCT is more costly than bare AAC and shall not be used unless warranted for the site conditions • Unsuitable for long spans (>120m) and not suitable for tight stringing • Weight and wind loading is greater than for bare conductors and may cause excessive loading on structures • Restrictions on use of Live Line techniques	80mm^2	Spur lines, rural areas with light loading
		120mm^2	Normal feeder segments
		180mm^2	Main feeder ‘trunk’ from a substation, or to supply large loads (>370A)

5.3 Electrical properties and ratings

5.3.1 Bare conductor

Table 11 - Bare conductor electrical properties and ratings

Material	Conductor Name	Cross-Sectional Area (mm²)	Strands (No. /Dia.)		DC Resistance @ 20°C (Ω/km)	Current Rating (A)					
						50°C		75°C		100°C	
			Metric (mm)	Imperial (inches)		Summer Day	Winter Night	Summer Day	Winter Night	Summer Day	Winter Night
AAC (1350) AS1531	LEO	34.36	7/2.50		0.833	82	149	161	200	204	257
	LIBRA	49.48	7/3.00		0.579	100	188	202	253	257	326
	MARS	77.28	7/3.75		0.370	126	251	267	338	342	436
	MERCURY	111.30	7/4.50		0.258	152	318	335	429	432	552
	MOON	124.00	7/4.75		0.232	160	341	357	459	462	591
	NEPTUNE	157.60	19/3.25		0.183	179	399	415	538	540	694
	PLUTO	209.80	19/3.75		0.137	203	481	497	650	649	838
	TAURUS	336.70	19/4.75		0.086	245	655	666	884	877	1141
	TRITON	408.50	37/3.75		0.071	260	538	751	1004	994	1296
	URANUS	506.10	61/3.25		0.057	275	851	855	1152	1137	1489
AAAC (1120) AS1531	CHLORINE	34.36	7/2.50		0.864	77	139	151	187	192	242
	HYDROGEN	111.33	7/4.50		0.266	142	297	314	402	406	520
	KRYPTON	157.60	19/3.25		0.189	167	373	390	505	508	653
HDCu AS1746		16.84	7/1.75		1.060	70	119	131	161	166	207
		21.99	7/2.00		0.815	81	141	155	191	195	222
		41.58	7/2.75		0.433	115	213	230	287	293	370
		59.70	19/2.00		0.303	140	269	288	363	369	468
		97.80	19/2.56	19/.101	0.186	180	371	390	498	504	643
		112.90	19/2.75	19/.109	0.160	193	407	428	523	554	703
		134.30	19/3.00		0.134	210	455	478	616	620	724
		129.16	37/2.11	37/.083	0.141	206	444	464	568	602	702
		219.80	37/2.75		0.082	261	626	649	849	849	1097

Material	Conductor Name	Cross-Sectional Area (mm²)	Strands (No. /Dia.)		DC Resistance @ 20°C (Ω/km)	Current Rating (A)					
						50°C		75°C		100°C	
			Metric (mm)	Imperial (inches)		Summer Day	Winter Night	Summer Day	Winter Night	Summer Day	Winter Night
ACSR/GZ (1350) AS3607	ALMOND	34.36	6/1/2.50		0.975	74	133	144	179	183	230
	APPLE	49.48	6/1/3.00		0.677	89	167	180	225	229	290
	BANANA	77.31	6/1/3.75		0.433	111	221	235	298	301	384
	CHERRY	120.40	6/4.75+7/1.60		0.271	139	297	312	400	403	516
	QUINCE	16.84	3/4/1.75		3.250	36	60	66	81	83	104
	RAISIN	34.36	3/4/2.50		1.590	52	95	102	127	130	164
	SULTANA	49.48	4/3/3.00		0.897	73	137	147	185	188	238
	WALNUT	77.31	4/3/3.75		0.573	91	182	193	244	247	315
	GRAPE	181.60	30/7/2.50		0.196	171	394	409	532	533	686
	LEMON	261.50	30/7/3.00		0.136	200	500	513	676	673	872
	LIME	356.00	30/7/3.50		0.100	224	612	622	827	820	1068
	MANGO	431.20	54/7/3.00		0.076	245	714	721	965	955	1247
	OLIVE	586.90	54/7/3.50		0.056	259	860	860	1165	1147	1506
SC/GZ AS1222.1	*(*)*	*9.43*	*3/2.00*		*20.0*	*17*	*30*	*33*	*40*	*41*	*51*
		17.82	3/2.75		11.0	24	45	48	60	61	77
		21.99	7/2.00		8.7	26	45	50	61	63	78
		41.58	7/2.75		4.6	37	68	73	91	93	117
		58.07	7/3.25		3.3	44	85	92	116	117	148

(*) SC/GZ 3/2.00 shall not be used on the Ausgrid network. Data is shown for information only.

5.3.2 Insulated/covered conductor

Table 12 - Insulated conductor electrical properties and ratings

Material	Conductor Name	Cross-Sectional Area (mm^2)	Strands (No. /Dia.)		DC Resistance @ 20°C (Ω/km)	Current Rating (A)	
						80°C (ABC or CCT)	
			Metric (mm)	Imperial (inches)		Summer Day	Winter Night
11kV CCT (AAAC 1120) AS3675	CCT80	77.3	7/3.75		0.383	255	325
	CCT120	124.0	7/4.75		0.239	335	435
	CCT180	182.8	19/3.50		0.163	425	555
LV ABC (Hard-drawn Aluminium Alloy 1350) AS3560.1	LV ABC25 (2C)	2 x 25 = 50	Nom.7/2.16		1.20	105	125
	LV ABC25 (4C)	4 x 25 = 100	Nom.7/2.16		1.20	95	125
	LV ABC95 (4C)	4 x 95 = 380	Nom.19/2.52		0.320	215	285
	2 x LV ABC95 (4C)	2 x 4 x 95 = 760	Nom.19/2.52		0.160	430	570
	LV ABC150 (4C)	4 x 150 = 600	Nom.19/3.17		0.206	280	375
	2x LV ABC150 (4C)	2 x 4 x 150 = 1200	Nom.19/3.17		0.103	560	750

Notes:

1. For selection of maximum design temperature, refer to Clause 3.6.
2. Ausgrid's 'Ratings & Impedance Calculator' contains the up-to-date current rating data.

Standard Input Parameters are -

Conductor temperature: As required
Emissivity: 0.6
Summer day/night - ambient 35° C
Summer night - Solar radiation intensity: 500
Winter day – solar radiation intensity: 1000
Winter night - solar radiation intensity: 0
Windspeed: 0.6m/s
Solar absorptivity: 0.8
Summer day - Solar radiation intensity: 1000
Winter day – ambient: 25° C
Winter night – ambient: 10° C

3. For further information on rating, contact Ausgrid's ratings group via your Ausgrid Representative.
4. Conductors other than the current preferred sizes are included for reference purposes only.
5. Conductor data is generally in accordance with the applicable Australian Standards. Note that products from different manufacturers may vary slightly from the above data.
6. Refer to NS100 Annexure C – Cable Codes and Nomenclature for alternative conductor descriptions and codes.

5.4 Mechanical properties

5.4.1 Bare conductor

Table 13 - Bare conductor mechanical properties

Material	Conductor Name	Strands (No. /Dia.)		Cross-Sectional Area (mm²)	Nom. Cable Diameter (mm)	UTS (kN)	Mass (kg/m)	Modulus of Elasticity (GPa)	Linear Expansion Coefficient (x 10^{-6} per °C)
		Metric (mm)	Imperial (inches)						
AAC (1350) AS1531	LEO	7/2.50		34.36	7.50	5.71	0.094	59	23
	LIBRA	7/3.00		49.48	9.00	7.98	0.135	59	23
	MARS	7/3.75		77.28	11.30	11.80	0.211	59	23
	MERCURY	7/4.50		111.30	13.50	16.90	0.304	59	23
	MOON	7/4.75		124.00	14.25	18.9	0.339	59	23
	NEPTUNE	19/3.25		157.60	16.25	24.70	0.433	56	23
	PLUTO	19/3.75		209.80	18.80	31.9	0.576	56	23
	TAURUS	19/4.75		336.70	23.80	51.30	0.924	56	23
	TRITON	37/3.75		408.50	26.30	62.20	1.12	56	23
	URANUS	61/3.25		506.10	29.30	75.20	1.400	54	23
AAAC (1120) AS1531	CHLORINE	7/2.50		34.36	7.50	8.18	0.094	59	23
	HYDROGEN	7/4.50		111.30	13.50	24.30	0.304	59	23
	KRYPTON	19/3.25		157.60	16.25	37.40	0.433	56	23
HDCu AS1746		7/1.75		16.84	5.25	6.89	0.151	112	17
		7/2.00		21.99	6.00	8.89	0.197	112	17
		7/2.75		41.58	8.25	16.20	0.375	112	17
		19/2.00		59.70	10.00	23.60	0.538	110	17
	Twin-and-twist (*)	7/2.03 + 7/2.64	7/.080 + 7/.104	22+38	14.02	25.21	0.547	110	17
		19/2.56	19/.101	98.21	12.83	39.56	0.887	110	17
		19/2.75		112.90	13.80	43.10	1.020	110	17
		19/3.00		134.30	15.00	50.80	1.210	110	17
		37/2.11	37/.083	129.16	14.76	52.51	1.170	108	17
		37/2.75		219.80	19.30	83.90	1.990	108	17

Material	Conductor Name	Strands (No. /Dia.)		Cross-Sectional Area (mm²)	Nom. Cable Diameter (mm)	UTS (kN)	Mass (kg/m)	Modulus of Elasticity (GPa)	Linear Expansion Coefficient (x 10^{-6} per °C)
		Metric (mm)	Imperial (inches)						
ACSR/GZ (1350) AS3607	ALMOND	6/1/2.50		34.36	7.50	10.50	0.119	79	19.3
	APPLE	6/1/3.00		49.48	9.00	14.90	0.171	79	19.3
	BANANA	6/1/3.75		77.31	11.30	22.70	0.268	79	19.3
	CHERRY	6/4.75+7/1.60		120.40	14.30	33.40	0.402	76	19.9
	QUINCE	3/4/1.75		16.84	5.30	12.70	0.095	119	13.9
	RAISIN	3/4/2.50		34.36	7.50	24.40	0.195	119	13.9
	SULTANA	4/3/3.00		49.48	9.00	28.30	0.243	106	15.2
	WALNUT	4/3/3.75		77.31	11.30	43.90	0.380	106	15.2
	GRAPE	30/7/2.50		181.60	17.50	63.50	0.677	80	18.4
	LEMON	30/7/3.00		261.50	21.00	90.40	0.973	80	18.4
	LIME	30/7/3.50		356.00	24.50	122.00	1.320	80	18.4
	MANGO	54/7/3.00		431.20	27.00	119.00	1.440	75	19.9
	OLIVE	54/7/3.50		586.90	31.50	159.00	1.960	75	19.9
SC/GZ AS1222.1		*3/2.00 (**)*		*9.43*	*4.31*	*11.70*	*0.074*	*180*	*11.5*
		3/2.75		17.82	5.93	22.20	0.140	180	11.5
		7/2.00		21.99	6.00	26.00	0.173	170	11.5
		7/2.75		41.58	8.25	49.00	0.328	170	11.5
		7/3.25		58.07	9.75	68.70	0.458	170	11.5

(*) Twin-and-twist shall not be used for new work on the Ausgrid network. Data is shown for modelling existing sites only.

(**) SC/GZ 3/2.00 shall not be used on the Ausgrid network. Data is shown for information only.

5.4.2 Insulated/covered conductor

Table 14 - Insulated/covered conductor mechanical properties

Material	Conductor Name	Strands (No. /Dia.)		Cross-Sectional Area (mm²)	Max. Cable Diameter (mm)	Everyday Tension (kN)	Maximum Working Tension (kN)	UTS (kN)	Mass (kg/m)	Modulus of Elasticity (GPa)	Linear Expansion Coefficient (x 10^{-6} per °C)
		Metric (mm)	Imperial (inches)								
11kV CCT (AAAC 1120) AS3675	CCT80	7/3.75		77.3	19.40	2.64	8.80	17.60	0.425	65	23
	CCT120	7/4.75		124.0	22.40	4.07	13.6	27.10	0.608	65	23
	CCT180	19/3.50		182.2	25.70	6.26	20.9	41.70	0.831	65	23
LV ABC (Hard-drawn Aluminium Alloy 1350) AS3560.1 (Refer to Note 4)	LV ABC25 (2C)	7/2.16		2 x 25 = 50	18.40	1.26	1.96	7.00	0.20	59	23
	LV ABC25 (4C)	7/2.16		4 x 25 = 100	22.20	2.52	3.92	14.00	0.40	59	23
	LVABC95 (4C)	19/2.52		4 x 95 = 380	38.40	9.60	14.9	53.20	1.35	56	23
	LVABC150 (4C)	19/3.17		4 x 150 = 600	45.60	15.1	23.5	84.00	2.02	56	23

Notes:

1. Conductors other than current preferred sizes are included for reference purposes only.
2. The conductor data in Table 13 and Table 14 is generally in accordance with applicable Australian Standards. Note that products from different manufacturers may vary slightly from the above data.
3. Definitions for Table 13 and Table 14:
   - Cross-Sectional Area (CSA) – is equal to the area of each strand times the number of strands. Conductor strength, mass, and current rating are all proportional to the CSA.
   - Maximum Cable Diameter – used to determine the wind force on the conductor. For a 7-strand bare conductor, overall projected diameter is three times the strand diameter. For a 19-strand conductor, overall projected diameter is five times the strand diameter. For a 37-strand conductor, overall projected diameter is seven times the strand diameter. For insulated conductor, the diameter is over the insulation. For LV ABC, the diameter is over the laid-up cores.
   - Everyday Tension – the maximum long-term average tension of the conductor. Normally analysed at 15°C with light wind.
   - Maximum Working Tension – the maximum short-term tension in the conductor. Normally analysed with the Maximum Wind Load case.
   - UTS (Ultimate Tensile Strength) – is also known as minimum / calculated / nominal breaking load. Design tensions are specified as a percentage of this figure.
   - Mass – specified per metre of conductor. For equivalent sags, heavier conductors need to be strung to higher tensions than lighter conductors.
   - Modulus of Elasticity – is a measure of stress or load applied to a material to cause a given strain (deformation or stretch).
   - Linear Expansion Coefficient – is the rate at which a conductor expands in length as temperature increases. Aluminium has a higher expansion coefficient than copper or steel and so tends to sag more as it heats up.

5.5 CCT design considerations

NS126 details the design and operational considerations for CCT lines. The following items shall be read in conjunction with NS126.

5.5.1 Design Tensions

Due to its high weight in comparison with bare conductors, CCT is generally strung at moderate tensions, typically not exceeding 10% UTS, and with spans usually less than 120m in length.

5.5.2 Lightning protection

CCT is more prone to lightning damage than bare conductor. For lightning protection and lightning shielding requirements, refer to NS126.

5.5.3 Earthing points

Earthing points must be established at all points where it is envisaged that access permit earths or working earths will be required during future operations / maintenance / extension works. For provision of earthing points on CCT conductor, refer to NS126.

5.6 Sub-transmission bundled (twin) conductors

New line designs shall employ single conductor per phase. Any proposed use of bundled conductors are to be managed via the NS181 Network Standard Variations process.

For reconstruction work on existing lines, where the work area is limited to only a few spans, the existing bundled conductor arrangement can remain. If the reconstruction work is extensive, then converting the bundled conductor to single conductor shall occur, if required ratings can be achieved. Where used, horizontal bundle arrangements shall be employed.

Spacers shall be installed in accordance with Ausgrid drawing 231652 or the manufacturer's recommendations, considering conductor size, tension and wind conditions.

6.0 CONDUCTOR STRINGING

6.1 General

When selecting a stringing tension, designers shall apply the following guidelines:

- Do not make lines unnecessarily tight - this increases the cost of structures and the number of stays required. In areas with loose sands or soft clays it is critical to keep stringing tensions low to limit pole embedment depth to reasonable levels (refer to clause 7.5 for further detail).
- Attempt to keep spans of similar length within a termination section where it is practical to do so, taking into account terrain, property boundaries etc. Through-termination constructions shall be used to isolate any spans that are significantly shorter or longer than adjacent spans.
- Within any termination section, no span length shall be more than double the ruling span, or less than half the ruling span. (Outside this ratio Ruling Span Assumption fails at higher/lower conductor operating temperature and can cause excessive sag in longest span in tension section). On tight-strung lines, it is preferable that the longest span is not more than double the shortest span within any termination section. If this is not done, large forces can occur when the line is cold, damaging insulators and crossarms.
- Sub-circuits should not be strung tighter than super-circuits (ADSS excepted).
- Stringing tension tables in designs shall provide construction crews with conductor sags for stringing with sight battens/boards, wave sagging times (3 return waves) and conductor tensions for tensioning with a dynamometer. A typical stringing table is shown Figure 10. For conductor stringing, the reference weather condition is 5°C in still air.

HR-50890 - HR-50891	**VOLTS:** OHEW			**CONDUCTOR:** APPLE				
EQUIV. SPAN(m): 75.93	**SPAN (m):** 75.98							
AMBIENT TEMPERATURE (Deg C)	5 (I)	10 (I)	15 (I)	20 (I)	25 (I)	30 (I)	35 (I)	40 (I)
SAG (m)	1.13	1.19	1.26	1.32	1.38	1.44	1.5	1.55
TIME FOR 3 RETURN WAVES (Secs)	5.87	6.03	6.19	6.34	6.49	6.62	6.75	6.88
TENSION (kN)	1.03	0.98	0.93	0.88	0.84	0.81	0.78	0.75

Figure 10 - Example stringing table

6.2 Engineering notes

For very short spans that have to be slack-strung, it is recommended that sag be set to 4% of span length.

It is recommended that a minimum stringing tension of 10% UTS be used for ACSR conductors with a high proportion of steel strands so that helical termination (dead-end) fittings remain adequately tensioned to maintain proper grip.

6.2.1 Stringing tension limits

It is recommended that designers nominate stringing tensions that do not exceed the following:

- For LV ABC conductor, the tension should be limited to 6% UTS if services are required within the section under tension (beyond this limit phases are difficult to pry apart). The tension shall not exceed 10% UTS, as termination clamps begin to crush the insulation above this limit. Designers shall also be wary of using high tensions with double bundled ABC in built up urban areas. Two bundles of this conductor become a very large pole tip load as tension is increased. Tension can be quite low (2 - 4%) for this conductor type in built up areas with short spans.
- Ground clearance, conductor tension, pole strength and foundation strength all need to be balanced to come up with the optimum solution for a design.
- Tight stringing of bare conductors usually requires conductor armour rods/grips at supports, vibration damping and suitable clamping arrangements. Conductors can suffer fatigue, wire fracture, conductor elongation and/or failure if excessive static and dynamic stresses are applied. This can result from excessive mechanical loading including tension, bending and compressive stresses, vibration amplitude and frequency. It is important that adequate margin be allowed for construction stresses and the increase in tensions in short spans during extreme cold weather. Designers shall investigate the need for the installation of armour rods and vibration dampening in accordance with AS/NZS7000.

6.2.2 Ruling span

Where a conductor is rigidly fixed at both ends of a span, the span behaves independently of any other spans in the line. However, where the conductor is free to move at its supports (such as when it is being strung on rollers, or where it is supported by suspension insulators which can swing to the side), the various spans within a termination section will interact if they differ significantly in length. The simple sag tension relationships will not apply - large spans will dominate.

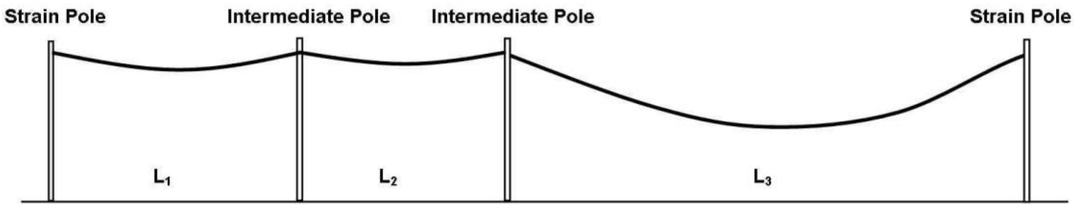


Figure 11 - Ruling Span

The Ruling Span (RS) or Mean Equivalent Span is a theoretical span length which represents the behaviour of the spans within the termination section and can be used to determine the conductor tension, which will be identical in all spans within the termination section.

The significance of RS is particularly important in tight-strung lines where the span lengths in a termination section vary significantly. If no correction is made for RS, then sag calculations for the maximum conductor operating temperature may be very inaccurate and lead to clearance violations.

6.2.3 Creep

Most materials subjected to stress will suffer from a permanent elongation or inelastic stretch, known as creep. The extent of creep for overhead conductors will depend upon the:

- material - aluminium is more susceptible than copper or steel
- manufacturing process
- conductor tension - the tighter the line, the more significant the effect of creep
- operating temperature - the higher the operating temperature, the more creep progresses
- time - creep becomes evident within hours of erecting a line and progresses steadily over many years
- stranding - there is a settling in of the strands
- ruling span.

Creep is generally calculated by line design software. The preferred method is to use a non-linear conductor model. Some line design software will calculate creep via a linear conductor model and a temperature offset, however, this is less accurate than using a non-linear model.

In construction, creep can be managed through over-tensioning the conductor in line with the calculated creep and stringing charts. The conductor may also be pre-stressed for an extended period of time prior to termination and tying-in tasks.

In circumstances where an existing conductor is being re-tensioned, creep shall not be allowed for in stringing charts. Stringing charts shall clearly distinguish between new conductors that allow for future creep (generally called the ‘initial’ conductor phase), and existing conductors or pre-stressed conductors that display tensions for conductors that have already crept (generally called the ‘final’ conductor phase).

Due to creep, the sag in a span of mains will increase following installation and may in time lead to insufficient clearances if not allowed for correctly. Designers shall use ‘final’ sags when determining clearances.

7.0 POLES

7.1 Pole selection guidelines

Pole selection and material guidelines shall be in accordance with NS128.

7.2 Pole steps

Pole steps shall be installed in accordance with NS128.

7.3 Painting of poles

Timber poles shall not be painted.

Non-timber poles may be painted after seeking approval from Ausgrid. Ausgrid will not maintain the painted surface and will not allow painting of poles except by the manufacturer or the manufacturer’s representative. Any proposal to paint non-timber poles are to be managed via the NS181 Network Standard Variations process.

7.4 Pole data

7.4.1 Timber poles

The range of timber poles used within the Ausgrid Network is listed in NS128.

For details of existing timber poles, including information on pole discs, refer to NS145, NS128 and specific Timber Pole Supplier's datasheets.

To determine the maximum wind load, Ausgrid applies a strength reduction factor of 0.6 to the ultimate strength of the timber pole. For the sustained load limit, Ausgrid applies a strength reduction factor of 0.34 (refer to Clause 3.7).

7.4.2 Fibre-cement poles

The range for direct-buried fibre-cement poles used within the Ausgrid Network is shown in Table 15. Stockcodes and Vendor Part Numbers for these poles can be obtained through the AML (refer to NS181).

Table 15 - Available Fibre-cement poles

Item	Pole Length (m)	Ultimate Tip Load (kN)
1	9.5	16
2	9.5	24
3	11.0	16
4	11.0	24
5	12.5	16
6	12.5	24
7	14.0	16
8	14.0	24
9	15.5	16
10	15.5	24
11	17.0	16
12	17.0	24
13	18.5	16
14	18.5	24
15	20.0	16
16	20.0	24
17	21.5	16
18	21.5	24
Equipment poles		
19	14	24
20	15.5	24
21	14m pole manufacturer drilling, 1-phase PT	24
22	14m pole manufacturer drilling, 3-phase PT	24
23	15.5m pole manufacturer drilling, 1-phase PT	24
24	15.5m pole manufacturer drilling, 3-phase PT	24

7.4.3 Fibreglass poles

The range of fibreglass poles used within the Ausgrid Network is listed in NS128.

7.4.4 Concrete poles and piles

The pole range for direct-buried concrete poles used within the Ausgrid Network is shown in Table 16.

Table 16 - Available standard concrete poles

Item	Pole Length (m)	Ultimate Tip Load (kN)	Item	Pole Length (m)	Ultimate Tip Load (kN)
1	9.5	10	**47**	21.4	32
2	9.5	16	**48**	21.4	40
3	9.5	24	**49**	21.4	60
4	10	60	**50**	21.4	80
5	10	80	**51**	23	16
6	10	100	**52**	23	24
7	11	10	**53**	23	32
8	11	16	**54**	23	40
9	11	24	**55**	23	60
10	11	32	**56**	23	80
11	11	40	**57**	24	16
12	12.5	10	**58**	24	24
13	12.5	16	**59**	24	32
14	12.5	24	**60**	24	40
15	12.5	32	**61**	24	60
16	12.5	40	**62**	24	80
17	14	10	**63**	26	24
18	14	16	**64**	26	32
19	14	24	**65**	26	40
20	14	32	**66**	26	60
21	14	40	**67**	26	80
22	15.5	10	**68**	28	24
23	15.5	16	**69**	28	32
24	15.5	24	**70**	28	40
25	15.5	32	**71**	28	60
26	15.5	40	**72**	28	80
27	17	16	**73**	30	24
28	17	24	**74**	30	32
29	17	32	**75**	30	40
30	17	40	**76**	30	60
31	17	60	**77**	30	80
32	17	80	**78**	32	24
33	18.5	16	**79**	32	32
34	18.5	24	**80**	32	40
35	18.5	32	**81**	32	60
36	18.5	40	**82**	32	80
37	18.5	60	**83**	34	40
38	18.5	80	**84**	34	60
39	20	16	**85**	36	40
40	20	24	**86**	36	60
41	20	32	**87**	36	80
42	20	40	**88**	38	60
43	20	60	**89**	38	80
44	20	80			
45	21.4	16			
46	21.4	24			

High-strength poles are often required for sub-transmission designs or where the use of a stay is not suitable, practical or cost-effective. Any proposed use high-strength poles are to be managed via NS181 processes. The high-strength concrete pole range is shown in Table 17.

Table 17 - Available high strength concrete poles

Item No.	Pole Length (m)	Ultimate Tip Load (kN)	Item No.	Pole Length (m)	Ultimate Tip Load (kN)	Item No.	Pole Length (m)	Ultimate Tip Load (kN)
93	20	100	**130**	20	130	**167**	17	160
94	20.5	100	**131**	20.5	130	**168**	17.5	160
95	21	100	**132**	21	130	**169**	18	160
96	21.5	100	**133**	21.5	130	**170**	18.5	160
97	22	100	**134**	22	130	**171**	19	160
98	22.5	100	**135**	22.5	130	**172**	19.5	160
99	23	100	**136**	23	130	**173**	20	160
100	23.5	100	**137**	23.5	130	**174**	20.5	160
101	24	100	**138**	24	130	**175**	21	160
102	24.5	100	**139**	24.5	130	**176**	21.5	160
103	25	100	**140**	25	130	**177**	22	160
104	25.5	100	**141**	25.5	130	**178**	22.5	160
105	26	100	**142**	26	130	**179**	23	160
106	26.5	100	**143**	26.5	130	**180**	23.5	160
107	27	100	**144**	27	130	**181**	24	160
108	27.5	100	**145**	27.5	130	**182**	24.5	160
109	28	100	**146**	28	130	**183**	25	160
110	28.5	100	**147**	28.5	130	**184**	25.5	160
111	29	100	**148**	29	130	**185**	26	160
112	29.5	100	**149**	29.5	130	**186**	26.5	160
113	30	100	**150**	30	130	**187**	27	160
114	30.5	100	**151**	30.5	130	**188**	27.5	160
115	31	100	**152**	31	130	**189**	28	160
116	31.5	100	**153**	31.5	130	**190**	28.5	160
117	32	100	**154**	32	130	**191**	29	160
118	32.5	100	**155**	32.5	130	**192**	29.5	160
119	33	100	**156**	33	130	**193**	30	160
120	33.5	100	**157**	33.5	130	**194**	30.5	160
121	34	100	**158**	34	130	**195**	31	160
122	34.5	100	**159**	34.5	130	**196**	31.5	160
123	35	100	**160**	35	130	**197**	32	160
124	35.5	100	**161**	35.5	130	**198**	32.5	160
125	36	100	**162**	36	130	**199**	33	160
126	36.5	100	**163**	36.5	130	**200**	33.5	160
127	37	100	**164**	37	130	**201**	34	160
128	37.5	100	**165**	37.5	130	**202**	34.5	160
129	38	100	**166**	38	130	**203**	35	160
						204	35.5	160
						205	36	160
						206	36.5	160
						207	37	160
						208	37.5	160
						209	38	160

Concrete Piles are only used where required by the footing design. The concrete pile range is shown in Table 18. Any proposed use of piles including those shown in Table 18, are to be managed via NS181 processes.

Table 18 - Available concrete piles

Item No.	Pole/Pile Combination	Item No.	Pole/Pile Combination	Item No.	Pole/Pile Combination
357	12.0m/L/24kN	**389**	18.0m/L/40kN	**421**	24.0m/L/80kN
358	12.0m/L/32kN	**390**	18.0m/L/60kN	**422**	25.5m/L/32kN
359	12.0m/L/40kN	**391**	18.0m/L/80kN	**423**	25.5m/L/40kN
360	12.0m/L/60kN	**392**	18.0m/L/100kN	**424**	25.5m/L/60kN
361	12.0m/L/80kN	**393**	18.0m/L/120kN	**425**	25.5m/L/80kN
362	12.0m/L/100kN	**394**	18.0m/L/140kN	**426**	27.0m/L/32kN
363	12.0m/L/120kN	**395**	18.0m/L/160kN	**427**	27.0m/L/40kN
364	12.0m/L/140kN	**396**	19.5m/L/24kN	**428**	27.0m/L/60kN
365	12.0m/L/160kN	**397**	19.5m/L/32kN	**429**	27.0m/L/80kN
366	13.5m/L/24kN	**398**	19.5m/L/40kN	**430**	28.5m/L/40kN
367	13.5m/L/32kN	**399**	19.5m/L/60kN	**431**	28.5m/L/60kN
368	13.5m/L/40kN	**400**	19.5m/L/80kN	**432**	28.5m/L/80kN
369	13.5m/L/60kN	**401**	19.5m/L/100kN	**433**	28.5m/L/100kN
370	13.5m/L/80kN	**402**	19.5m/L/120kN	**434**	30.0m/L/40kN
371	13.5m/L/100kN	**403**	19.5m/L/140kN	**435**	30.0m/L/60kN
372	13.5m/L/120kN	**404**	21.0m/L/24kN	**436**	30.0m/L/80kN
373	15.0m/L/24kN	**405**	21.0m/L/32kN	**437**	31.5m/L/40kN
374	15.0m/L/32kN	**406**	21.0m/L/40kN	**438**	31.5m/L/60kN
375	15.0m/L/40kN	**407**	21.0m/L/60kN	**439**	31.5m/L/80kN
376	15.0m/L/60kN	**408**	21.0m/L/80kN	**440**	33.0m/L/40kN
377	15.0m/L/80kN	**409**	21.0m/L/100kN	**441**	33.0m/L/60kN
378	15.0m/L/100kN	**410**	21.0m/L/120kN	**442**	33.0m/L/80kN
379	15.0m/L/120kN	**411**	22.5m/L/24kN	**443**	34.5m/L/40kN
380	16.5m/L/24kN	**412**	22.5m/L/32kN	**444**	34.5m/L/60kN
381	16.5m/L/32kN	**413**	22.5m/L/40kN	**445**	34.5m/L/80kN
382	16.5m/L/40kN	**414**	22.5m/L/60kN	**446**	36.0m/L/40kN
383	16.5m/L/60kN	**415**	22.5m/L/80kN	**447**	36.0m/L/60kN
384	16.5m/L/80kN	**416**	22.5m/L/100kN	**448**	36.0m/L/80kN
385	16.5m/L/100kN	**417**	24.0m/L/24kN	**449**	37.5m/L/40kN
386	16.5m/L/160kN	**418**	24.0m/L/32kN	**450**	37.5m/L/60kN
387	18.0m/L/24kN	**419**	24.0m/L/40kN		
388	18.0m/L/32kN	**420**	24.0m/L/60kN		

7.4.5 Steel poles

The pole range for direct-buried steel poles used within the Ausgrid Network is shown in Table 19.

Any proposed use of additional pole sizes, including high-strength poles, and poles with pile / rag-bolt mounts are to be managed via NS181 processes.

These poles can be ordered with a painted finish.

Table 19 - Available steel poles

Item	Pole Length (m)	Ultimate Tip Load (kN)	Item	Pole Length (m)	Ultimate Tip Load (kN)
1	10.0	60	**28**	23.0	80
2	10.0	80	**29**	24.5	24
3	10.0	100	**30**	24.5	32
4	17.0	24	**31**	24.5	40
5	17.0	32	**32**	24.5	60
6	17.0	40	**33**	24.5	80
7	17.0	60	**34**	26.0	24
8	17.0	80	**35**	26.0	32
9	18.5	24	**36**	26.0	40
10	18.5	32	**37**	26.0	60
11	18.5	40	**38**	26.0	80
12	18.5	60	**39**	28.0	24
13	18.5	80	**40**	28.0	32
14	20.0	24	**41**	28.0	40
15	20.0	32	**42**	28.0	60
16	20.0	40	**43**	28.0	80
17	20.0	60	**44**	30.0	24
18	20.0	80	**45**	30.0	32
19	21.5	24	**46**	30.0	40
20	21.5	32	**47**	30.0	60
21	21.5	40	**48**	30.0	80
22	21.5	60	**49**	32.0	24
23	21.5	80	**50**	32.0	32
24	23.0	24	**51**	32.0	40
25	23.0	32	**52**	32.0	60
26	23.0	40	**53**	32.0	80
27	23.0	60			

7.5 Foundations

For distribution and sub-transmission voltages, Ausgrid requires pole foundations to be designed to match the tip strength capacity and height of the pole.

The pole foundation design typically specifies:

- the sinking or embedment depth of the pole in the ground,
- the type of backfill, and
- the size of the auger to be used to bore the hole in the ground.

Ausgrid has developed a Pole Embedment Calculator (PEC) for foundation design, allowing entry of detailed soil parameters for single-layer and multi-layer soils. This calculator and instruction user manual is available from the Network Standards section of the Ausgrid website (www.ausgrid.com.au).

Alternatively, foundation design may be carried out by a qualified Civil/Structural engineer or foundation design software assessed and approved by Ausgrid. A certified plan of the design must be provided to Ausgrid before construction commences. In this circumstance, foundations shall be designed in accordance with AS/NZS7000.

These methods for foundation design override embedment depths that may appear on historical standard construction drawings and documents.

Consideration shall also be taken for additional sinking depths and construction methodologies associated with the installation of equipment on to poles like underground cables and earthing. The Designer shall take into consideration factors such as cable bending radii, orientation of the trenches, excavation depths, and time that trenches remain open.

For lines designed to a standard pre-dating AS/NZS7000:2010, poles installed to Ausgrid's standard embedment depth will have adequate footing strength for working loads in medium bearing strength soils (300kPa/m^2).

For new line or modifications to existing lines, the PEC program is developed specifically for the design of Ausgrid's pole foundations. The PEC software is intended to be used in a large range of soil types and for the full range of poles that are available on Ausgrid's NS181 AML.

The PEC will not provide a solution in all cases. Expert advice/design assistance shall be sought for designs involving the following situations:

- Poles where the PEC calculator gives a result that is more than 2m deeper than the historical rule-of-thumb (10% of the pole length plus 600mm). PEC will solve only if this rule is satisfied;
- Poles that are to be installed in swampy soils (very low strength, high water table);
- Poles that are to be installed in very loose sands that are more than 2m deep; and
- Poles where the PEC calculator cannot find a solution from the available sizes and design loads.

7.6 Pole positioning

7.6.1 Alignment / setback

The choice of pole alignment/setback for each specific site must meet all Ausgrid's safety and design criteria, and must also consider the requirements of other organisations, such as TfNSW.

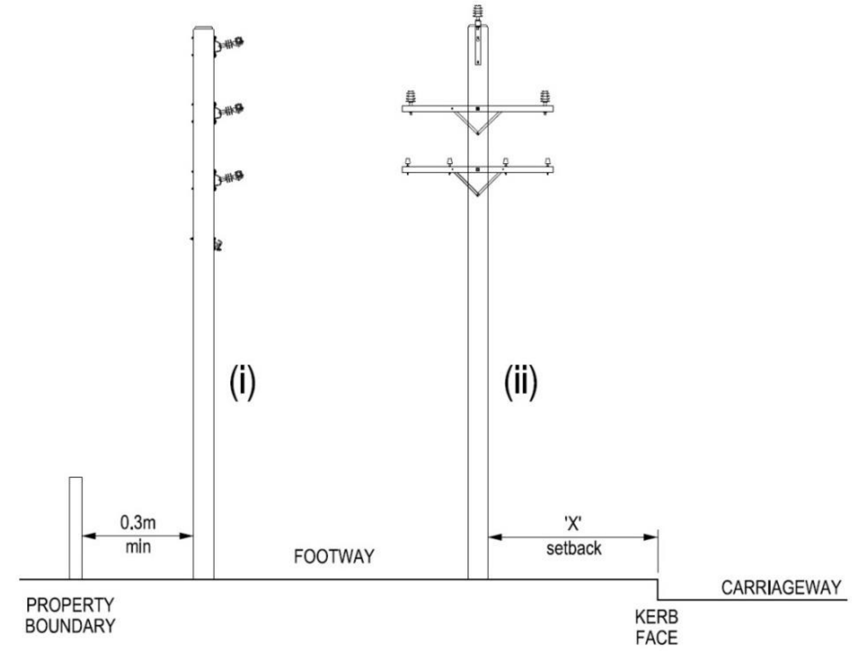


Figure 12 - Pole alignment / setback options

Figure 12 alignment (i) shows a property-side alignment. This may be selected for ABC or vertical constructions where mains comply with the clearance-to-boundary requirements of Clause 10.1.

Figure 12 alignment (ii) shows a road-side alignment with setback requirement 'X' between the face of kerb and the roadside face of pole as follows:

Table 20- Carriageway setbacks

<table>
<tr><th colspan="3">Situation</th><th>Setback 'X'</th></tr>
<tr><td colspan="3">Main Roads, State Highways, Freeways</td><td>After considering Ausgrid's requirements (in NS167 and NS220), designers shall maintain a 'Clear Zone' on TfNSW-controlled roads as far as reasonably practicable as per TfNSW requirements - refer to Table 21 Clause 7.6.2. Elsewhere, as far as reasonably practicable, maintain a 2.5m minimum setback. Note that the setback may be reduced if a pole is behind (but not touching) a guard rail or other barrier.</td></tr>
<tr><td rowspan="3">Other Roads</td><td colspan="2">Narrow footways (<5m)</td><td>0.5m minimum where practicable; 0.25m absolute minimum (for entire above ground face of pole) where site conditions prevent alternative pole placements.</td></tr>
<tr><td rowspan="2">Wide footways (>5m)</td><td>Sydney and Central Coast Areas</td><td>2.5m</td></tr>
<tr><td>Newcastle and Upper Hunter Areas</td><td>1.5m</td></tr>
</table>

Notes:

1. Setbacks and locations shown are a general guideline only and are subject to local authority requirements and coordination with other services, for example water mains. See NS128 and NS130 for utility allocations in various regions as per NSW Street Opening Coordination Council (SOCC).
2. Poles are to be installed at least 300mm from existing services and other in-ground items and there is to be at least 300mm clearance around timber poles to facilitate below-ground inspection and treatment.
3. When replacing or installing poles on an existing line, it may be more practical to use the existing alignment to keep the line straight. Setbacks less than 500mm should be addressed wherever practicable – offset constructions may help keep the line straight while moving the pole.
4. Ensure that setback is calculated from the pole face rather than pole centre. If the pole diameter cannot be obtained from the pole data in Clause 7.4, seek information directly from the pole supplier.
5. Mains shall not encroach on or come within minimum clearances to infrastructure on private property including under maximum blowout conditions. In accordance with AS/NZS 7000:2016 Appendix CC it is generally not required to obtain easements for overhead powerlines located on road reserves because of building setback conditions contained in local authority planning schemes. This can be applied provided that encroachment on private land is limited to conductor blow-out ie all portions of supporting structures and the conductors under no-wind conditions are wholly within the road reserve.

Refer to NS128 and NS167 for further information.

7.6.2 Austroads Clear Zone

When designing along TfNSW roads, as far as reasonably practicable after considering Ausgrid's requirements, all poles shall remain outside of the clear zone shown in Table 21. Further details and notes regarding this Figure can be found in Austroads Guide to Road Design - Part 6: Roadside Design, Safety and Barriers.

Table 21 - Austroads Clear zone distances from edge of through travelled way

Design speed (km/h)	Design ADT (Average Daily Traffic)	Clear zone width (m)					
		Fill batter			Cut batter		
		6:1 to flat	4:1 to 5:1	3:1 and steeper (2)	6:1 to flat	4:1 to 5:1	3:1 and steeper (2)
≤ 60	< 750	3.0	3.0	[2]	3.0	3.0	3.0
	750 – 1500	3.5	4.5	[2]	3.5	3.5	3.5
	1501 – 6000	4.5	5.0	[2]	4.5	4.5	4.5
	> 6000	5.0	5.5	[2]	5.0	5.0	5.0
70 – 80	< 750	3.5	4.5	[2]	3.5	3.0	3.0
	750 – 1500	5.0	6.0	[2]	5.0	4.5	3.5
	1501 – 6000	5.5	8.0	[2]	5.5	5.0	4.5
	> 6000	6.5	8.5	[2]	6.5	6.0	5.0
90	< 750	4.5	5.5	[2]	3.5	3.5	3.0
	750 – 1500	5.5	7.5	[2]	5.5	5.0	3.5
	1501 – 6000	6.5	9.0	[2]	6.5	5.5	5.0
	> 6000	7.5	10.0 [1]	[2]	7.5	6.5	5.5
100	< 750	5.5	7.5	[2]	5.0	4.5	3.5
	750 – 1500	7.5	10.0 [1]	[2]	6.5	5.5	4.5
	1501 – 6000	9.0	12.0 [1]	[2]	8.0	6.5	5.5
	> 6000	10.0 [1]	13.5 [1]	[2]	8.5	8.0	6.5
110	< 750	6.0	8.0	[2]	5.0	5.0	3.5
	750 – 1500	8.0	11.0 [1]	[2]	6.5	6.0	5.0
	1501 – 6000	10.0 [1]	13.0 [1]	[2]	8.5	7.5	6.0
	> 6000	10.5 [1]	14.0 [1]	[2]	9.0	9.0	7.5

Notes 1 and 2: refer to Austroads Guide to Road Design – Part 6: Roadside Design, Safety and Barriers

The TfNSW requirements do not necessarily take precedence but are to be considered along with all of Ausgrid's other required design criteria as they apply to each particular situation. Table 21 does not apply where poles are or will be installed behind a guard rail or other barrier. TfNSW may choose to vary from the table for any given site.

For Table 21:

- With the ground sloping down from road to pole at 6:1, a traffic volume of 2000 vehicles per day and a speed of 110km/h, the Clear Zone = 10m

- With the ground sloping up from road to pole at 8:1, a traffic volume of >6000 vehicles per day, and a speed of 100km/h, the Clear Zone = 8.5m

7.6.3 Longitudinal positioning considerations

NS167 contains the requirements for longitudinal positioning of poles. In addition, the Designer must be able to demonstrate that they have considered the points below.

Desirable features:

- In urban areas, position poles on the footway in line with alternate lot boundaries so that all lots can be serviced and so that there is minimal impact to house frontages. (On large lots, still try to align poles with lot boundaries).
- Straight lines are preferable, both for minimising forces on structures and aesthetics. Where deviation angles are required, minimise the deviation angles where practical.
- When using LV ABC, switching sides of the road may be the most appropriate solution on narrow roads to avoid vegetation, buildings or other clearance issues.
- Keep span lengths reasonably similar if practicable, otherwise termination points will be needed (remember 2:1 rule).
- Coordinate pole positions with road lighting requirements.
- Position poles to minimise vegetation clearing.
- On undulating ground, poles should be placed on the tops of ridges, or on the ‘shoulders’ either side of a gully.
- Where poles are earthed, ensure adequate clearances from telecommunications earths (refer NS116 Annexure C).
- Provide good access to poles, especially for poles with switches and other plant.

Undesirable features:

- Locations that will cause mains or services to cross private property. Also, minimise the number of spans of mains or services crossing roadways.
- Locations that will obstruct views from houses. This is especially important where there is pole-mounted plant.
- Poles within 1.5m from existing driveways or a location that would block gateways or access tracks on rural properties.
- Switching sides of the road more often than is necessary, particularly with LV open wire mains, as phase transpositions may be required.
- Locations where poles are likely to impede the vision of motorists or where they are likely to be struck by errant vehicles, for example, on a sharp corner, or the outside radius of a tight curve.
- Poles placed at the bottom of a gully. Not only is this inefficient, it also creates problems with uplift. Also, after heavy rain the gully may become a watercourse and the foundation may be jeopardised.
- Locations in swampy ground or loose sand where the foundation will be poor.
- Locations close to the top of an embankment where foundation strength may be compromised.
- Locations where excavation is difficult, e.g. on rocky ridges.
- Locations where there are numerous or sensitive underground services, e.g. a congested footpath with a major optical fibre cable.

- Locations where access is difficult, e.g. steep embankments, poor quality access tracks, crops, heavy vehicular traffic, median strips, behind locked gates.

7.6.4 Easement positioning considerations

Refer to NS143 Easements, Leases and Rights of Way.

7.7 Engineering notes

7.7.1 Timber pole strength

For line design, we are primarily concerned with the tip load capacity of the pole, that is, its capacity to withstand an overturning bending moment. However, combined bending moment and compressive strength can be a limitation for timber poles supporting very heavy plant items. Designers should be aware that not all line design software packages calculate combined bending moment and compressive strength.

The ultimate tip strength (kN) of a solid, round timber pole can be taken to be:

$$F_T = \frac{1000 \times (k \cdot f'_b \cdot \pi \cdot D^3)}{32 \cdot h}$$

where:

k = factor accounting for load duration, degradation, shaving, immaturity and processing (use value of 0.8 for assessing an in-service pole)

f'_b = characteristic strength in bending (MPa) – dependent on strength class as shown in Table F1 of AS/NZS7000

100MPa for S1, 80MPa for S2

D = ground line diameter (m)

h = tip height above ground (m)

For additional information, refer to AS/NZS7000 Annexure F (Timber Poles).

7.7.2 In-service timber poles

Ausgrid may not accept the risk of a loading increase on an existing pole. The typical proposed load increase may be due to adding new mains (not services), upgrading or re-tensioning conductors, the counter loading impact of a proposed undermining of pole foundation strength or trenching/civil works to install an underground cable. NS146 contains further information on altering loads on poles and reinforced poles during construction.

Part of the process of Ausgrid's pole inspection practice is the recording of sufficient measurements to calculate remnant strength. The accuracy of these measurements, and therefore the estimated remnant strength is too unreliable to use as the ultimate capacity in a design using existing poles. Hence, the Designer shall use the nominal capacity of the pole when it was new and apply the design loads and strength reduction factors as if it is a new structure. Where there is a pole disc, designers shall use the information from NS128; where there is no pole disc, designers shall use the formula in clause 7.7.1.

The Designer may judge whether the pole in question is sufficiently aged and or deteriorated to warrant replacement in any case. However, remnant strength shall not be used for the pole design if it is decided to keep the existing structure.

7.7.3 Reinforced poles

Poles are reinforced according to the assessment guideline shown in NS145 – Pole Inspection and Treatment Procedures. Pole reinforcement is designed to augment a pole's strength at groundline and assumes that the head of the pole has no significant defects or deterioration. While the reinforcing applied to poles typically provides additional capacity above the existing load requirements, any prospective change to loading of the asset will require an evaluation of the final design against the capacity of the nail.

The maintenance and construction loads described in Clause 3.3.1 also apply to reinforced poles.

Further information on reinforced poles can be found in NS146.

7.7.4 Pole Deflection

When a pole is subjected to a resultant horizontal force (for example, at a one-way termination without a stay, or at an unbalanced two-way termination without a stay), the pole will deflect in the direction of the force. The size of the force will influence the amount of pole deflection, so the Designer needs to understand how this deflection may affect their design. If pole raking is required, see NS128.

The following deflection limits on manufactured poles apply to the poles approved by Ausgrid as shown on the AML:

- Prestressed concrete poles shall have a maximum total deflection of 4% of the above ground pole length whilst 50% of the ultimate pole tip load is applied to the pole tip.
- Reinforced concrete poles shall have a maximum total deflection of 6% of the above ground pole length whilst 50% of the ultimate pole tip load is applied to the pole tip.
- Steel poles shall have a maximum total deflection of 4% of the above ground pole length whilst 50% of the ultimate pole tip load is applied to the pole tip.
- Fibre-reinforced poles shall have a maximum total deflection of 5% of the above ground pole length whilst 50% of the ultimate pole tip load is applied to the pole tip, and a maximum deflection of 15% of the above ground pole length whilst 100% of ultimate load is applied to the pole tip.

8.0 STAYS

8.1 General requirements

Stay arrangements are used when the permissible design load limits of poles are exceeded. The stay arrangement shall normally be designed to take the full applied load rather than just the portion by which the load exceeds the pole capacity. However, designs which share the resultant conductor tension between the pole which is stayed and the stay wire may be approved by Ausgrid.

Where reasonably practicable, stays should be avoided. The use of fully self-supporting angle or termination poles is the preferred alternative to the use of stays, although in locations where buried services or narrow footpaths restrict the use of poles with large butt diameters, stay poles or ground anchors can be used.

Timber, concrete and steel poles may be stayed using stay poles, ground anchors or sidewalk stays. Any proposal to stay a composite pole are to be managed via the NS181 Network Standard Variations process. Ground anchors may be screw type, rock anchors or concrete block type. Any proposal to use a driven tipping plate soil type anchors are to be managed via the NS181 Network Standard Variations process.

For new Security Level II or III designed lines, stays shall not be used unless approved in accordance with the NS181 Network Standard variation process. For all existing Ausgrid assets, the use of stays may still be acceptable however Ausgrid reserves the right to force the above rule and will be determined on a case by case basis.

Ground stays may pose a trip hazard or electric shock hazard and should not be installed on footpaths, road reserves, or other locations where members of the public are likely to come into contact with the stay wire.

Stay insulators shall be installed where the stay wire passes through or near other circuits, or where other attachments are located on the stay pole, as shown on Ausgrid’s standard construction drawings.

In the case of ground anchors with no nearby power circuits or where no attachments are likely to be made to the stay pole, the stay wire may be earthed instead. Earthed stay wires are also required where stay tensions exceed that normally handled by stay insulators.

During network augmentation or replacement, designs should enable the removal of existing stays where reasonably practical.

8.1.1 Load case

All load cases documented in Clause 3.5 are required to be checked and complied with. Generally, the maximum wind load case will be the dominant case when selecting and sizing stays. Additionally, where one pole is to be stayed to another power pole carrying a circuit, it must be demonstrated that the additional load being transferred into this other pole is checked against the requirements of Clause 3.5.

8.1.2 Stay sizing

The stay shall be designed to take the full load applied and not just the portion by which the load exceeds pole capacity. Do not assume that the pole and stay share load, since the pole tip will flex under load, whereas the stay anchor is rigid and will immediately be subjected to the full load. The Designer shall consider the effects of balancing loads. The stay shall be designed and installed to balance the static conductor loads between the stay, including the ground anchor and the main structure.

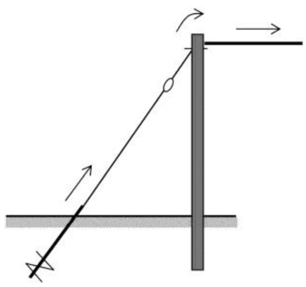


Figure 13 - Stay loading

8.1.3 Pole sizing

The use of an un-stayed higher strength pole is preferable to a lower strength pole that is stayed. Where a stay cannot be avoided, a minimum size 8kN (32kN ultimate) pole shall be used. Additionally, the pole and foundation shall be capable of withstanding the Failure Containment Load detailed in Clause 3.3.3 with the stay removed (Note: Failure Containment Load shall be applied with all phase conductors assumed to be intact instead of one third broken). This policy ensures that the pole will not collapse in the event of stay component failure in moderate weather conditions.

The 8kN minimum pole size ensures that the pole will not buckle under the additional pressure of vertical loads applied by the stay wire through the longitudinal axis of the pole.

8.1.4 Stay angle selection

Wherever reasonably practical the stay angle to the ground shall be 45°.

However, where space is limited, designers may increase the ground angle, bringing the stay anchor closer to the pole, with a maximum angle of 60°. This will increase tension in the stay wire and increase downward compressive forces on the pole and its foundation.

While reducing the ground angle below 45° reduces stay tension, it creates practical difficulties in terms of stay anchor installation. The stay anchor rod shall be in line with the stay wire; otherwise there will be a tendency for the rod to bend and the galvanised coating may be compromised.

8.1.5 Construction stays

Temporary stays on strategic poles could be required while construction is in progress, prior to all conductors being erected and correctly tensioned. Depending on construction strategies, these locations shall be identified and the corresponding construction load case must be complied with.

Note that it is up to the Designer and the work planners to ensure that the construction sequencing is taken into consideration, using the loads applicable from the construction load case.

8.1.6 Stay location selection

Where practicable, ground stays (including sidewalk stays) shall not be used in frequented areas such as roadside footpaths, public areas, bicycle ways, horse riding areas or livestock forcing areas near stock yard access ways.

Permanent Ground Stay Anchor metalwork needs to be positioned to avoid corrosion by ground level soil coverage of the galvanised steel stay wire and its galvanised steel termination fittings.

Use of ground stays in flash-flood prone areas shall be avoided in places where flood debris can accumulate on the flooded stay enhancing water wake footing erosion and drag loading.

8.1.7 Stay guards and barriers

Where used in non-public unfrequented locations or rural areas, stay guards or barriers shall be positioned to protect the ground stay from instances such as large animals rubbing against it or collisions with the stay wire by vehicles, people or animals. Guards shall not be positioned close to a fence in a way that could cause stock (cattle, horses etc) to become entrapped or injured.

Barriers may be required for flood protection of stays and poles.

8.2 Stay type selection

Ground Stay

Suitable for most rural type applications. Where ground stays/anchors are used, adequate protective measures in accordance with details provided on standard construction drawings, shall be employed to warn people of the presence of stay wires or to protect the wire from damage by livestock, etc.

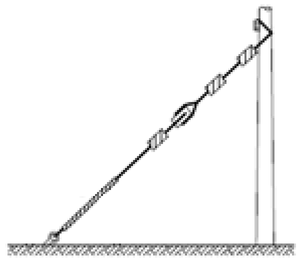


Figure 14 - Ground Stay arrangement

Sidewalk Stay

Used where there is insufficient space for a ground stay e.g. where the stay is confined to the width of a footpath. They have limited capability and are less efficient than a regular ground stay.

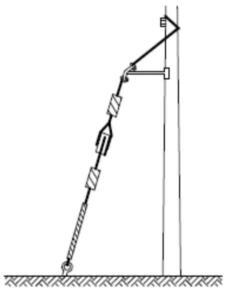


Figure 15 - Sidewalk stay arrangement

Pole (Aerial) Stay

Used where a ground stay is unsuitable e.g. crossing a roadway and most urban areas.

In non-urban environments, the stay pole may be supported with a ground stay.

Pole stays may also include other Ausgrid power poles which carry circuits. Foundations for stay poles shall be designed as per Clause 7.5.

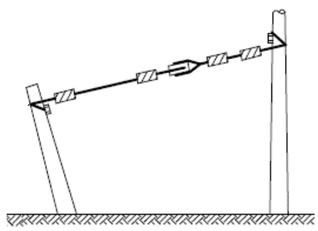


Figure 16 - Typical pole stay arrangement

8.3 Ground anchor selection

8.3.1 Ground anchor type

Refer to Ausgrid's ground anchor standard construction drawings.

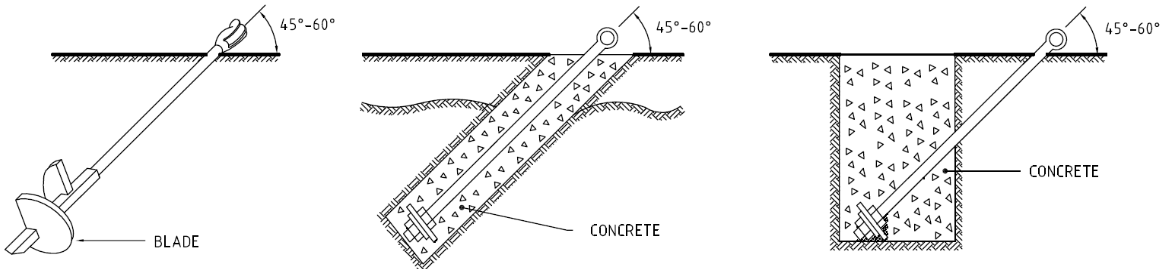


Figure 17 - Ground anchor types

Screw Anchor
Used for most soil types (Soil Classes 2 – 7)

Rock Anchor
Used in bedrock and cemented sand where screw anchors cannot be driven to the required depth. (Soil Class 1)

Mass Concrete
Used in very poor soil or where drainage is poor e.g. swampy areas, loose sand or to avoid interfering with underground services. (Soil Class 8, also Classes 6 and 7 if necessary)

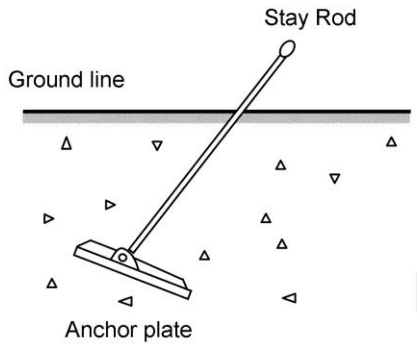


Figure 18 - Pivoting plate anchor

Pivoting plate anchor

With this type of anchor, the anchor plate is aligned with the stay rod when driven into the ground. The stay rod is then partially retracted, and the anchor plate pivots to the position shown.

Pivoting plate anchors may only be used if approved by the NS181 Network Standard variation process.

The following table provides screw anchor strength and minimum torque settings to be used under different soil conditions.

Table 22 - Screw Anchor Strength and Minimum Installation Torque

No. of blades	Blade diameter	Typical use	Element	Good soil		Average soil		Poor soil	
				2	3	4	5	6	7
1 SINGLE	200mm	GOOD SOIL	Strength (kN)	92	76	64	48	36	20
			Install Torque (Nm)	7600	5600	3700	2300	1300	400
			No. Shear Pins	8	6	4	3	3	
	250mm	AV. SOIL	Strength (kN)	-	84	68	56	40	24
			Install Torque (Nm)	-	6100	4200	2500	1500	600
			No. Shear Pins	-	7	6	5	3	
	300mm	POOR WET SOIL	Strength (kN)	-	92	76	64	48	32
			Install Torque (Nm)	-	6800	4400	3100	1750	800
			No. Shear Pins	-	7	5	4	3	
2 DOUBLE	200mm	POOR DRY SOIL	Strength (kN)	-	-	96	76	56	36
			Install Torque (Nm)	-	-	5700	3800	2200	1800
			No. Shear Pins	-	-	6	4	3	
	250mm	POOR DRY SOIL	Strength (kN)	-	-	108	88	68	48
			Install Torque (Nm)	-	-	6000	4100	2500	900
			No. Shear Pins	-	-	7	6	3	

Soil Category	Soil Class	Description
Good	1	Solid bedrock — USE ROCK ANCHOR
	2	Hardpan; dense fine sand; compact gravel; laminated rock; slate schist; sandstone
	3	Hard clay; dense sand; shale; broken bedrock; compact clay-gravel mixtures
Average	4	Medium dense sand gravel mix; very stiff to hard clays and silts
	5	Medium dense coarse sand or sandy gravel; stiff to very stiff silts and clays
Poor	6	Loose to medium dense sand; firm to stiff clays and silts
	7	Medium stiff clay; loose sand; fill; silt
	8	Soft clay; very loose sand; swampy ground; humus; saturated silt — USE MASS CONCRETE ANCHOR

8.4 Stay wire sizing

8.4.1 Ground stays

The following table provides available stay wire sizes and loads to be used when designing for stays.

Table 23 - Stay Wire Sizes and Capacity

Steel Stay Wire	Stay Wire Breaking Load (kN UTS)	Maximum Design Load (kN) Strength Factor 0.8
7/2.75	49	39.2
19/2.00	70.5	56.4
2 x 19/2.00	141.0	112.8
16mm Wire Rope	184	147.2

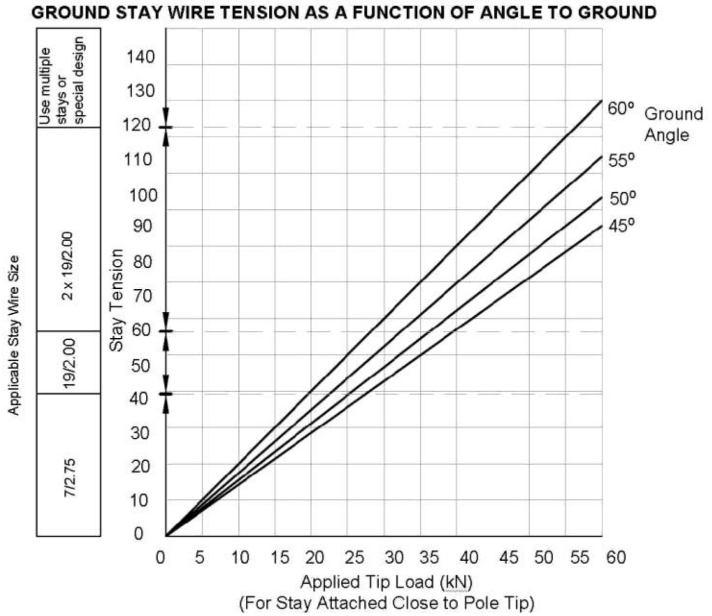


Figure 19 - Tip load vs ground angle relationship

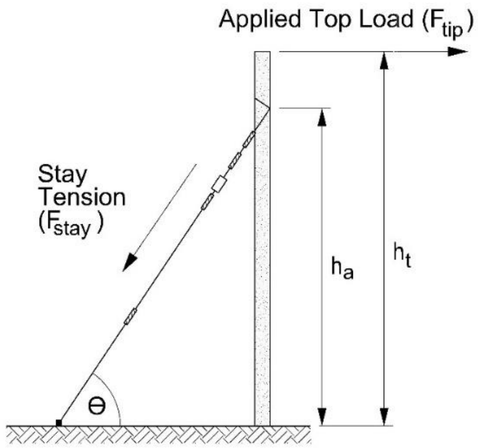


Figure 20 - Stay wire loading

Stay wire load is affected by:

- angle of stay to ground—preferred angle range is 45° - 60°
- attachment height—attach on pole as high as practicable.

Stay tension may be calculated as follows:

$$F_{stay} = \frac{F_{tip}}{\cos\theta} \times \frac{h_t}{h_a}$$

where:

F_{stay} = Stay tension (kN)

F_{tip} = Applied tip load (kN)

θ = Angle of stay to the ground

h_a = Stay attachment height above ground (m)

h_t = Pole tip height above ground (m)

8.4.2 Sidewalk stay

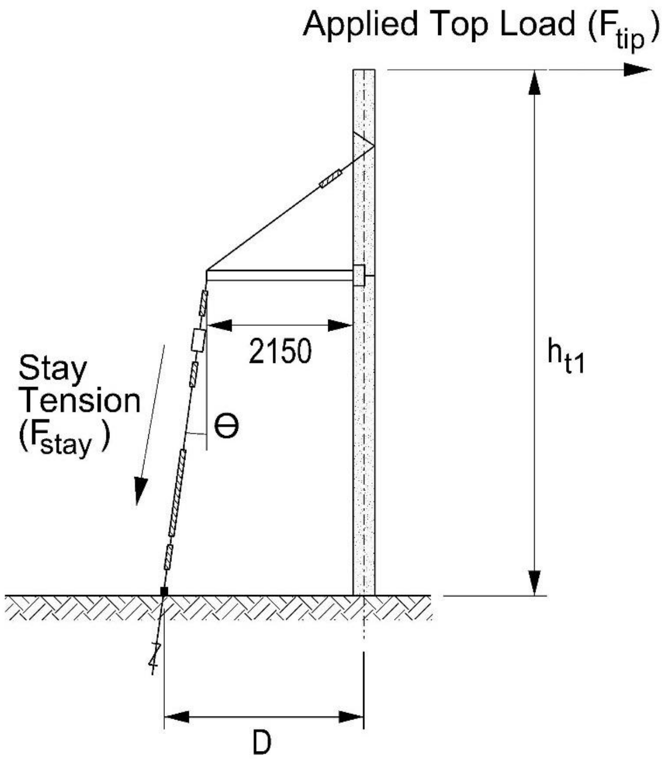


Figure 21 - Sidewalk stay wire loading

Calculation Formula

$$F_{stay} = \frac{F_{tip}\, h_t}{D \cos\, \phi}$$

F_{stay} = Stay tension (kN)

F_{tip} = Applied tip load (kN)

Φ = Angle of stay to vertical

h_t = Pole tip height above ground (m)

D = Distance from pole centre to ground anchor (m)

The following table provides sidewalk stay sizes and loads for a range of designs.

Table 24 - Wire Selection guide

Stay Wire Size	Maximum Applied Tip Load (kN)					
	Φ	0°	5°	10°	15°	20°
	D	2.45m	3.05m	3.76m	4.49m	5.26m
7/2.75		9.6	11.9	14.5	17.0	19.4
19/2.00		13.8	17.1	20.9	24.5	27.8
2 x 19/2.00		27.4	34.0	41.5	48.6	55.4

The table assumes a tip height of 10.0 m. For significantly different heights, use the formula shown.

8.4.3 Pole (aerial) stay

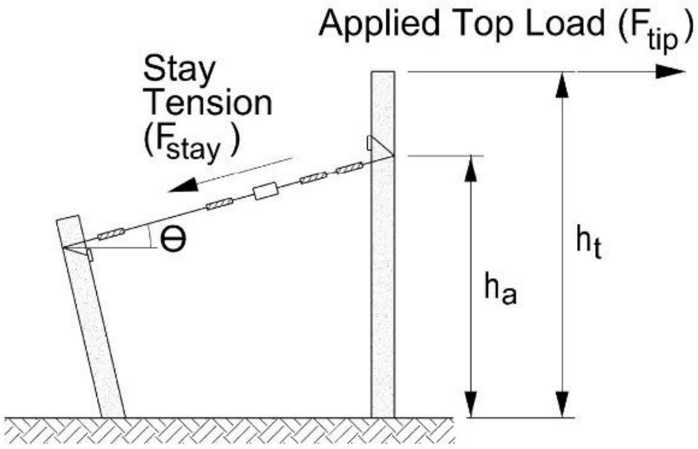


Figure 22 - Pole stay wire loading

Stay wire load is affected by:

- angle of stay to pole stay
- attachment height—attach on pole as high as practicable.

Stay wire sizes and capacity are shown in Table 23.

Stay tension may be calculated as follows:

$$F_{stay} = \frac{F_{tip}}{\cos\theta} \times \frac{h_t}{h_a}$$

where:

F_{stay} = Stay tension (kN)

F_{tip} = Applied tip load (kN)

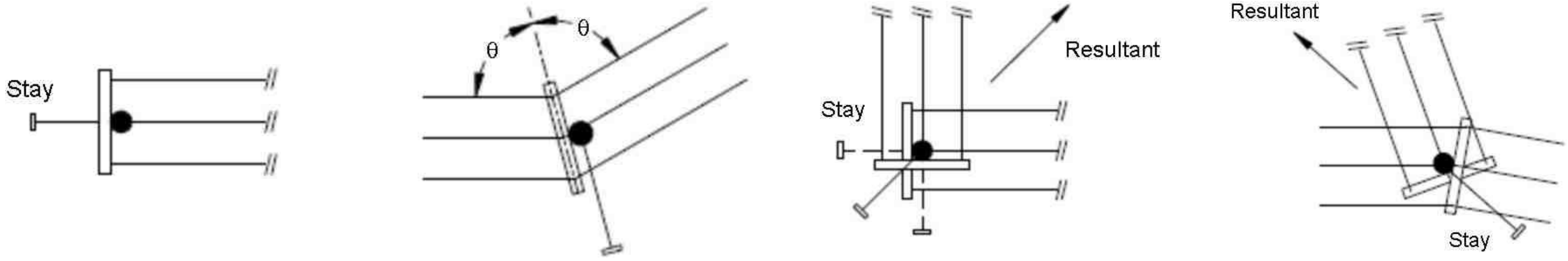
θ = Angle of stay to the ground

h_a = Stay attachment height above ground (m)

h_t = Pole tip height above ground (m)

8.5 Stay positioning

8.5.1 Single stay



TERMINATION POLE
Stay opposite attached circuit

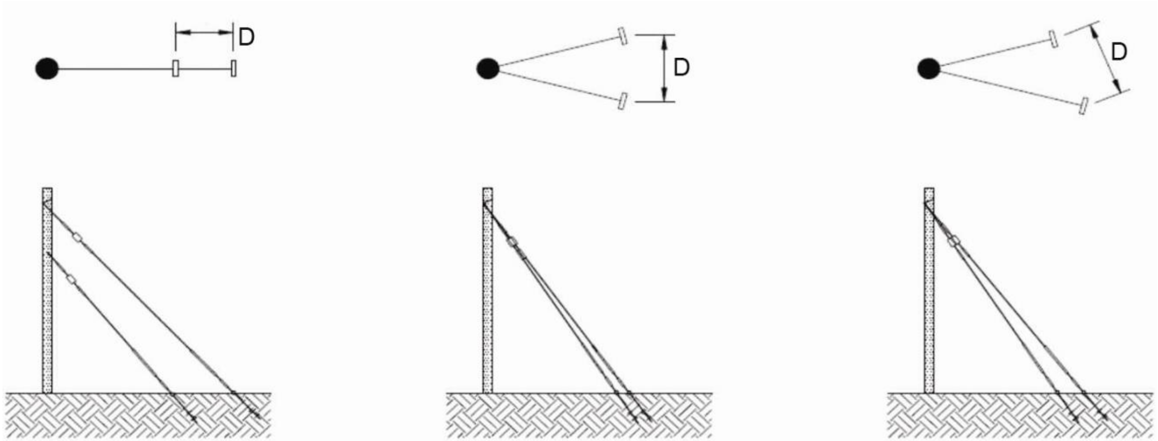
LINE DEVIATION POLE
Stay opposite bisector of deviation angle.

CORNER OR HEAVY DEVIATION ANGLE
Use either a single stay opposite resultant force direction or two stays – one opposite each circuit (advantages for construction).

COMPLEX POLE
Stay opposite resultant force direction.

Figure 23 - Stay wire configurations

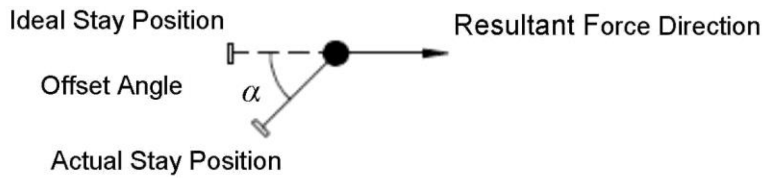
8.5.2 Dual stay



Dual stays are used where required stay tension exceeds the capacity of a single stay. As a general rule, 'D' should be greater than 2.0m for screw anchors.

Figure 24 - Dual stay wire configurations

STAY POSITIONING – OFFSET FROM IDEAL POSITION



As the stay offset angle increases, more load must be borne by the pole.

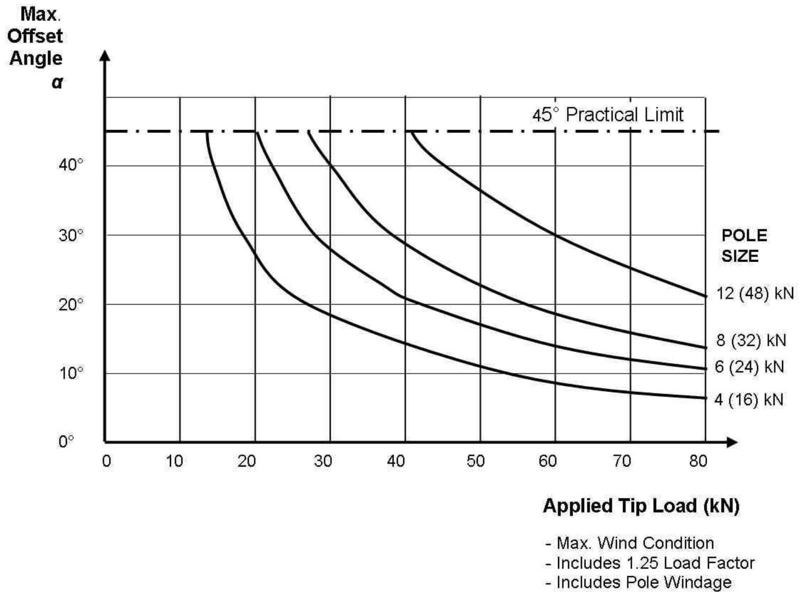


Figure 25 - Offset stay forces

Notes:

1. This graph is provided as a general guideline for distribution poles. Precise calculations may yield slightly different results for individual cases.
2. The maximum practical offset angle shall be taken to be 45°.

9.0 POLETOP CONSTRUCTIONS AND ATTACHMENTS

9.1 Application guide

Ausgrid standard constructions can be found in the 'Reference Drawing Lists' for the associated network standard i.e. NS125, NS126 and NS135 for LV, HV and sub-transmission lines respectively. These can be found on the Ausgrid website by following the link to Network Standards.

Flat (horizontal) construction has the advantage of requiring minimal pole height, but at the expense of greater overall overhead line and easement width.

Flat constructions are preferred for spans in areas frequented by large aquatic birds. Increased horizontal conductor separation can reduce conductor flashover due to bird impact. Bird diverters can be added to conductors to provide more effective visual warning to birds in flight.

Vertical construction is excellent for narrow easements or to reduce vegetation clearing but requires additional pole height.

Vertical Delta or Delta Pin construction provides both horizontal and vertical separation between phases, which helps reduce the incidence of conductor clashing.

Generally, the more compact a pole-top construction is, the less visually obtrusive it is, although reduced phase separation means reduced spanning capability (shorter spans). Designers should aim to keep constructions reasonably consistent along a line. Not only is this more visually pleasing but rolling from one style to another can reduce spanning capability and cause confusion with phasing.

Eyebolt and eyenut deviation angles can affect the allowable tension on conductors. Standard Construction Drawings 520331 and 520324 (refer to Figures 26 and 27) shall be consulted to ensure that tension limits are not exceeded. This typically becomes an issue when large deviation angles are specified at a corner or at the edge of a precipice. If the eyenut arrangement capacity is exceeded, the Designer must analyse for eyebolt-only connections, and specify this clearly on their design documentation if this is the required solution.

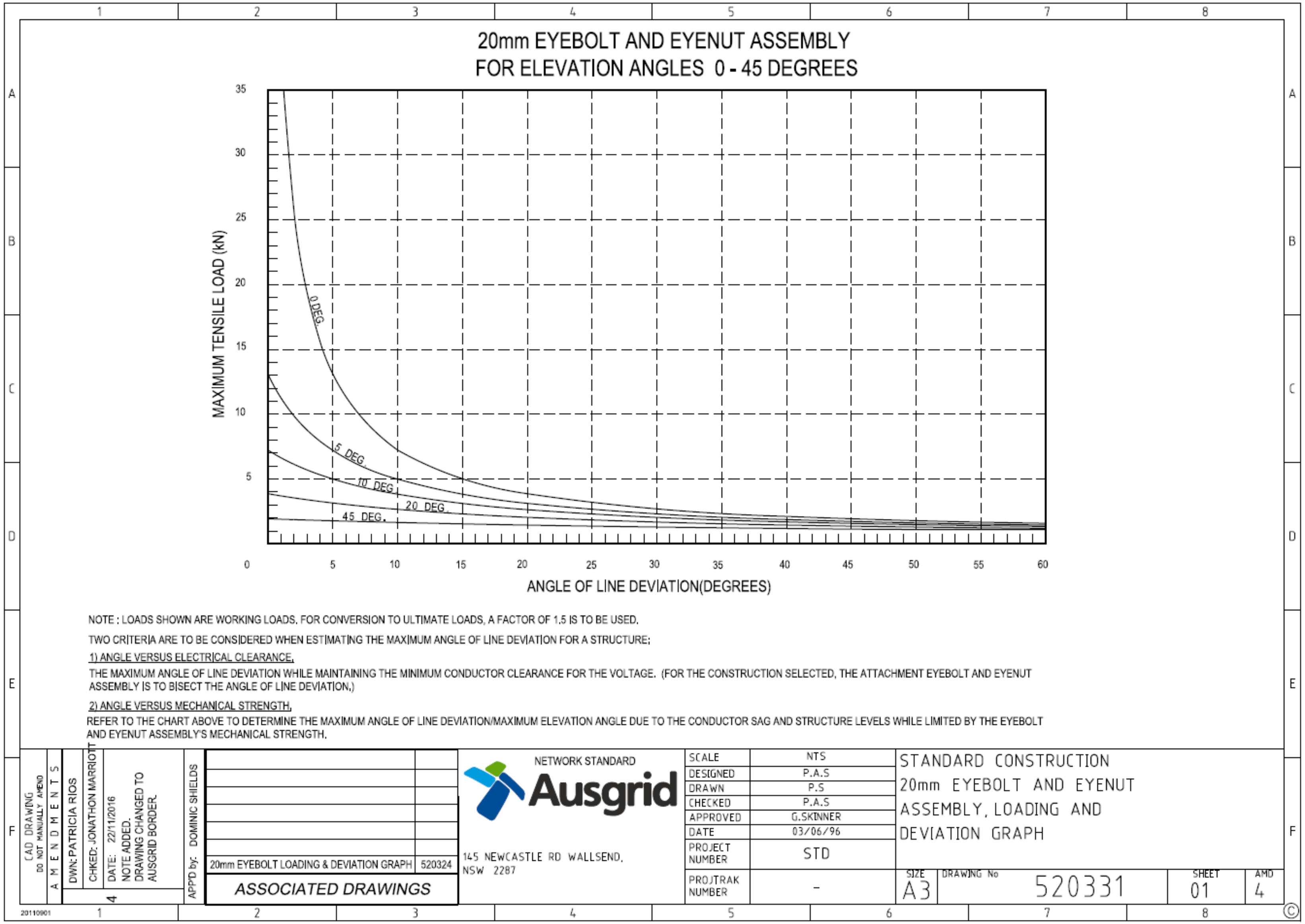
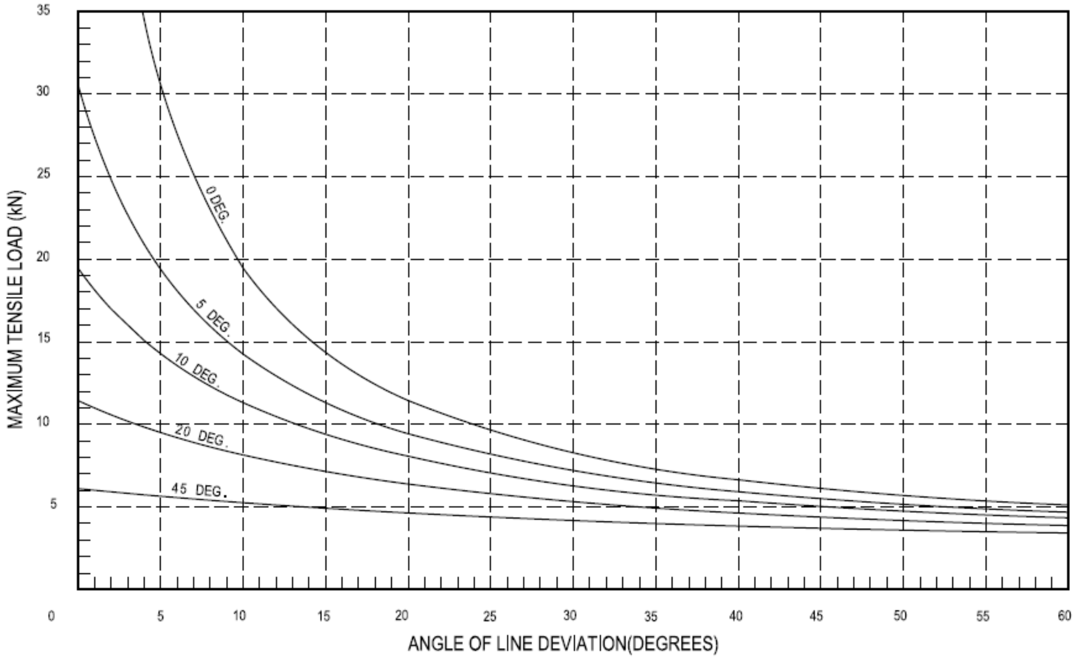


Figure 26 - Eyebolt and Eyenut loading

20mm EYEBOLT ONLY
FOR ELEVATION ANGLES 0 - 45 DEGREES



NOTE : LOADS SHOWN ARE WORKING LOADS. FOR CONVERSION TO ULTIMATE LOADS, A FACTOR OF 1.5 IS TO BE USED.

TWO CRITERIA ARE TO BE CONSIDERED WHEN ESTIMATING THE MAXIMUM ANGLE OF LINE DEVIATION FOR A STRUCTURE;

1) ANGLE VERSUS ELECTRICAL CLEARANCE.

THE MAXIMUM ANGLE OF LINE DEVIATION WHILE MAINTAINING THE MINIMUM CONDUCTOR CLEARANCE FOR THE VOLTAGE. (FOR THE CONSTRUCTION SELECTED, THE ATTACHMENT EYEBOLT IS TO BISECT THE ANGLE OF LINE DEVIATION.)

2) ANGLE VERSUS MECHANICAL STRENGTH.

REFER TO THE CHART ABOVE TO DETERMINE THE MAXIMUM ANGLE OF LINE DEVIATION/MAXIMUM ELEVATION ANGLE DUE TO THE CONDUCTOR SAG AND STRUCTURE LEVELS WHILE LIMITED BY THE EYEBOLTS MECHANICAL STRENGTH.

CAD DRAWING DO NOT MANUALLY AMEND

AMENDMENTS: 4 — DWN: PATRICIA RIOS; CHKED: JONATHON MARRIOTT; DATE: 22/11/2016; NOTE ADDED. DRAWING CHANGED TO AUSGRID BORDER. APP'D by: DOMINIC SHIELDS

ASSOCIATED DRAWINGS	
20mm EYEBOLT & EYENUT ASSEMBLY.	520331
LOADING & DEVIATION GRAPH	

NETWORK STANDARD

Ausgrid

145 NEWCASTLE RD WALLSEND. NSW 2287

SCALE	NTS
DESIGNED	P.A.S
DRAWN	P.S
CHECKED	P.A.S
APPROVED	G.SKINNER
DATE	03/06/96
PROJECT NUMBER	STD
PROJTRAK NUMBER	-

STANDARD CONSTRUCTION
20mm EYEBOLT
LOADING AND
DEVIATION GRAPH

SIZE	DRAWING No	SHEET	AMD
A3	520324	01	4

20110901 ©

Figure 27 - Eyebolt loading

9.2 Vertical to horizontal transitions

Where midspan phase separation is violated in the transition from vertical to horizontal geometry consideration shall be given to an intermediate delta structure. If an intermediate delta structure cannot be used, careful analysis of phase positions at each structure could achieve required mid span clearances.

9.3 Bridgings

Bridgings, also known as 'tappings', are required to join mains at termination and tee-off structures. Bridgings, also known as 'droppers', are also used to join electrical apparatus to the mains. Refer to the relevant Standard Construction drawing for information on the required line fittings to make bridgings.

It is essential that electrical clearances are maintained between bridging conductors and pole hardware. It may be necessary to use bridging insulators to maintain these clearances. Regardless of the arrangement, bridging conductors must remain securely fitted during all weather and fault conditions.

The Designer also needs to consider where electrical clearances may be compromised between multiple bridging conductors on the same pole, for example, between over/under-built circuits. Where required, the Designer shall provide advice on the design drawing regarding the configuration of bridging conductors.

If bridging conductors are required over the top of the crossarm for all three phases, the Designer needs to consider the risk of wildlife flashover. In bushfire-prone areas, near highly-vegetated areas or on conductive poles, the Designer may consider the need for a composite-fibre crossarm (in lieu of a steel crossarm) to reduce the risk of flashover, as long as mechanical strength is adequate.

9.4 Pole-mounted plant and attachments

9.4.1 Transformers

Refer to NS122 for design information on pole mounted substations specifically regarding;

- Site requirements especially environmental and physical restrictions on pole locations
- Pole size and strength requirements
- Transformer orientation on poles
- LV mains and service requirements

The following table shows approximate weights and effective areas for typical transformers installed on Ausgrid poles.

Table 25 - Weight and area of transformers 100kVA and above

<table>
<tr><th rowspan="2">Primary Voltage</th><th rowspan="2">Capacity</th><th rowspan="2">Approximate Weight
(see Note 1)</th><th colspan="2">Approximate Effective Area</th></tr>
<tr><th>Face</th><th>Side</th></tr>
<tr><td rowspan="3">11kV</td><td>100kVA</td><td>765kg</td><td>0.89m²</td><td>0.54m²</td></tr>
<tr><td>200kVA</td><td>1055kg</td><td>1.03m²</td><td>0.62m²</td></tr>
<tr><td>400kVA</td><td>1700kg</td><td>1.22m²</td><td>0.74m²</td></tr>
</table>

Notes:

1. Transformer weight has only a small effect on the overturning moment or tip load of the pole as the centre of mass is only a short distance from the pole axis.
2. The effect of mining lease open cut mine air blast pressure wave can be up to 100mm /sec or higher in special cases, and it is not allowed for in standard maximum wind design. A separate design assessment is appropriate case by case.

9.5 Aerial warning markers

Where overhead lines encroach into space considered to be the legitimate domain of aircraft, or where aircraft are known to operate in the vicinity of overhead lines, the overhead lines may need to be marked to indicate their position and/or direction. The Designer shall refer to Australian Standard AS3891.1, AS3891.2 and Civil Aviation Guidelines to determine whether the overhead line requires aerial warning markers. If they are required, the markers shall be in accordance with AS3891.1 and AS3891.2.

In areas where an overhead line crosses above another line, the lower of which is subjected to aerial inspections, then structures shall be marked in accordance with AS3891.2.

The Designer shall also consider the appropriateness of aerial warning markers in areas likely to be used by aircraft involved in firefighting. This may be pertinent where the presence of smoke is likely to reduce the visibility of overhead lines – for example where aircraft would be flying low over waterways collecting water.

The installation of markers on existing lines, for example to assist in low-level flying for agricultural or similar purposes, is typically undertaken at the cost of the person requesting them. When designing new lines in these areas, the Designer shall take into account the need for aerial warning markers through consultation with potentially-affected parties.

For the assessment of overhead lines that potentially encroach into airspace, the Designer shall:

- Determine the conductor height above ground level by modelling the line at 5°C under still air conditions
- Compare structure heights and conductor heights above ground level against the requirements in AS3891.1 and/or AS3891.2 and/or Civil Aviation Guidelines
- Consult with affected parties as required
- Model the line to assess the impact of the additional wind load and weight of the aerial warning markers

For marking of waterway crossings, refer to Clause 10.7.

9.5.1 Bird Diverters

Designers shall consider the installation of bird diverters for areas:

- With a high-level of bird activity, for example wetlands
- Frequented by birds with large wingspans
- Identified in the Environmental Impact Assessment

9.6 Engineering notes

9.6.1 Conductor clashing

To prevent conductor clashing refer to requirements in Clause 10.3.5:

Larger spacing between conductors at supports reduces the likelihood of conductor clashing.

The probability of mid-span clashing also increases as conductor sag increases. Sag increases with span length, but decreases with increased stringing tension, so tighter stringing enables greater distances to be spanned. Also, as deviation angle increases, there is a reduction of spacing between phase conductors, as illustrated right.

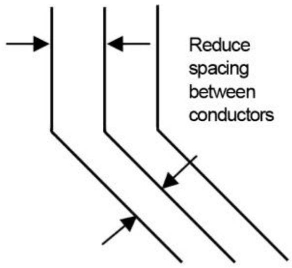


Figure 28 - Conductor clashing

9.6.2 Crossarms

A crossarm acts as a beam, attached to the pole via a king bolt, and supported at a secondary point (and potentially a tertiary point) when a brace is used. A crossarm must be capable of supporting the vertical, transverse and longitudinal loads of its attachments under the limit states of Clause 3.3. Special attention shall be given to construction and maintenance loads, Q, which are likely to be imposed on the crossarm, for example, safe working procedures catering for the addition of a 100kg worker (refer to Q in Clause 3.3.4).

9.6.3 Timber crossarms

Designs for new timber crossarms shall employ the following parameters:

Strength group = S2 (unseasoned)

Stress grade = F17

Fibre stress (bending) = 42MPa

Crossarm dimensions: depth = 100mm and width = 100mm or 150mm (refer to the specific Standard Construction drawing for the correct width)

For designs using existing timber crossarms, the material may be regarded as seasoned when:

- the crossarm has been in service for more than five years, and
- the site is more than 10km from the coast.

In this case, the following parameters shall be employed:

Strength group = SD2 (seasoned)

Stress grade = F27

Fibre stress (bending) = 67MPa

Crossarm dimensions – depth = 90mm; width = 90mm or 140mm (dimensions of seasoned crossarms are nominally 10mm less than for unseasoned crossarms)

9.6.4 Composite fibre crossarms

Composite fibre (CF) crossarms may be used where the mechanical strength of timber crossarms is insufficient. For example, CF crossarms may be used where they permit longer spans reducing the overall cost of the line. Situations where a CF crossarm may be required include but are not limited to:

- LV termination structures;
- 11kV termination structures;
- Sub-transmission feeders (intermediate and termination structures);
- Conductive poles, particularly with athwartship and/or termination constructions where bridging conductors increase the risk of wildlife flashover (refer to Clause 9.3). This is pertinent in bushfire-prone areas or near highly-vegetated areas where wildlife is more prevalent.

9.6.4.1 CF crossarm details

CF crossarms are generally available in three sizes shown below and shall comply with electrical, mechanical and other requirements as shown in drawing 237491:

Table 26 - Crossarm details

Crossarm Type	Approx. Dimensions (mm)	Ausgrid Stock Code
Composite Fibre LV or 11kV Termination	2750 x 125 x 125	183933
Composite Fibre HV Intermediate	3030 x 100 x 100	183934
Composite fibre HV Termination	3070 x 125 x 125	183935

9.6.4.2 CF crossarm limitations

Any items to be attached to the CF crossarm must make use of either the predrilled holes or the approved support brackets as shown in drawings 235149, 235150, 238151. To preserve the structural integrity of the CF crossarms and for the safety of personnel, CF crossarms shall not be drilled, cut or trimmed without the approval from Ausgrid's Transmission or Distribution Engineering.

9.6.4.3 Recording of CF crossarm details in SAP

All CF crossarm installations must be recorded in SAP in accordance with DG 214B. For ASP projects, this requirement is facilitated by the ASP/1 completing a 'Pole & Pillar Data Capture Sheet'. Where CF crossarms are specified in a design, a note shall be added to the design drawing to highlight this recording requirement to the constructor.

9.6.4.4 Design Capacities

Design capacities of CF crossarms are dependent on construction methodology and test results and are therefore proprietary. Ultimate capacities of CF crossarms approved for use on Ausgrid's network are:

Table 27 - Crossarm strength

Crossarm Type	Ultimate Moment (kN-m)	Ultimate Capacity (kN)
2750x125x125 LV or 11kV Termination	33.8	18.1
3030x100x100 HV Intermediate	17.7	11.0
3070x125x125 HV Termination	33.8	23.3

9.6.5 Steel crossarms

Steel crossarms may be used where the mechanical strength of timber crossarms and composite fibre crossarms is insufficient. This may facilitate longer spans which lower the overall cost of the line, however steel can result in lower reliability due to risks of wildlife flashovers and loss of insulation coordination. Situations that a steel crossarm may be required include but are not limited to:

- 11kV termination structures which involve the use of large conductors and/or high tensions;
- Sub-transmission feeders (intermediate and termination structures).

Steel crossarms shall not be used on LV bare distribution lines.

Steel crossarms shall not be used on HV distribution lines without considering the effect on insulation coordination. This may require insulators with higher flashover performance or longer creepage length. Refer to NS126 for further information.

Where the standard construction drawings for sub-transmission lines mandate steel crossarms, no further changes are required to the insulation level.

10.0 CLEARANCES

10.1 Ground and Structure Clearances

Lines shall be designed such that the distance between conductors and the ground is not less than that specified in Table 28, with the conductors at the maximum operating temperatures specified in Table 6.

Lines shall be designed such that the distance between conductors and structures is not less than that specified in Table 29, under the blowout conditions specified in Table 5.

The Ausgrid design clearance requirements shown exceed those provided for in AS/NZS7000 (the latter are shown in brackets in the table). These clearances do not apply to maintenance or inspection activities, the clearances for which are included in the relevant network standards. The increased clearances in this standard are intended to account for variations in the ground profile over time and the movement of poles, and are not intended to account for variations, deficiencies or errors during construction.

These tables indicate the minimum clearances required in the design of overhead lines under the ordinarily expected worst combination of weather conditions and current loadings. These clearances shall be achieved in all new designs and major reconstructions. Any proposal to design a lesser clearance shall be managed via the NS181 Network Standard Variations process. Under no circumstances will clearances be reduced below the AS/NZS7000 requirements listed.

Additional clearance shall be allowed if there is likely to be a future underbuilt circuit constructed. Also, additional clearance shall be allowed in special circumstances such as along private roads or adjacent to and over parts of public roads likely to carry high loads (for example, in mining areas, heavy industrial sites, and major highways or motorways).

A road is any recognised road or track traversable by vehicles, or land frequented by heavy vehicles carrying stock. This includes visibly worn vehicle paths across an area of land at the time of design.

Dimensions D and E shall not be taken as meaning only the literal vertical. The actual clearance may also extend outwards in an arc until it intersects with the relevant F dimension clearance.

Covered' conductor (e.g. CCT) is not insulated and must comply with clearances as shown for 'covered' conductor.

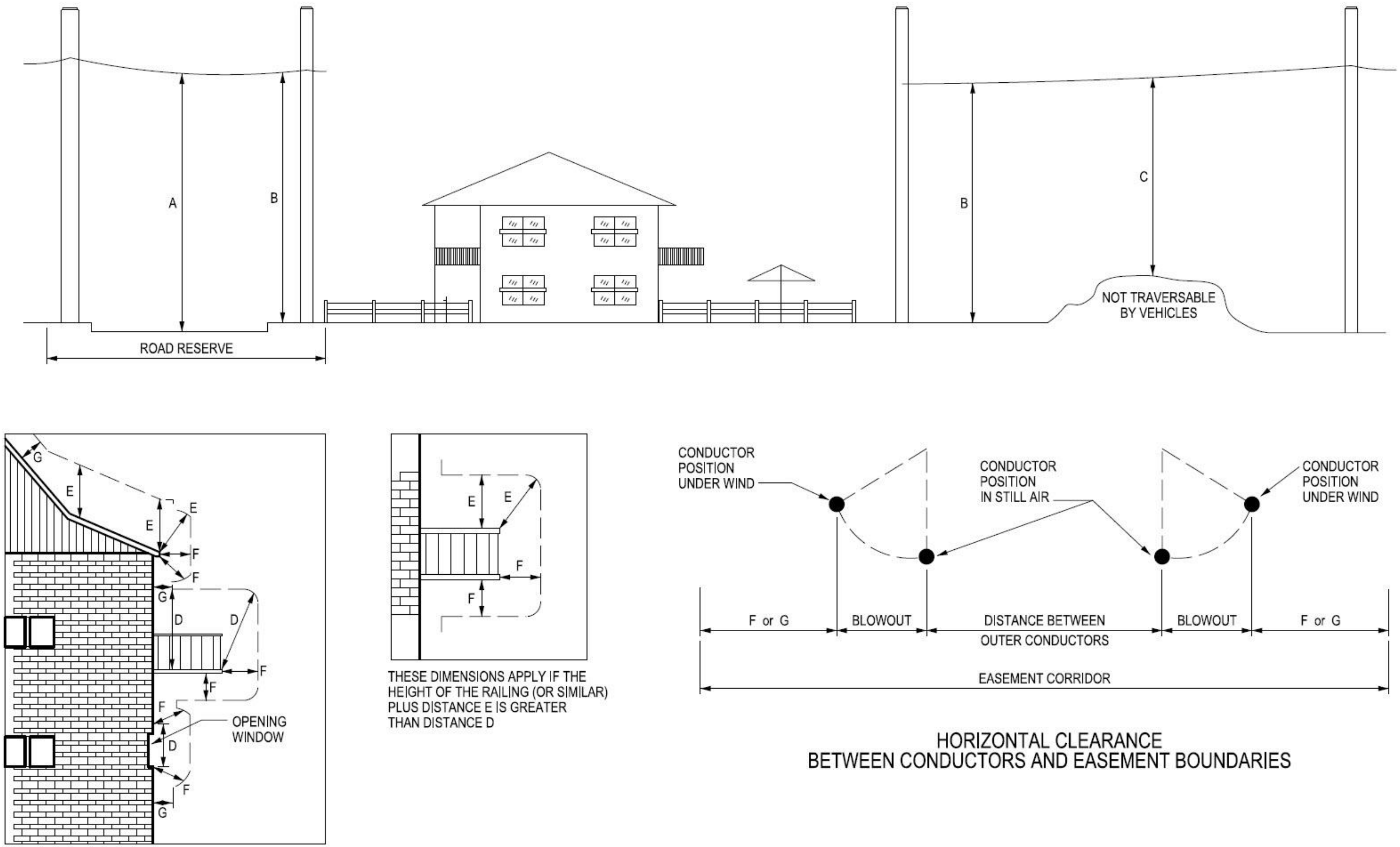


Figure 29 – Figure indicating locations around overhead mains – refer to Table 8 and Table 9

Table 28 - Minimum clearance from ground

DIMENSION	LOCATION	Distance to ground in any direction — Nominal System Voltage				
		LV insulated or bare	11kV, 22kV, and 12.7kV SWER bare or covered	33kV	66kV	132kV
		m	m	m	m	m
A	Over the carriageway of roads	6.0 (5.5)	7.5 (6.7)	7.5 (6.7)	7.5 (6.7)	7.5 (6.7)
B	Over land other than the carriageway of roads	6.0 (5.5)	6.0 (5.5)	6.0 (5.5)	7.0 (6.7)	7.5 (6.7)
C	Over land which, due to its steepness or swampiness, is not traversable by vehicles	5.0 (4.5)	5.0 (4.5)	5.0 (4.5)	6.0 (5.5)	6.0 (5.5)

Table 29 - Minimum clearance from structures, buildings and easement boundaries

DIMENSION	LOCATION	LV			11kV to 33kV			66kV to 132kV
		Insulated (LV ABC)	Bare or covered neutral	Bare or covered active	Insulated with earthed screen	Insulated without earthed screen	Bare or covered	Bare
		m	m	m	m	m	m	m
D	Vertically above those parts of any structure normally accessible to persons	2.7	2.7	3.7	2.7	3.7	4.5	5.0
E	Vertically above those parts of any structure not normally accessible to persons but on which a person can stand	2.0	2.7	2.7	2.7	2.7	3.7	4.5
F	In any direction (other than vertically above) from those parts of any structure normally accessible to persons, or from any part not normally accessible to persons but on which a person can stand	1.0	0.9	1.5	1.5	1.5	2.1	3.0
G	In any direction from those parts of any structure not normally accessible to persons	0.1	0.3	0.6	0.1	0.6	1.5	2.5

10.2 Service cables

Service cable clearances shall be in accordance with the Service and Installation Rules of New South Wales and NS124.

10.3 Intercircuit spacing

10.3.1 Clearance to interspan pole

Minimum clearances to interspan poles are shown in the table below. Where practicable unattached short height intermediate poles should not be used in new designs. Clearance issues to an existing interspan pole can be solved by replacing the interspan pole with a full height pole and attaching top and bottom circuits.

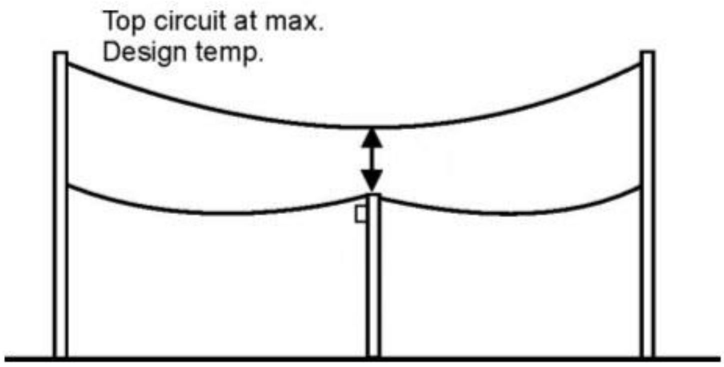


Figure 30- Clearance to interspan pole

Table 30 - Clearance to interspan pole

Top Circuit Voltage	Clearance to interspan pole (m)
11kV	1.5
33kV	1.8
66kV	1.8
132kV	2.4

10.3.2 Same support structure, same electrical circuit

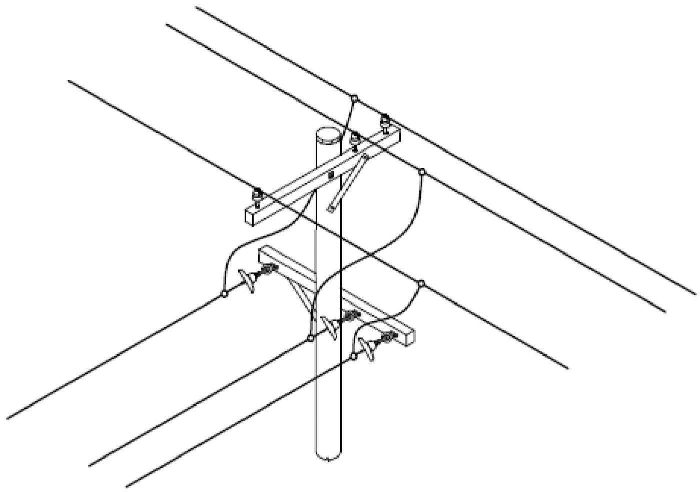


Figure 31 - Same support, same circuit

Table 31 - Same support, same circuit clearances

The following table provides minimum clearances between same circuits on the same support structure.

Upper Circuit / Lower Circuit	LV bare or covered (m)	LV insulated (LV ABC) (m)	11kV, 22kV, 12.7kV SWER Bare or CCT (m)
LV bare or covered	0.6 (see Note 1)	0.3 (see Note 3)	-
LV insulated (LV ABC)	0.3 (see Note 1)	0.3 (see Note 1)	-
11kV, 22kV, 12.7kV SWER Bare or CCT			0.75 (see Note 2)

Notes:

1. This separation represents a circuit conductor spacing.
2. The 0.75m separation represents the king bolt spacing between the upper and lower circuits
3. Where LV insulated is installed above LV bare or covered a minimum clearance of 0.3m is to be maintained between the LV insulated and the conductor of the lower circuit
4. Circuits are deemed the same circuit if there is a physical connection between the circuits, this may include open LV links

10.3.3 Same support structure, separate electrical circuits

The following table provides minimum clearances between different circuits on the same support structure.

Table 32 - Same support, different circuit clearances

Lower Circuit		Upper Circuit										
		132kV bare		66kV bare		11kV, 33kV, 12.7kV SWER bare, covered or insulated		22kV	LV bare or covered	LV insulated (LV ABC)	Other cables – conductive	Other cables – non-conductive
		LL	Non LL	LL	Non LL	LL	Non LL	m	m	m	m	m
		m	m	m	m	m	m					
	132kV bare	2.5	2.4									
	66kV bare	2.5	2.4	2.5	1.5							
	11kV, 22kV, 33kV, 12.7kV SWER bare, covered or insulated	2.5	2.4	2.5	1.5	2.5	0.9	2.5				
	LV bare, covered	2.5	2.4	2.5	1.8	2.5	1.2	2.5	0.6 (0.6)	0.3 (1.2)		
	LV insulated (LV ABC)	2.5	2.4	2.5	1.8	2.5	1.2	2.5	0.3 (0.6)	0.3 (0.3)	0.3	
	Other cables – conductive	2.5	2.4	2.5	1.8	2.5	1.2	2.5	0.3	0.3	0.2	0.2
	Other cables – non-conductive	2.5	2.4	2.5	1.8	2.5	1.2	2.5	0.3	0.2	0.2	0.2

LL – Live line area including all new lines
Non LL – Non live line area or existing line built to older spacings

Notes:

1. New Insulated 11kV circuits (HV ABC) are not allowed on Ausgrid network.
2. The separation represents the conductor spacing. In areas where the 11kV network cannot be worked on using live line techniques, lower circuits shall be installed with a minimum clearance of 1.2m. In areas where the 11kV network can be worked on using live line techniques, lower circuits shall be installed with a minimum clearance of 2.5m. Refer to NS214 - Guide to Live Line Design Principles for further guidance
3. Figures in brackets represent LV circuit separation at the structure when running in parallel (shared spans).

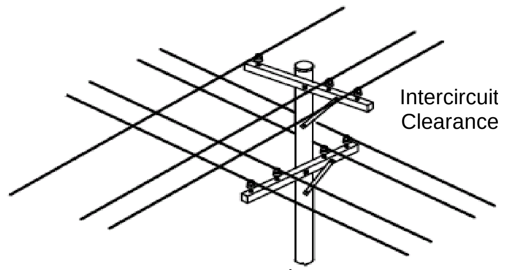


Figure 32 - Same support, different circuit

10.3.4 Unattached conductor crossings

The following table provides minimum unattached conductor clearances between different circuits.

Table 33 - Unattached conductor crossing clearances

Lower Circuit	Wind Condition	Upper Circuit: 132kV bare (m)	66kV bare (m)	33kV bare or covered (m)	11kV insulated (m)	11kV, 22kV, 12.7kV SWER bare or covered (m)	LV bare, covered or insulated (m)	Other cables – conductive (m)	Other cables – non-conductive (m)
132kV bare	No wind	3.0							
	Wind	1.5							
66kV bare	No wind	3.0	2.5						
	Wind	1.5	0.8						
33kV bare or covered	No wind	3.0	2.5	2.0					
	Wind	1.5	0.8	0.5					
11kV insulated	No wind	3.0	2.5	2.0	1.5				
	Wind	1.5	0.8	0.5	0.4				
11kV, 22kV, 12.7kV SWER bare or covered	No wind	3.0	2.5	2.0	1.5	1.5			
	Wind	1.5	0.8	0.5	0.4	0.5			
LV bare, covered or insulated	No wind	3.0	2.5	2.0	1.5	1.5	1.0		
	Wind	1.5	0.8	0.5	0.4	0.5	0.4		
Other cables – conductive	No wind	3.0	2.5	2.0	1.5	1.5	1.0	0.6	0.4
	Wind	1.5	0.8	0.5	0.4	0.5	0.4	0.4	0.2
Other cables – non-conductive	No wind	3.0	2.5	2.0	1.5	1.5	1.0	0.4	0.4
	Wind	1.5	0.8	0.5	0.4	0.5	0.4	0.2	0.2

Notes:

1. Refer to Table 34 for the weather conditions to analyse the 'No Wind' and 'Wind' conditions.
2. The above clearances may need to be increased due to local factors or to meet safe approach distances required for construction, operation and maintenance.
3. If conditions are such that it is likely that the lower circuit can flick up into the upper circuit, the vertical separation at the crossing point shall be twice the sag of the lower circuit when the conductors or cables are at their maximum design temperature.

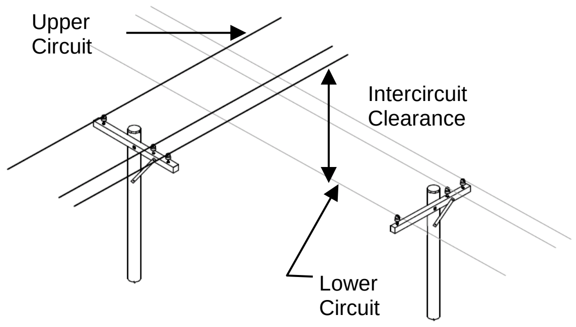


Figure 33 - Different support, different circuit

The following table provides wind and ambient temperatures to be applied when determining clearances from unattached conductors.

Table 34 - Weather conditions for determining unattached conductor clearances

Condition	Upper Conductor	Lower Conductor	Clearance
No Wind	Maximum operating temperature	15°C	Refer to Table 33 **'No Wind'** condition
Low wind on lower conductor (100Pa)	35°C	35°C	Refer to Table 33 **'Wind'** condition
High wind on lower conductor (500Pa)	35°C	35°C	Power Frequency (as per AS7000)

10.3.5 Conductor Separation

10.3.5.1 General

This clause provides the minimum requirements between conductors or cables attached to the same support and sharing the same span to prevent circuit-to-circuit or phase-to-phase flashover under operating conditions. Where conductors or cables are carried on the same pole or support as those of a higher voltage, the lower voltage conductors shall be placed below the higher voltage conductors or beside in the case of vertical circuit construction.

Any two bare conductors having a difference in voltage with respect to each other shall have vertical, horizontal or angular separation from each other in accordance with the values required by Clause 10.3.5.2 (see Figure 34), provided that the clearance at the support or at any part in the span is not less than the separation nominated in Item (b) (see Figure 35).

The separation given by Clause 10.3.5.2 is intended to cater for differential (out of phase and in phase) movement of conductors under wind conditions with minimum turbulence. The separation given by Clause 10.3.5.3 is a minimum under any circumstances.

10.3.5.2 At mid span

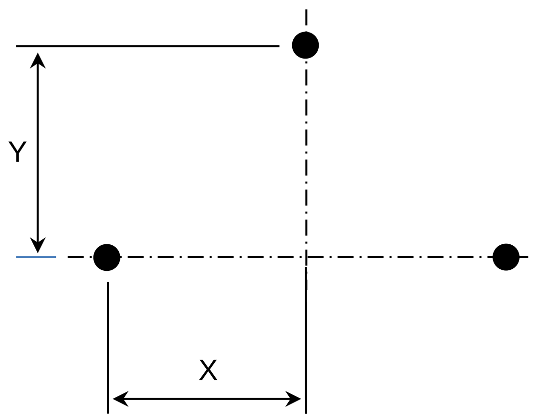


Figure 34 - Conductor Separation at Mid Span (One Circuit)

At mid span, the following equation must be satisfied:

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

Where:

X: is the projected horizontal distance in metres between the conductors at mid span;
(X = (X1 + X2)/2) where X1 is the projected horizontal distance between the conductors at one support and X2 is the projected horizontal distance between the conductors at the other support in the same span.

Y: is the projected vertical distance in metres between the conductors at mid span;
(Y = (Y1 + Y2)/2) where Y1 is the projected vertical distance between the conductors at one support and Y2 is the projected vertical distance between the conductors at the other support in the same span.

U: is the r.m.s. vector difference in potential (kV) between the two conductors when each is operating at its nominal voltage. In determining the potential between conductors of different circuits or between an earth wire and an aerial phase conductor, phase differences in the nominal voltages shall be considered.

k: is a constant, normally equal to 0.4 but which can be increased for added reliability for critical lines or spans, e.g. to 0.6. See Note 5 in Clause 10.3.5.3.

D: is the greater of the two conductor sags in metres at the centre of an equivalent level span and at an average conductor operating temperature with electrical load (typically 50°C in still air). This may be higher for high temperature conductors.

l_i: is the length in metres of any free swing suspension insulator associated with either conductor. Zero for pin and post insulators

For the purposes of this clause an equivalent level span shall mean a span:

(a) which has the same span length in the horizontal projection as the original span;

(b) in which conductor attachments at supports are in the same horizontal plane; and

(c) in which the horizontal component of the conductor tension is the same as in the original span.

U can be determined by using the formula

$$U = \sqrt{Va^2 + Vb^2 - 2VaVbCos\emptyset}$$

Where

Va = upper circuit nominal voltage phase to earth value (kV)

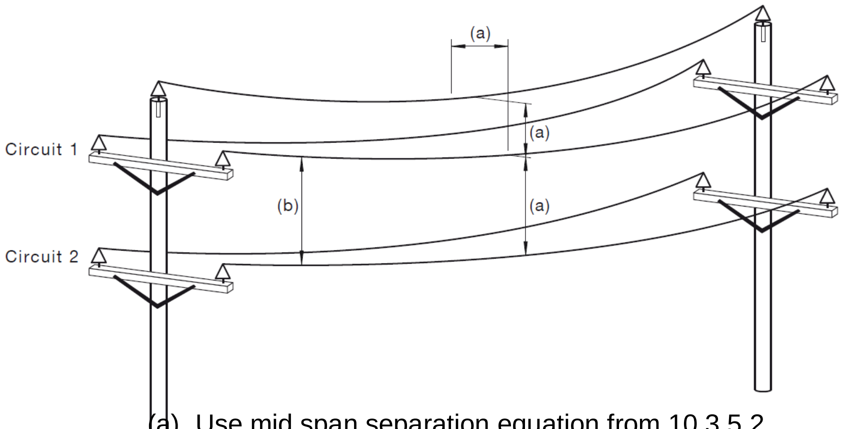
Vb = lower circuit nominal voltage phase to earth value (kV)

Ø = phase angle difference between circuits (degrees)

10.3.5.3 At any point in the span (other than the supports)

Where $U \leq 11kV \ldots\ldots\ldots\ldots\ldots\ldots 0.38m$

Where $U > 11kV \ldots\ldots\ldots\ldots\ldots\ldots \big(0.38 + 0.01(U - 11)\big)m$



(a) Use mid span separation equation from 10.3.5.2
(b) Use any point in span from 10.3.5.3

Figure 35 - Minimum conductor separation – attached on same structure

Notes:

1. When conductors of different circuits are located vertically one above the other, consideration shall be given to the need to prevent clashing of conductors of different circuits under the influence of load current in one or both circuits.
2. This clause is not intended to apply to insulated conductors (with or without earthed screens) of any voltage.
3. The spacing for covered conductors may be reduced provided the covering is adequate to prevent electrical breakdown of the covering when the conductors clash and a risk management strategy is in place to ensure that conductors do not remain entangled for periods beyond what the covering can withstand.
4. Where spacers are used, separation may be less than those specified. It is suggested that the spacer be taken to be a conductor support for the purpose of calculating conductor spacing.

5. The empirical mid span formula in Clause 10.3.5.2 is intended to minimise the risk of conductor clashing, however, circumstances do arise where it is not practicable to give guidance or predict outcomes. Some of these situations involve:

   a. Extremely turbulent wind conditions
   b. The different amount of movement of conductors of different size and type under the same wind conditions
   c. Conductor movement under fault conditions (particularly with horizontal construction).

   The following k factors shall apply for distribution power lines:

   d. Extremely turbulent wind conditions – k = 0.6
   e. High to extreme bushfire prone areas – k = 0.6
   f. Under high phase to phase fault conditions - k = 0.4 for fault currents up to 4000 A, 0.5 for fault currents 4000 A to 6000 A and 0.6 for fault currents above 6000 A
   g. In all other situations a k factor of 0.4 is recommended.

   For all sub-transmission situations a k factor of 0.6 is required. This includes reconstruction and pole replacement works on spans adjacent to the work site.

6. Mid span clearances may need to be increased in situations where the conductors transition from horizontal to vertical or where the adjacent conductors are of different characteristics (diameter, weight) which can cause out of phase movement.

7. The following situations may also need to be reviewed when considering spacing of conductors but it is not practicable to provide guidance in this document. Knowledge of local conditions would be required to make design decisions.

   a. Aircraft warning devices.
   b. Large birds which may collide with conductors, causing them to come together, or whose wingspan is such as to make contact between bare conductors and conducting cross arms.
   c. Flocks of birds resting on conductors are known to “lift-off” simultaneously, causing violent conductor movement.
   d. Terrain factors that may contribute to aerodynamic lift and/or random motion
   e. Spray irrigators; and
   f. Safety approach clearances for construction, operation and maintenance.

10.4 Telecommunications clearances

Telecommunication clearances shall be as follows;

- For clearances between Ausgrid-owned ADSS cables and associated equipment and other Ausgrid assets, refer to NS201;
- For clearances between Ausgrid’s assets and third-party communications cables and equipment, refer to NS232;

The minimum clearance above telecommunication lines shall be determined with the power line super-circuit at maximum design temperature and the telecommunication sub-circuit at 15°C.

Any proposal to attach telecommunication cables to poles with the highest voltage of 66kV or above, is to be managed via the NS181 Network Standard Variations process.

10.5 Railway crossings

The following table provides minimum clearances over railway tracks.

Table 35 - Clearances at railway crossings

Dimension	Application	LV Insulated or Bare	11kV, 22kV, 12.7kV SWER, 33kV, 66kV	132kV
		m	m	m
A	Over electrified railway tracks	12.0	12.0	12.0
B	Over non-electrified railway tracks	8.0	10.0	12.0

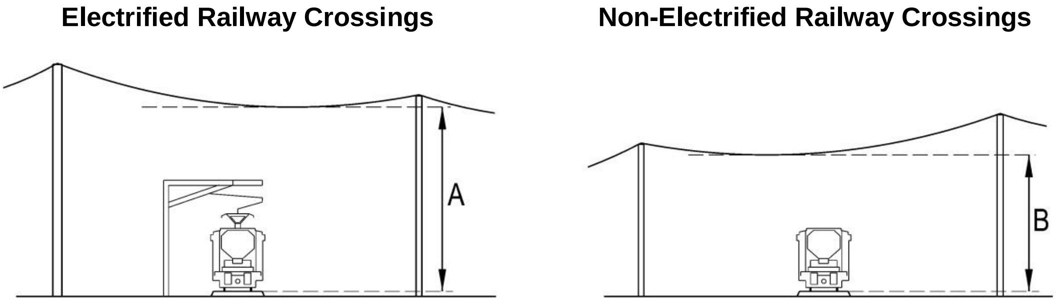


Figure 36 - Clearances for railway crossings

Notes:

1. Other minimum clearances as listed in the local railway network Regulations, Codes or Agreements are to be complied with including but not limited to:

   "Requirements for Electric Aerials Crossing RailCorp Infrastructure, T HR EL 10005 ST"

   "Requirements for Electric Aerials Crossing ARTC Infrastructure, PYS 02"

   Design requirements that implement minimum clearances below the figures in the table above but are within the limits of the local railway network regulations, codes or agreements, shall be reviewed and approved in accordance with NS181.
2. Railway crossings shall be designed in association with the relevant Railway Corridor Management Group's requirements.
3. An approval document shall be submitted to the Railway Corridor Management Group for acceptance. The document shall provide details commensurate with the relevant Railway Corridor Management Group requirements. The document shall show plan and profile views of the proposed crossing and include details of poles, conductor heights and other relevant data.
4. The design shall include considerations given to the risk of electrolysis corrosion resulting from stray DC currents due to electric trains. In particular when installing below ground metallic infrastructure such as earthing systems and steel or reinforced-concrete structures close to the rail corridor. Refer to "T HR EL 12002 GU Electrolysis from Stray DC Current" for further information. Refer to NS270 Stray Direct Current Management.

10.6 Transmission undercrossings

The Designer shall consult with TransGrid or other Transmission asset owner, submitting a detailed plan of the line route in the vicinity of the crossing, showing positions of distribution and transmission structures, as well as a distribution line profile with conductors at 15°C.

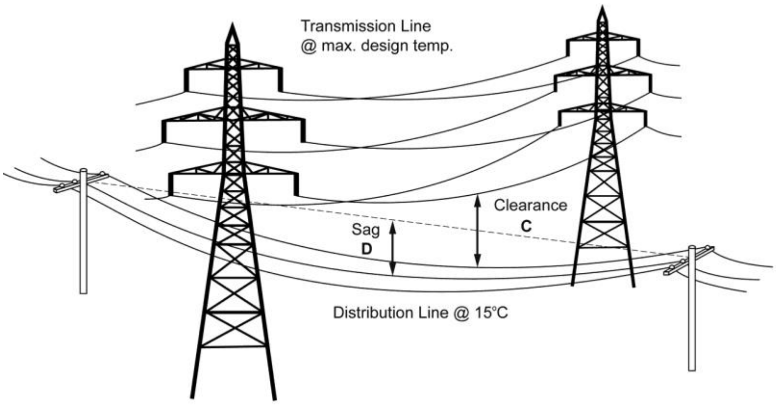


Figure 37 - Transmission undercrossing

Minimum clearances from Ausgrid lines passing beneath Transmission lines are shown in the table below.

Table 36 - Transmission undercrossing clearances

	Upper Circuit					
Lower Circuit			132kV	>132 – 275kV	>275 – 330kV	>330 – 500kV
			m	m	m	m
	Ausgrid Circuits and Cables - All voltages	No wind	3.0 (2.4)	4.0 (2.8)	5.0 (3.8)	6.0 (5.2)
		wind	1.5	2.2	2.6	3.6

Notes:

1. The table provides minimum requirements to prevent circuit to circuit flashover, under both normal and fault conditions, between aerial conductors or cables of different circuits that cross each other and are not attached to the same pole or support at the point of crossing. The Ausgrid design clearance requirements shown exceed those provided for in AS/NZS7000 (the latter are shown in brackets in the table), to allow for variations over time. The increased clearance is not intended to account for variations, deficiencies or errors during construction, and the clearances from this table shall apply.
2. Wind condition is where the lower circuit is subject to blowout and swings upward.
3. The clearances listed in the table may need to be increased due to local factors or to meet safe approach distances required for construction, operation and maintenance.
4. Minimum clearance of distribution conductors from TransGrid structures is 15m.
5. A sketch of Transmission undercrossings shall be submitted to TransGrid for approval. The sketch shall show plan and profile views of the proposed undercrossing and include details of poles, conductor heights and other relevant data.
6. If conditions are such that it is likely that the lower circuit can flick up into the higher circuit e.g. due to vegetation, the vertical separation (C) at the crossing point shall be C = 2D where:

   C = Required intercircuit clearance with upper circuit at maximum design temperature

   D = Conductor sag of the lower circuit at maximum design temperature
7. Install terminations on undercrossing circuit either side of transmission line easement to permit easier undercrossing conductor temporary removal to permit Transmission Line reconductoring works.
8. Do not position Distribution or Sub-transmission line support structures under a TransGrid conductor span.
9. Consider HV Induction Hazard reduction in line design construction & maintenance. Refer to ISSC 32 Guide for Network Providers to Provide Information to the Construction Industry for Working Near Overhead Power Lines.

10.7 Navigable waterway crossings

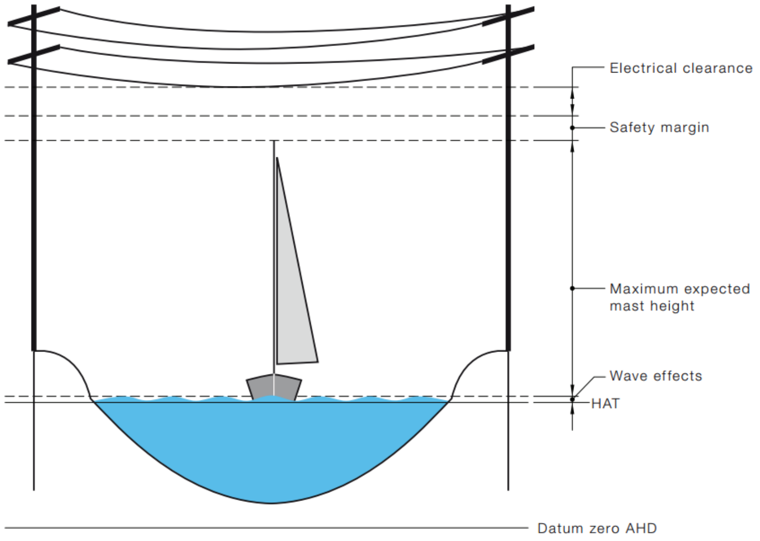


Figure 38 - Clearance levels over water crossings

Required clearance at crossing above HAT $\geq W + H_{vessel} + E + S + SCF$

The following tables define these factors and indicate the sources of the data.

Table 37 - Required waterway data

Required Waterway Crossing Data		
Clearance Element	**Data Source**	**Considerations**
HAT: Highest Astronomical Tide	NSW Maritime / Dept. of Lands	
W: wave effects	NSW Maritime/ Dept. of Lands	
H_{vessel}: Height of expected vessels	NSW Maritime/ Dept. of Lands	
E: Electrical clearances	Ausgrid	As per Table 38
S: Safety margin	Ausgrid	2200 mm
SCF: Sag Compensation Factor	Designer	To be determined by designer

Table 38 - Electrical clearances

Electrical Clearances for Uninsulated Conductors (E)	
Circuit Voltage	**Clearance**
≤ 33 kV	300 mm
66 kV to 132 kV	800 mm

Notes:

1. Waterway crossings over navigable waters are to be designed and constructed in accordance with NS268 and are subject to a risk assessment and final approval by Ausgrid.

2. Waterway crossings over navigable waters are determined in association with the relevant statutory bodies or landowners, e.g. TfNSW or Department of Lands and other interested entities. Risk treatment options may be required including but not limited to the following:

- Warning signs, signage lighting on both sides of the waterway
- Coloured marker balls and/or coverings attached to conductors.
- Waterway crossing signs are to be designed in accordance with NS268 and drawing 252151.

3. Any excavation or filling activities undertaken in association with the crossing must be approved by the responsible landowner.

4. The approval process is incorporated into the Crossings of NSW Navigable Waters: Electricity Industry Code.

5. SCF (Sag Compensation Factor) is a factor that will allow for such things as:

- construction inaccuracy,
- survey inaccuracy,
- pole movement, and
- that the crossing will be subsequently surveyed and assumed to be at ambient temperature when it may be at a higher temperature.

10.8 Streetlight clearances

Clearance between conductors and streetlights must be considered where they are:

- not attached to the same pole – refer to Table 39 and Figure 39; and
- both attached to the same pole – refer to Table 40 and Figure 40.

The clearances shown in Table 39 and Table 40 must be observed after the streetlight has been fixed in position. Refer to the Ausgrid Electrical Safety Rules (ESR) for minimum safe working distances during installation, maintenance, replacement or repositioning of streetlights in proximity to exposed mains and apparatus:

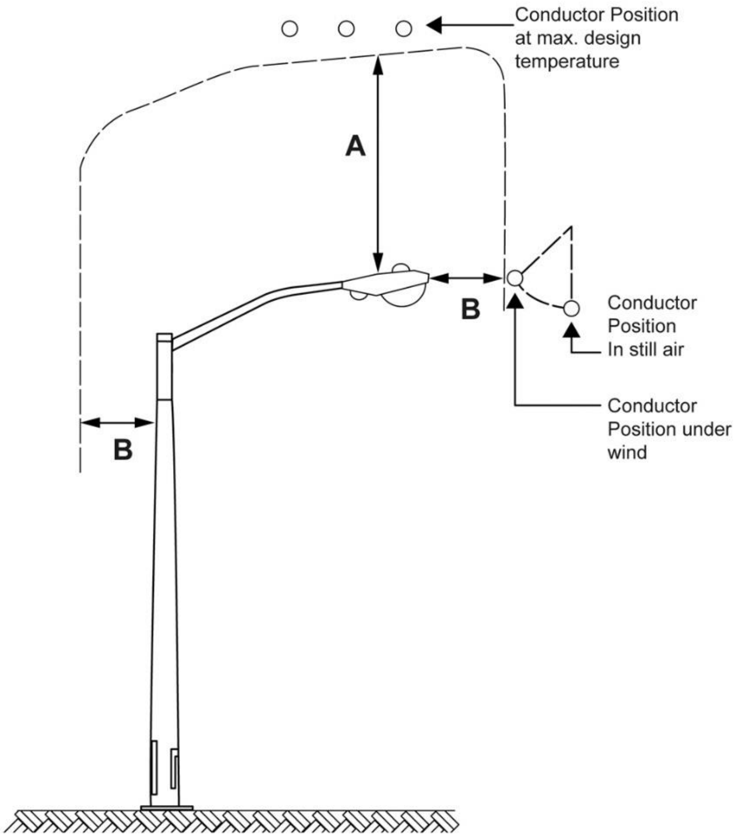


Figure 39 - Streetlights and conductors not attached to the same pole

Table 39 - Clearance between streetlights and conductors not attached to the same pole

Dimension	Location	LV		11kV – 22kV			33kV – 66kV	132kV
		Insulated	Bare or covered	Insulated with earthed screen	Insulated without earthed screen	Bare or covered	Bare	Bare
		m	m	m	m	m	m	m
A	Vertically: above the streetlight	0.1	0.5	1.5	1.5	1.5	2.1	3.1
B	Horizontally: from any part of the streetlight	0.1	0.5	0.1	1.5	1.5	2.1	3.1

Notes:

1. These minimum clearances are required under the ordinarily expected worst combination of weather conditions and current loadings

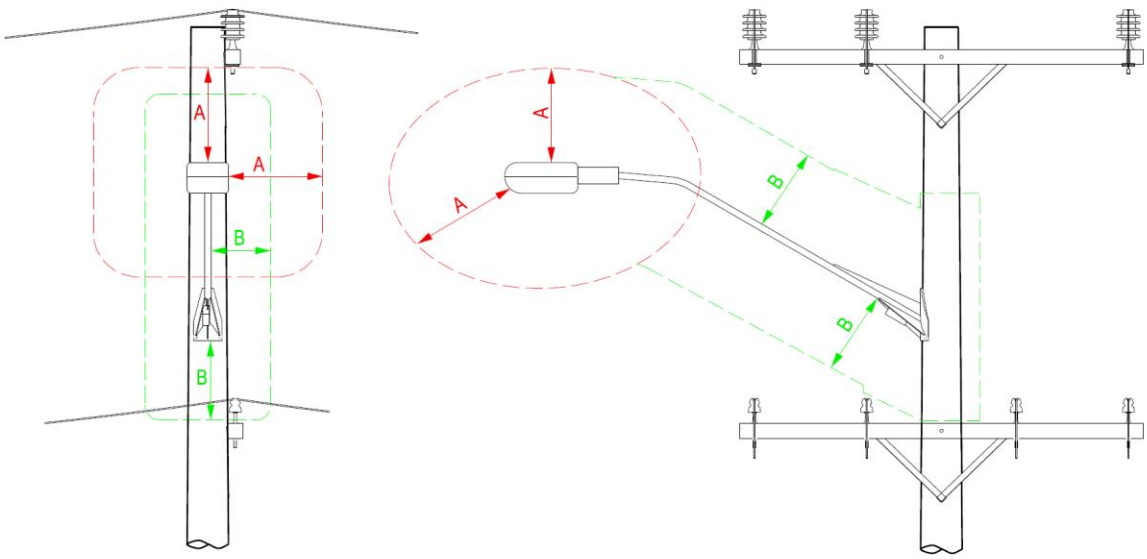


Figure 40 - Streetlights and conductors attached to the same pole

Table 40 - Clearance between streetlights and conductors attached to the same pole

Dimension	Location	LV		11kV – 22kV			33kV – 66kV	132kV
		Insulated	Bare or covered	Insulated with earthed screen	Insulated without earthed screen	Bare or covered	Bare	Bare
		m	m	m	m	m	m	m
A	From streetlight lantern	0.1	0.5	1.2	1.2	1.2 (2.5)	1.5 (2.5)	2.0
B	From any part of streetlight (other than lantern)	0.1	0.32	0.1	0.9	0.9 (2.5)	1.2 (2.5)	1.7

Notes:

1. These minimum clearances are required under the ordinarily expected worst combination of weather conditions and current loadings
2. The dimensions shown in brackets must be met where live line techniques are used on 11kV – 33kV networks.

10.9 Vegetation clearance

Ausgrid trims vegetation adjacent to power lines according to NS179. This document generally stipulates the separation required between vegetation and power lines based on voltage and span length.

The Designer shall make all efforts to ensure that conductor blowout at 500Pa does not travel outside the required vegetation management corridor specified in NS179. If this cannot be achieved, the Designer shall produce a risk assessment document confirming that the blowout is greater than vegetation management corridor and there is no risk of vegetation contact. This shall be submitted to Ausgrid and will be retained in Ausgrid's document management systems. An Ausgrid Officer shall check the proposed span to determine if this risk assessment is appropriate.

Except for the condition detailed above, vegetation clearances must be met at the time of commissioning. If the line design requires removal or trimming of trees, this must be arranged as part of the line design and commissioning process.

10.10 Swimming pools

Overhead lines shall be designed such that the distances between conductors and existing swimming pools are not less than those specified in Table 41.

Swimming pools shall not be installed closer to overhead lines than the distances specified in Table 41.

This clause does not apply to the separation between existing pools and existing overhead lines.

Table 41 – Minimum clearance between swimming pools and overhead lines

Dimension	Location	Insulated service (see note 1)		LV		11kV	33kV and above (see note 2)
		Option 1	Option 2	Insulated	Bare or covered	All	All
		m	m	m	m	m	m
A	Horizontal distance from pool edge to closest conductor	3.5	1.5	1.5	2.5	2.5	2.5
B	Distance from nearest conductor to any point on the ground within the fenced pool area	4.6	6.5	6.5	7.0	7.5	8.0

Notes:

1. The designer shall select one of the two options for insulated service wires. Interpolation is not permitted.
2. Voltages above 33kV shall be referred to Ausgrid for a site-specific earthing assessment, which may require increased clearances.

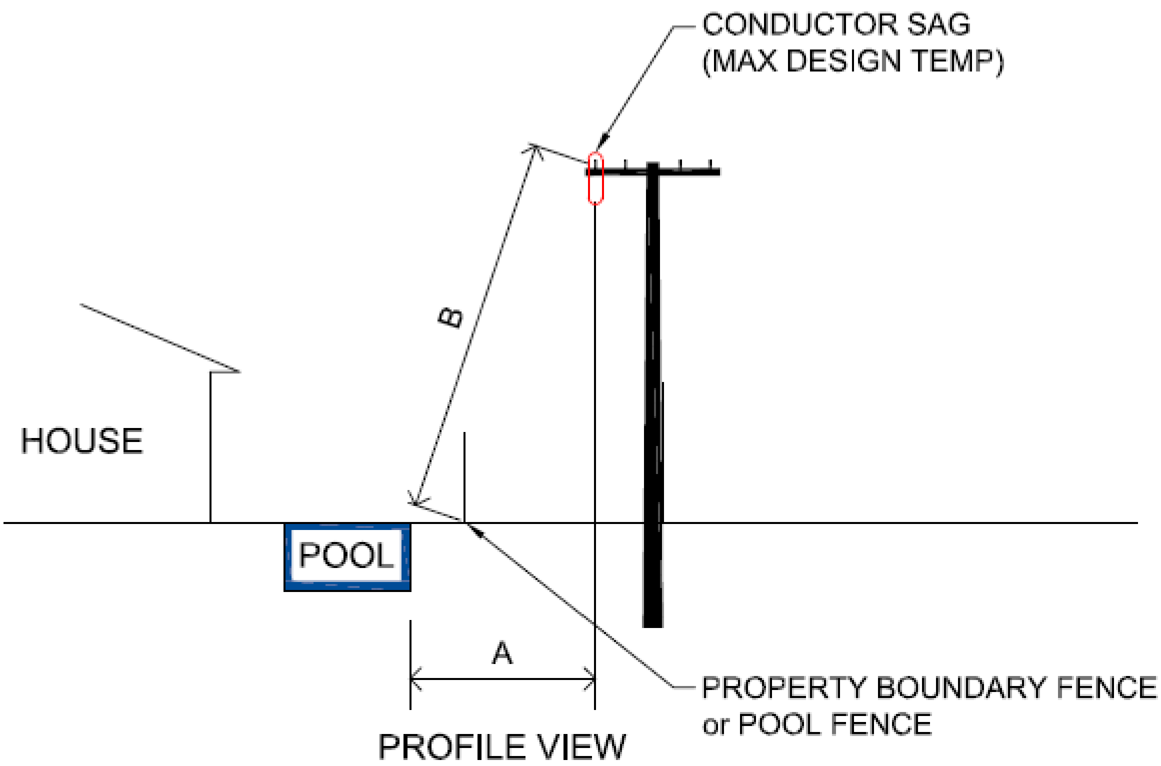


Figure 41 – Clearances between swimming pools and overhead lines

11.0 SOFTWARE

11.1 Software overview

This section specifies the minimum requirements for overhead line design software packages used for designing HV and LV distribution and sub-transmission overhead mains on Ausgrid's network in accordance with the requirements of NS125, NS126, NS135, NS220, AS/NZS7000 & AS/NZS ISO9001. The specification requirements are split into two categories:

- Distribution designs where the greatest span length is less than 250m; and
- Distribution designs where any span length is greater than 250m and all sub-transmission designs.

Software packages for overhead line design must meet a minimum set of requirements dependent on the above category of design.

The design requirements for distribution power lines are generally less onerous than those applied to sub-transmission power lines. For this reason, the design check criteria for distribution lines allows for assumptions and approximations to be accepted to carry out the design using simplified software programs that do not provide a finite element analysis. This simplified level of assessment does not compromise the design compliance with Ausgrid Network Standards and Australian Standards.

Due to the importance of sub-transmission lines, the criteria for sub-transmission design calculations and checks are more rigorous. Accordingly, Ausgrid require a line design submission developed using finite element analysis, commensurate with Network and Australian standards whilst adopting best industry practice. Distribution designs containing any span greater than 250m must also be developed using finite element analysis.

11.2 Process for Software Approval

Whilst the design of sub-transmission and distribution lines can be carried out manually, Ausgrid require that the design is completed with the use of specialised software packages. These may include overhead line design software and pole footing design software. The software shall enable design compliance with all relevant standards, codes and regulations and conform to current industry practice.

In all instances any new software utilised for complete design or part thereof shall be approved by Ausgrid. The approval process for the software is in accordance with NS181.

11.3 Design Submission Requirements

The Designer is responsible for the production of a design in accordance with the Network Standards and the appropriate Australian Standards and Guidelines. The minimum requirements of the design are set by Ausgrid's Network Standards, unless further requirements are defined within the design information package.

11.4 Requirements

11.4.1 Limit State Design

The software must allow for the design of overhead lines based on limit state principles for serviceability and strength limit state for the various line components as per Clause 3.0 and as per AS/NZS7000.

Limit state design shall be carried out by:

- setting up structural models;
- applying the relevant load cases; and
- Verifying that the limit states are not exceeded when design values for loads, material properties and geometrical data are used in the models.

Design values are generally obtained by using characteristic or combination values in conjunction with strength reduction factors and load factors as defined in this Ausgrid Standard and relevant Australian Standards.

11.4.2 Discrete Components Check

Any element of an overhead line which carries structural load or is a secondary structural or framing element shall be considered as a 'structural element' and is required to be structurally checked and analysed in accordance to limit state philosophies. It is requested that all structural checking be completed within the software however Ausgrid will consider other forms of calculation checks with prior written approvals.

Structures and components shall be designed using a reliability-based (risk of failure) approach. The selection of load factors, in particular weather-related loads, and component strength factors are documented in Clause 3.0 and AS/NZS7000. Typical structural components include, but are not limited to, cross arms, conductors, insulators and stays. Strength checks with respect to limit state design are required on all components.

11.4.3 Weather Case Conditions

The software must have the capability of implementing all weather cases which will be used for particular design load checks to be performed. Multiple weather cases are required to be set up for compliance to the relevant standards as discussed elsewhere in this document. The inclusion of air density factor, wind velocity and wire temperature is required as a minimum. Span Reduction Factors are desirable but not essential in accordance with Clause 3.5.

It must be possible to view and check the position of the conductor in any of these weather cases for encroachments to minimum statutory requirements including mechanical clearance and blowout encroachments and electrical power frequency withstand and lightning impulse checks.

11.4.4 Load Case Conditions

The software must have the ability to simulate all load conditions from Clause 3.5. There must be a mapped link from the load case to the corresponding weather case.

A complete load tree for the structure is required and includes not only the design loads at the structure attachment points but also the design pressures to be applied to the body of the structure itself in its transverse, vertical and longitudinal directions. The design pressures depend on the relative orientation of the wind and the structure. A definition of load factors, explaining exactly what they apply to is required. An example diagram clearly showing the load definitions is desirable (such as a Tee-off).

11.4.4.1 Construction and Maintenance Loads

The supports shall be able to be checked for all construction and maintenance loads, which are likely to be imposed on them with an appropriate load factor, taking into account temporary guying, lifting arrangements, stringing to one side, etc., as per Clause 3.3.3, 8.1.5 and 9.6.2.

11.4.4.2 Failure Containment Loads

The supports shall be able to be checked for all failure containment and broken wire considerations as required by Clause 3.3.3. The loads must be able to be configured and checked for worst case scenarios.

11.4.4.3 Loads from the Supported Conductor

Although any attached conductor will impose a single force to the structure, this force is resolved into orthogonal components with respect to the span geometry and then resolved into orthogonal components with respect to the structure geometry. This allows the conventional longitudinal, transverse and vertical conductor load combination to be calculated with appropriate load factors for the structure. The software must have demonstrated ability to address the load factor requirements accordingly.

11.4.5 Wind Direction

The direction of the wind acting onto the structure and the conductors must act to ensure that the worst case wind loading is being checked at the structure. There must be visibility as to which direction the wind is blowing onto the structure to result in the worst case. Consideration shall be given to the design of structures for wind for a range of directions and shall include transverse, longitudinal and oblique directions.

For the maximum wind loading direction, it must be clear as to whether this is the highest loading on any component (for example, a crossarm) or the highest loading on the pole.

Wind loadings shall be applied to all elements of an overhead line as determined in accordance with Clause 3.5.

11.4.5.1 Synoptic and Downdraft Wind

(i) Transverse direction – Apply full transverse wind load on the conductors, insulators and fittings and support, together with deviation loads derived at maximum wind and all relevant vertical loads.

(ii) Longitudinal direction – Apply full longitudinal wind load on the conductors, insulators, fittings and support, together with corresponding deviation loads and all relevant vertical loads.

(iii) Oblique (or yawed) wind (see AS/NZS7000 Appendix B) – Apply full oblique wind at an angle to the transverse axis on the conductors, insulators, fittings and support, together with deviation loads derived at maximum wind and all relevant vertical loads.

11.4.5.2 Tornado Wind (Where required applicable to high Security Level lines – (see AS/NZS7000 Appendix B)

(i) Apply maximum wind load to the structure only. Wind load to act from any direction, together with deviation loads including conductor loads at no wind and all relevant vertical loads.

(ii) For wide transverse structures (for example, horizontal single circuit towers), consideration shall be given to the potential for wind causing torsional load due to rotation about the support centre.

11.4.6 Actions on Lines

Self-weight of structures, insulator sets, other fixed equipment and conductors resulting from the adjacent spans act as permanent loads and shall be allowed for within the software. Aircraft warning spheres and similar elements are to be considered as permanent dead loads and are a desirable addition to the software.

11.4.7 Strength Reduction Factors and Load Factors

The software must allow for Strength Reduction Factors and Load Factors to be input as per Clause 3.7 and 3.5. All corresponding calculations must factor the loads according to this setting and the load equation.

11.4.8 Ruling Span versus Actual Span

For distribution lines with span lengths less than 250 metres, the ruling span method of modelling the wire system is acceptable however it is desirable that actual span or finite element analysis of the wire system is used in the software. For distribution lines with span lengths greater than 250 metres and all sub-transmission lines it is essential that actual span or finite element analysis of the wire system is used.

It is desirable that the software has the ability to complete cut and shut (nip tuck) calculations in order to show differences in tensions from installing mid-span poles or changing poles within a dead-end when not untying the conductor from their suspension pins or insulators.

11.4.9 Materials

The material libraries within the software must be able to be interrogated to ensure the information used to create the material libraries is transparent and auditable. The data corresponding to the libraries of materials must reflect the material that is being delivered as part of the design.

11.4.9.1 Pole Design

The structure orientation must be clearly defined to identify the longitudinal and transverse directions within the software.

For Distribution design <250m spans:

- Pole tip load calculations are required however it is desirable that a finite element analysis of pole strength is carried out based upon the inherent strength of the material rather than a nominated tip load.

For Distribution design >250m spans & Sub-transmission designs:

- It is essential that a finite element analysis approach is taken for strength checks on concrete, steel and timber poles and lattice tower structures;
- Concrete poles must include the bending moment capacity data from the concrete pole supplier;
- Where required the software must have the ability to strength check steel sleeved, flanged and base mounted poles;
- For timber poles, the software must have the ability for input of timber pole properties for finite element analysis including modulus of elasticity, density, shear modulus and ultimate stress.

An exception to this rule is for fibre-cement poles whereby data is not available for FEA analysis. A pole tip load analysis is acceptable for these poles.

For Multi-pole structures:

- the software must have the ability to model multi-pole structures such as 'H' Type structures and transfer loads between poles through interconnection elements like cross arms and stay wires.

For Stayed structures:

- the software must have the ability to model stays and stayed structures and transfer the load accordingly through the stay wire to either another support structure or a ground anchor. The stay's characteristics must be able to be set, including install tension, modulus of elasticity and weight. When using stays, the pole must be checked at the stay attachment point as well as ground level.

11.4.9.2 Conductors

The software must be able to model all homogeneous and bi-metallic conductors used on Ausgrid's network.

Damage and failure limits of conductors must be able to be checked with respect to the table in Clause 3.7.

Metallurgical creep must be accounted for by one of the following methods:

- Non-linear + creep polynomials (essential for distribution >250m span & sub-transmission);
- Linear + Creep Temperature shift (acceptable for distribution <250m spans); or
- Linear + Creep temperature improved modelling (acceptable for distribution <250m spans).

The software must make sag and tension calculations for cables in their initial and final creep conditions.

The cable model must consider the following:

- Conductor diameter, drag coefficient, calculated breaking load and be able to calculate conductor vertical and horizontal sag-tension including these variables.
- It must be possible to ensure that the tension/damage limits of the conductors are not being exceeded during load case checking.

The stringing table output must indicate whether or not creep needs to be allowed for.

The difference in span length and therefore sags for angled structures must be accounted for including multi-poled structures.

11.4.9.3 Insulators

It is essential that the software is able to model insulators as either strain termination clamps, suspension arrangements (including horizontal line posts), and where required, 2-part braced post insulators.

Insulators must have mechanical stresses including tensile, compressive and cantilever loadings from conductor tension and weight of fittings checked against allowable. It must be possible to implement insulator strength reduction factors as required in the table in Clause 3.7.

For sub-transmission design and distribution design over 250m, it is essential that horizontal line post insulators be modelled using interaction and capacity load curves supplied by the manufacturer. The software must enable the interaction capacity data to be inputted and checked.

Uplift at insulator attachment points is required to be checked by the software to identify whether conductor uplift is occurring including net uplift of all conductors on termination structures.

It is required that insulator length and swing be accounted for by the software.

11.4.10 Clearances

The software must enable clearance checks to be performed and measured and calculated at specific weather cases. The clearances to be considered are:

- Clearance of conductors at the structure;
- Clearance for inspection and maintenance;
- Conductor phase-to-phase at mid-span;
- Conductor phase-to-phase anywhere in the span;
- Conductor to ground including side slope allowance;
- Phase conductor to objects;
- Circuit to circuit (attached to the same structure or at an unattached crossing);
- Insulator swing and calculation of swing angles;
- Blowout clearance; and
- Clearance to surface.

11.4.11 Survey and Terrain Modelling

To ensure the above clearance checks can be achieved, the software must be able to manipulate electronically and manually collected survey data.

Survey data must be able to be displayed in the software including in all views and have the ability to display offset side profiles; that is, all phase and neutral conductors with respect to the ground plane in profile view.

It is desirable that the software has the following functionality:

- Separate feature codes to be allocated to above ground obstacles so that separate clearance checks can be conducted;
- A feature code editor to be provided for classifying survey data with a feature code;
- The software to be able to consider break lines;
- Separate feature codes to be created for each category of terrain or obstacle points; and
- A ground survey point triangulated irregular network (TIN) surface model that can be created and clearance check to tinned surfaces must be able to be calculated.

11.4.11.1 Alignments

Design alignments need to be defined, including points of intersections, displayed width and with the ability to add or insert multiple alignments including tee offs and separate feeder alignments within the one design.

11.4.12 General Software Requirements

It is essential that the software has a profile view showing a ground clearance line. A plan and 3D view is desirable, as is the ability to output a design in a Google Earth file format.

The software must be capable of saving the line design model in a format that can be sent to Ausgrid for review.

11.4.13 Additional Desirable Criteria

The following requirements are desirable for software functionality:

- Modelling of bundled cables;

- Pole deflection checks;
- Coordinate system selection;
- The ability to report on pole pegging, clearances and component capacity utilisation;
- LiDAR compatibility; and
- Aerial photographs (in raster graphic formats including ECW, JPG, BMP, etc) and CAD drawings to be overlaid in various software views
-

12.0 AUTHORITIES AND RESPONSIBILITIES

For this Network Standard the authorities and responsibilities of Ausgrid employees and managers in relation to content, management and document control of this Network Standard can be obtained from the Company Procedure (Network) – Production / Review of Engineering Technical Documents within the document repository. The responsibilities of persons for the design or construction work detailed in this Network Standard are identified throughout this Standard in the context of the requirements to which they apply.

13.0 RELATED DOCUMENTS

All work covered in this document shall conform to all relevant Legislation, Standards, Codes of Practice and Network Standards. Current Network Standards are available on Ausgrid's Internet site at www.ausgrid.com.au.

ASPs and other persons external to Ausgrid are responsible for sourcing any required manufacturer's instructions and manuals.

13.1 Ausgrid documents

- Bushfire Risk Management Plan
- Customer Installation Safety Plan
- Electrical Safety Rules
- Electricity Network Safety Management System Manual
- DG 214B Composite Fibre Crossarms
- NEG EP05 Entry to Private Property
- NS104 Specification for Electrical Network Project Design Plans
- NS109 Design Standards for Overhead Supply Development and Distribution Centres
- NS116 Design Standards for Distribution Equipment Earthing
- NS122 Pole Mounted Substation Site Selection and Construction
- NS124 Specification for Overhead Service Connections up to 400 Amps
- NS125 Construction of Low Voltage Overhead Mains
- NS126 Construction of High Voltage Overhead Mains
- NS128 Pole Installation and Removal
- NS135 Construction of 33kV, 66kV and 132kV Overhead Mains
- NS143 Easements, Leases and Rights of Way
- NS167 Positioning of Poles and Lighting Columns
- NS179 Vegetation Management
- NS181 Approval of Materials and Equipment and Network Standard Variations
- NS201 All Dielectric Self Supporting Fibre Optic Cabling for the Installation of Distribution Assets
- NS212 Integrated Support Requirements for Ausgrid Network Assets
- NS214 Guide to HV Live Line Design Principles
- NS232 National Broadband Network equipment on Ausgrid Poles
- NS261 Requirement for Design Compliance Framework for Network Standards
- NS268 Design and Construction of Waterway Crossings
- NS270 Stray Direct Current Management
- Ausgrid drawing 61501: Overhead Stays and Stay Poles Anchorages, Footings and Termination Arrangements.
- Supply Policy – Electrical Standards (ES Range of Documentation)
- Network Engineering Guidelines—Distribution Type Design
- Public Electrical Safety Awareness Plan
- Public Lighting Management Plan
- Tree Safety Management Plan

13.2 Other standards and documents

The following list of references is numbered to make it easier to identify specific references within the text of this network standard. The list is still in alphabetic order and be accessed either numerically or alphabetically as the need arises.

1. Alcoa Aluminium Overhead Conductor Engineering Data
2. AS1154 Insulator and Conductor Fittings for Overhead Power Lines
3. AS/NZS1170 Structural Design Actions (Wind Code)

4. AS/NZS1170.2 Structural Design Actions – Wind Actions
5. AS1222 Steel Conductors and Stays
6. AS1418.10 Elevated Work Platform Electrical Insulation
7. AS1531 Conductors – Bare Overhead – Aluminium and Aluminium Alloy
8. AS1720.1 Timber Structures
9. AS1746 Conductors – Bare Overhead – Hard-drawn Copper
10. AS/NZS1768 Lightning Protection
11. AS1824 Insulation Coordination
12. AS3600 Concrete Poles
13. AS3607 Conductors – Bare Overhead Aluminium and Aluminium Alloy, Steel Reinforced
14. AS/NZS3675 Conductors – Covered Overhead – for Working Voltages 6.35/11(12)kV up to and including 19/33(36)kV
15. AS/NZS3835 Earth Potential Rise – Protection of Telecommunications Network Users, Personnel and Plant
16. AS3891.1 Air navigation - Cables and their supporting structures - Marking and safety requirements – Permanent marking of overhead cables and their supporting structures for other than planned low-level flying
17. AS3891.2 Air navigation - Cables and their supporting structures - Marking and safety requirements – Marking of overhead cables for planned low-level flying operations
18. AS4065 Concrete Utility Service Poles
19. AS4436 Guide for the Selection of Insulators in respect of Polluted Conditions
20. AS4677 Steel Utility Service Poles
21. AS5804-2010 High–voltage live working
22. AS/NZS7000 Overhead line design – Detailed procedures; and associated HB331 Handbook – Overhead Line Design
23. AS61508 Functional safety of electrical / electronic / programmable electronic safety-related systems
24. AS/NZS ISO/IEC 90003 Software Engineering –Guidelines for the application of AS/NZS ISO 9001:2000 to computer software
25. ASCE/SEI 48-05 ASCE Design of Steel Transmission Pole Structures
26. ASCE/SEI 104, 2003, Recommended Practice for Fiber-Reinforced Polymer Products for Overhead Utility Line Structures,
27. Ausgrid website www.ausgrid.com.au for current issue of Ausgrid's Network Standards
28. CIGRE SCB2 12.3 "Sag Tension Calculation Methods for Overhead Lines" CIGRE Technical Brochure No. 324, 2007
29. CIGRE WG 22 05 "Permanent Elongation of Conductors Predictor Equations and Evaluation Methods" CIGRE Electra No 75 1981
30. C. O. Boyse and N. G. Simpson "The problem of Conductor Sagging on Overhead Transmission Lines" Journal of the Inst. Of Elec. Eng. Vol 91 Pt II Dec 1944 pp 219 – 231.
31. EA NSW Overhead Line Construction, Standard Drawings and Design Data, Vol. 4 Drawing EAS/4/11/4
32. EC5 - Electricity Council of NSW – Guideline to Protective Earthing
33. EC23- 1995, Guide to Working on Overhead Lines subject to Induced or Transferred Voltages
34. Electricity Authority of NSW High Voltage and Earth Return for Rural Areas
35. ENA Doc 001-2019 National Electricity Network Safety Code
36. ENA Handbook C(b)1—2006 "Guidelines for Design and Maintenance of Overhead Distribution and Transmission Lines",
37. ESAA D(b)5 Current Rating of Bare Overhead Line Conductors
38. Gillespie A,. ,EEP 216 Overhead Line Design –Electrical, QUT
39. Gorur RS, Cherney EA, Burnham JT, 1999, Outdoor Insulators, Phoenix, Arizona
40. HB101 (CJC5) Coordination of Power and Telecommunications – Low Frequency Induction (LFI): Code of Practice
41. Holmes JD, 2002, A Re-analysis of Recorded Extreme Wind Speeds in Region A, Australian Journal of Structural Engineers, Vol4, No1, p29

42. IEEE 524-2003 Guide to the Installation of Overhead Transmission Line Conductors
43. IEEE 738 IEEE Standard for Calculating the Current-Temperature of Bare Overhead Conductors
44. IEEE 951 -1996 Guide for the assembly and erection of Metal Transmission Structures
45. IEEE 977-1991 IEEE Guide to Installation of Foundations for Transmission Line
46. ISSC3 Guideline for Managing Vegetation Near Power Lines
47. Kiessling F, Nefzger P, Nolasco JF, Kaintzyk U. , 2002, Overhead Power Lines, Springer, New York
48. Lee C., EEP 217 Overhead Line Design – Mechanical, QUT
49. Littlejohn GS, 2008, Ground Anchorages and anchored structures, ICE, Thomas Telford, London
50. Marcus Punch - "Towards Zero Harm" –NSW DPI Electrical Engineering Safety Seminar – Nov 2009
51. Mason M, March 2007, Thunderstorm Wind Gusts in Australia, School of Civil Engineering, University of Sydney, APEC 21st Century COE Short Term Fellowship, Tokyo Polytechnic University
52. Nadimpalli K, Cechet RP, Edwards M, 2007, Severe Wind Gust Risk for Australian Capital Cities – A National Risk Assessment approach, Risk and Impact Analysis Group, Geospatial and Earth Monitorig Division, Geoscience Australia, Canberra, Australia. Email : Krishna.nadimpalli@ga. gov. au
53. RMS of NSW Road Design Guide
54. Sanabria LA, Cechet RP, A Statistical Model of Severe Winds, Geoscience Australia Record 2007/12, Australian Government
55. S. E. Oliver, W.W. Moriarty, J.D. Holmes "A risk model for design of transmission line systems against thunderstorm downburst winds" Engineering Structures 22 (2000) 1173-1179
56. Service and Installation Rules for New South Wales
57. Southwire Overhead Conductor Manual 2nd Edition, Southwire Company, Georgia USA www.southwire.com
58. T HR EL 10005 ST - Requirements for Electric Aerials Crossing RailCorp Infrastructure
59. Townsend HE, 2002, Outdoor Atmospheric Corrosion, ASTM STP 1421, ASTM, Philadelphia, USA
60. UPAC Guide International Helicopter Association, UFOC Best Practices Safety guide for Helicopter Operators, Revision 12 : December 2008,
61. Vincent T. Morgan,1967, "The Current-Carrying Capacity of Bare Overhead Conductors" I. E. Aust. Power Systems Conference August 1967 paper 2326
62. Vincent T. Morgan "Thermal Behaviour of Electrical Conductors, Steady, Dynamic and Fault-Current ratings" John Wiley and Sons, Brisbane, 1991
63. Wareing B, 2002, Wood Pole Overhead Lines, IEEE P&E Series 48, IEE,
64. Wong CJ, Miller MD, Guidelines for Transmission Line Structural Loading, 3rd edit, ASCE Manuals and Reports on Engineering Practice No 74 2010

13.3 Acts and regulations

- Electricity Supply Act 1995.
- Electricity (Consumer Safety) Act 2004 (NSW)
- Electricity (Consumer Safety) Regulation 2015 (NSW)
- Electricity Supply (General) Regulation 2014 (NSW)
- Electricity Supply (Safety and Network Management) Regulation 2014 (NSW)
- Environmental Planning and Assessment Act 1979 (NSW)
- Work Health and Safety Act 2011 (NSW)
- Work Health and Safety Regulation 2017 (NSW)

14.0 DEFINITIONS

Refer to NS001 Glossary of Terms

15.0 RECORDKEEPING

The table below identifies the types of records relating to the process, their storage location and retention period.

Table 42 – Recordkeeping

Type of Record	Storage Location	Retention Period*
Approved copy of the Network Standard	Document repository Network sub process Standard – Company	Unlimited
Draft Copies of the Network Standard during amendment/creation	Work Folder for Network Standards (HPRM ref. 2014/21250/342)	Unlimited
Working documents (emails, memos, impact assessment reports, etc.)	Records management system Work Folder for Network Standards (HPRM ref. 2014/21250/342)	Unlimited

* The following retention periods are subject to change, for example, if the records are required for legal matters or legislative changes. Before disposal, retention periods should be checked and authorised by the Records Manager.

16.0 DOCUMENT CONTROL

Content Coordinator : Head of Asset Risk & Performance

Distribution Coordinator : Manager Asset Standards