Network Standard

Document No.
NS220

Title:
Overhead Line Design - DRAFT

Approved Date	Select Date	Revision		7	
Lifecycle Stage	Design	Internal Use	☒	External Use	☒
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Revision

No	Date	Description	Technical Approver	Authorised By
0	Date.	BMS conversion	Technical Approver.	Authorised By.
1	Date.	Initial release.	Technical Approver.	Authorised By.
2	4/05/2021	Minor amendments	Technical Approver.	Authorised By.
3	1/06/2022	References to ‘Dial Before You Dig’ changed to ‘Designated underground asset information provider’.	Technical Approver.	Authorised By.
4	25/05/2023	Inclusion of clearances to swimming pools.	Technical Approver.	Authorised By.
5	26/05/2023	Mandated composite fibre crossarms for standard construction.	Duminda Thenuwara	Matthew Cupples
6	26/06/2024	Inclusion of CCSX conductors.	Matthew Cupples	Jacob Bayley
7	21/11/2025	Conversion to new Network Standard template and revised title. Comprehensive review of content, document flow and Annexures. Revised design security levels for steel towers / sub-transmission lines. Revised LIWV voltages. Added risk assessment references. Revised design load and temperature case criteria. Revised conductor, tension, stringing and clearance criteria. Revised pole, stay arrangement and pole attachment criteria and references. Enhanced information regarding aerial warning markers.	Greg Ross	Jacob Bayley

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List of Annexures

Scope

This Network Standard is the Ausgrid interpretation of AS/NZS 7000 and should be interpreted in conjunction with the current versions of other relevant Ausgrid Network Standards and Standard Construction drawings. Where differences exist, precedence shall be granted to the more specific Ausgrid Network Standard except where appropriate written authorisation is obtained to do otherwise.

Reference Documents

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

Ausgrid Documents

Board Policy - Risk Management Policy (GV000-Y0014)

Bushfire Risk Management Plan

Electrical Safety Rules

Framework - Risk Management GV000- P0237

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

NS119 Public Lighting Design and Construction

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

NS214 Guide to HV Live Line Design Principles

NS232 National Broadband Network equipment on Ausgrid Poles

NS268 Design and Construction of Waterway Crossings

NS270 Stray Direct Current Management

Procedure – Risk Management Process (GV000-P0373)

Other Standards and Documents

AS3891.1 Air navigation - Cables and their supporting structures - Marking and safety requirements – Part 1: Marking of overhead cables and supporting structures

AS3891.2 Air navigation - Cables and their supporting structures - Marking and safety requirements – Part 2: Low level aviation operations

AS/NZS 7000:2016 Overhead line design

Austroads Guide to Road Design – Part 6: Roadside Design, Safety and Barriers

Boaters' guide to electricity cables crossings of NSW navigable waters

EEG-00-01 Requirements for Electrical Aerials Crossing ARTC Infrastructure

Service and Installation Rules for New South Wales

TS 03773:1.0 Requirements for Electrical Aerials Crossing Transport for NSW Heavy Rail Infrastructure

T HR EL 12002 GU Electrolysis from Stray DC Current (Transport for NSW TS 03676:0.0)

Acts and Regulations

Work Health and Safety Act 2011 (NSW)

Work Health and Safety Regulation 2017 (NSW)

Clause	Standard Requirements

1 General Requirements

1.1 Design Assessment

1.1.1 The structural design of overhead lines shall ensure that (refer to Figure 1):

- the mechanical load forces do not exceed the strength of the structures or other components related to the structures, and
- adequate clearances are provided between the conductors and the ground or from other objects in the vicinity of the line, between the various phase or earth conductors and between different circuits.

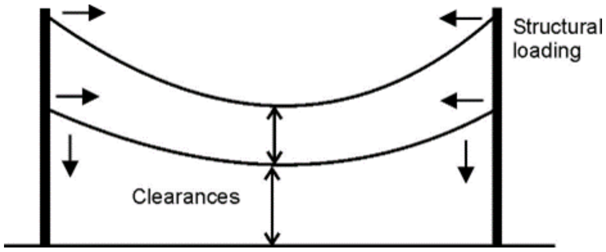


Figure 1 - Structural loading and clearances

1.1.2 Overhead line designs shall be performed using software approved by Ausgrid. The software shall incorporate the design criteria in accordance with this Network Standard (refer to Annexure C).

1.1.3 The overhead line shall comply with Clause 1.1.1 over the full design range of:

- Weather conditions (temperature / sag) that could be reasonably encountered, and
- Load (wind) conditions that could be reasonably encountered.

1.1.4 The following limit state load conditions shall be assessed as a minimum:

- Ultimate Strength Limit – Maximum Wind Load, and
- Serviceability Limit - Damage, and
- Sustained Load, and
- Failure Containment (unbalanced support loading), and
- Construction and Maintenance Loading.

1.1.5 Variations from the requirements of this Network Standard shall be managed in accordance with the NS181 Network Standard Variations process.

1.2 Design Security Levels

1.2.1 Design Security Levels shall be applied to the design of new overhead lines in accordance with AS/NZS 7000 Security Levels and Table 1 (which includes their application to overhead line voltage / type, design lives and design wind return periods).

Table 1 - Ausgrid Overhead Mains Design Security Level

AS/NZS 7000 Security Level	Line/Load Type	Design Working Life	Design Wind Return Period
I	LV and HV pole lines	50 years	50 years
II	33kV and 66kV pole lines	50 years	100 years
III	132kV pole lines	50 years	200 years
	132kV steel tower lines	100 years	200 years

	132kV steel tower lines (high importance)	100 years	400 years

1.2.2 Risks associated with 132kV dual-circuit support structures shall be assessed by Ausgrid in accordance with Clause 1.4 and quantitative analysis to determine whether single-circuit support structures shall be utilised. Risks to be assessed include:

- Maintainability (for example, clearances and outage requirements for maintenance, repairs or replacement on either line).
- Failure recovery times (immediate response and return to pre-failure state).
- Unserved energy risk.

1.2.3 Joint-use or underbuilt lines shall be designed according to the overhead line with the highest required Security Level.

1.3 Insulation Co-ordination

1.3.1 Standard rated lightning impulse withstand voltages shall be applied to the design of new overhead lines in accordance with IEC60071, NS264, Table 2 and standard construction drawings.

Table 2 – Lightning Impulse Withstand Voltage (LIWV)

Nominal Voltage	LIWV
11kV	95kV (75kV)
22kV	145kV
33kV	200kV (170kV)
66kV	325kV
132kV	650kV (550kV)

Note: The values within brackets may be deemed sufficient for equipment connected by cable (excluding transformers).

1.4 Risk Assessment

1.4.1 Any risk assessment required pursuant to this document shall be performed in accordance with:

- Ausgrid Risk Management Policy GV000-Y0014, and
- Ausgrid Framework - Risk Management GV000- P0237,
- Ausgrid Risk Management Process GV000-P0373, and
- The qualitative Risk-Ranking Matrix technique shown in those documents.

1.4.2 Refer to the Organisational Risk Matrix, shown in the risk management Framework (GV000-P0237).

1.5 Design Documentation

1.5.1 Design documentation shall meet the requirements of NS104 and shall be provided to Ausgrid.

1.5.2 Design documentation shall also be provided in accordance with Annexure B.

2 Design Load Cases

2.1 Limit states

2.1.1 The structural strength shall always exceed the applied mechanical load to prevent the overhead line transitioning beyond the limit of its intact state to a damaged or failed state.

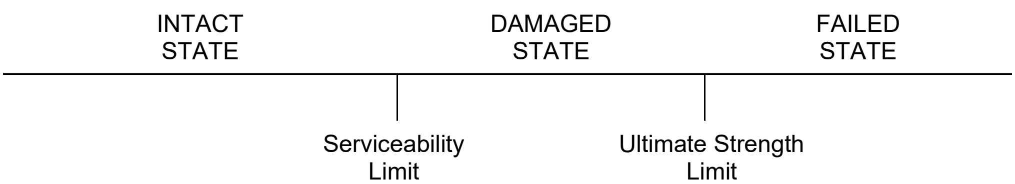


Figure 2 - Mechanical State Scale

2.1.2 The general limit state equation that shall be applied is:

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

where:

- **φ** is the strength reduction factor, which takes into account variability of the material, workmanship etc (refer to Table 13 - Component Strength Factors
-).
- **Rn** is the nominal strength of the component.
- **γx** are the load factors, taking into account the variability of the load, importance of the structure, stringing, maintenance, safety considerations, etc.
- **Wn** is the wind load.
- **X** is the applied loads pertinent to each loading condition.

2.2 Ultimate strength limit – maximum wind load condition

2.2.1 Structures and foundations shall comply with the ultimate strength limit state equation to resist the effect of wind load in all directions (short term wind gusts), including:

- the self-weight of the structure, and
- the vertical loads due to the attached conductors, and
- the conductor loads under maximum wind conditions.

2.2.2 The ultimate strength limit state equation that shall be applied is:

$\varphi R_n > W_n$ (ultimate) $+ 1.1\ G_s + 1.25\ G_c + 1.25\ F_t$

where:

- **Wn** is the effect of transverse wind load on the structure.
- **Gs** is the vertical downloads due to the self-weight of the structure and fittings.
- **Gc** is the vertical downloads due to the conductors, and
- **Ft** is the conductor loads under maximum wind conditions.

Table 3 - Ultimate Strength Limit Conditions

Conditions		Load Factors				
Design Wind Pressure	Temperature	Non-Conductor Dead Load (G_s)	Conductor Dead Load (G_c)	Conductor Tension (F_t)	Live Load (Q)	Broken Conductor Load (F_b)
Note 1	15°C	1.1	1.25	1.25	-	-

Notes:

1. Design wind pressure (see Table 9) will depend on terrain category, line security level and microburst considerations.
2. For other load cases, e.g. snow and ice, seismic, torsional loading, and maximum wind uplift, refer to AS/NZS 7000.

2.3 Serviceability limit - damage

2.3.1 Structures shall comply with the serviceability limit – damage state equation to assess the performance and functionality under normal everyday conditions ensuring no damage is occurring to components at the serviceability strength state.

2.3.2 The serviceability limit - damage state equation that shall be applied is:

$\varphi R_n > W_n$ (serviceability - damage) $+ 1.1\ G_s + 1.1\ G_c + 1.0\ F_t$

where:

- **Ft** is the conductor load under everyday conditions.

Table 4 - Serviceability (Damage) Limit Conditions

Conditions		Load Factors				
Design Wind Pressure	Temperature	Non-Conductor Dead Load (G_s)	Conductor Dead Load (G_c)	Conductor Tension (F_t)	Live Load (Q)	Broken Conductor Load (F_b)
144 Pa	5°C	1.1	1.1	1.0	-	-

2.4 Sustained load

2.4.1 Structures and foundations shall comply with the sustained load (everyday condition) state equation to resist sustained everyday conductor tensions

2.4.2 The sustained load state equation shall be used for assessing concrete pole cracking and advanced foundation designs.

2.4.3 The sustained load state equation that shall be applied is:

$$\phi R_n > W_n \text{ (sustained)} + 1.1\ G_s + 1.25\ G_c + 1.1\ F_t$$

where:

- **Ft** is the conductor load under everyday conditions.

Table 5 - Sustained Load Limit Conditions

Conditions		Load Factors				
Design Wind Pressure	Temperature	Non-Conductor Dead Load (G_s)	Conductor Dead Load (G_c)	Conductor Tension (F_t)	Live Load (Q)	Broken Conductor Load (F_b)
0 Pa	5°C	1.1	1.25	1.1	-	-

2.5 Failure containment

2.5.1 Structures and foundations shall be designed to withstand the unbalanced (equivalent longitudinal) loads resulting from a broken conductor failure containment condition in accordance with Table 6Table 6.

Table 6 – Assessment of Failure Containment Conditions

Line Component	Assessment	Apply to		
		LV	11kV-22kV	33kV-132kV
Suspension or intermediate supports - single circuit	The worst effect of failure of either one phase (with allowance for bundles) or the earth wire.	No	No	Yes
Suspension or intermediate supports - dual circuit	The worst effect of failure of either any two phases on opposite sides of the structure, or any phase and the earth wire.	No	No	Yes
Tension and terminal supports	The worst-case loading effect of the equivalent longitudinal load displacement of one earth wire and one phase per circuit.	Yes	Yes	Yes
Stayed structures (pole and foundation)	The failure containment load with one stay wire removed (assuming all phase	Yes	Yes	Yes

	conductors are intact and moderate weather conditions).			
Critical crossings identified through a risk assessment (Note 1)	Failure containment in the form of cascading failure prevention of conductor's using termination structures, collapsable / bendable gain bases or other safe load release alternatives.	Yes	Yes	Yes

Notes:

1. Examples include, but are not limited to, major roads and highways.

2.5.2 The failure containment state equation that shall be applied is:

$\varphi R_n > W_n$ **(failure containment)** $+ 1.1\ G_s + 1.25\ G_c + 1.25\ F_t + 1.25\ F_b$

where:

- **Fb** is the unbalanced tension resulting from the broken conductor condition.

Table 7 – Failure Containment Limit Conditions

Conditions		Load Factors				
Design Wind Pressure	Temperature	Non-Conductor Dead Load (G_s)	Conductor Dead Load (G_c)	Conductor Tension (F_t)	Live Load (Q)	Broken Conductor Load (F_b)
300 Pa	15°C	1.1	1.25	1.25	-	1.25

2.6 Construction and maintenance loading

2.6.1 Structures and foundations shall be designed to tolerate the maximum conductor tension reasonably expected to be imposed during construction or maintenance operations including:

- Wind pressure in all directions of 100Pa,
- Everyday temperature conditions; and
- Prestressed conductor tensions prior to allowance of creep.

2.6.2 All potential construction and maintenance loads shall be assessed including:

- Safe working procedures which prevent overstressing of the support, and
- Conductor stringing methodology, and
- Construction staging, or maintenance practices affecting vertical downloads, and
- The need for temporary slinging, staying or lifting arrangements.

2.6.3 Any alterations or temporary rearrangements of loading shall meet the specified construction and maintenance load case criteria.

2.6.4 Notes shall be included in design drawings indicating, where required, the need for temporary construction stays. Assessment of conductor stringing and construction staging is required when developing supports for this load case.

2.6.5 The construction and maintenance state equation that shall be applied is:

$\varphi R_n > W_n$ **(construction & maintenance)** $+ 1.1\ G_s + 1.5\ G_c + 1.5\ F_t + 2.0\ Q$

where:

- **Ft** is the load on the pole due to intact conductor tension loads for the maintenance conditions.
- **Q** is the dynamic loads due to personnel and equipment that may be applied to the pole or pole top hardware during construction or maintenance (refer to AS/NZS 7000).

Table 8 – Construction & Maintenance Limit Conditions

Conditions		Load Factors				
Design Wind Pressure	Temperature	Non-Conductor Dead Load (G_s)	Conductor Dead Load (G_c)	Conductor Tension (F_t)	Live Load (Q)	Broken Conductor Load (F_b)
100 Pa	15°C	1.1	1.5	1.5	2.0	-

2.7 Wind Pressure Cases

2.7.1 Maximum wind pressures shall be applied in accordance with Table 9 and Table 10**Error! Reference source not found.**.

Table 9 - 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 provided in Table 9Table 9
3. Line Security Level I, II & III Design Life and Return Period in accordance with Table 1.
4. This document does not cover the wind pressure values for steel tower lines (100-year design life and 200-year or 400-year (high importance) wind return period). The Designer shall use software approved by Ausgrid and the automated wind load calculations built into that software.
5. These wind pressures are calculated with the input parameters from Table 10**Error! Reference source not found.**. Wind pressures shall be recalculated if the assumptions in Table 10**Error! Reference source not found.** do not apply.

Table 10 - Wind Pressure Input Parameters

		Line Security I		Line Security II		Line Security III	
Assumption Criteria		Rural	Urban	Rural	Urban	Rural	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

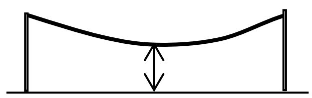
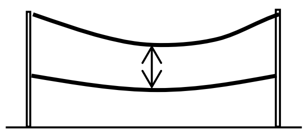
Notes:

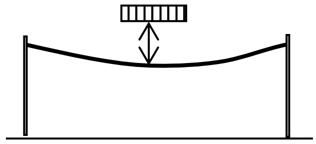
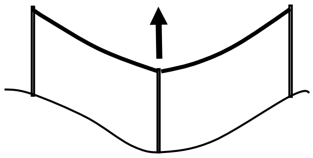
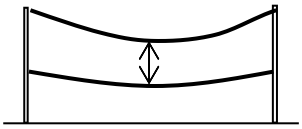
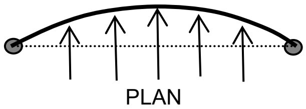
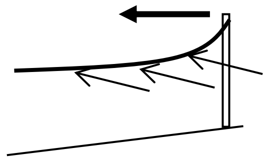
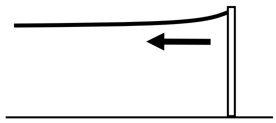
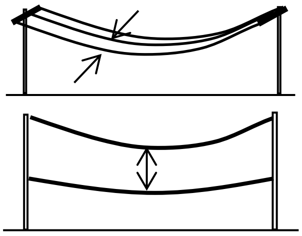
1. Wind pressures shall be recalculated if the assumptions in Table 10**Error! Reference source not found.** do not apply.
2. The design wind pressures are based on assumptions that are critical to the accuracy of the design pressure for any given location. In general, the topographic factor is the only 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.

2.8 Line temperature cases

2.8.1 Line temperature cases shall be applied in accordance with Table 11Table 11 when designing and assessing circuit operation.

Table 11 - Line Temperature Cases

Situation	Line Temperature	When used	
Maximum design temperature	Refer to Table 12 **(no wind)Table 12 - Maximum Design Operating Temperature for all Voltages**	Assessing clearance from ground or objects below the line.	
'Everyday' design temperature	15°C no wind	Assessing super-circuit sag against sub-circuit sag	

Minimum design temperature	5°C no wind	Assessing clearance from objects above the line	
Uplift	5°C no wind 15°C serviceability	Assessing for uplift forces, especially on intermediate structures under 1) no wind condition, and 2) serviceability wind conditions of 500Pa.	
Sub-circuit (anywhere in the span) Refer to Clauses 8.6 and 8.7	**Super-circuit** Maximum design temperature (refer to Table 12) – no wind **Sub-circuit** 15°C no wind	Assessing super-circuit to sub-circuit separation	
Blowout	40°C serviceability – no load factors	Assessing horizontal line displacement (sideways ‘sag’) under serviceability wind conditions of 500Pa.	
Maximum wind condition	15°C	Assessing mechanical forces under maximum wind.	
Sustained load condition	5°C no wind	Assessing sustained mechanical forces and reference temperature for conductor stringing	
Midspan conductor clearances	**Phase to phase** 50°C no wind **Circuit to circuit** 50°C no wind	Assessing interphase and intercircuit conductor spacing to avoid clashing at midspan	

2.8.2 Maximum design operating temperatures shall be applied in accordance with Table 12Table 12.

Table 12 - Maximum Design Operating Temperature for all Voltages

Voltage	Conductor	Max Temperature
132kV	ACSR	120°C
132kV	AAC or AAAC	100°C
66kV	ACSR	120°C, if new (Note 1)

66kV	AAC or AAAC	100°C, if new (Note 1)
33kV	ACSR	120°C, if new (Note 1)
33kV	AAC or AAAC	100°C, if new (Note 1)
11kV	Bare	75°C
11kV	CCT or CCSX	80°C
LV	AAC, AAAC or ACSR	75°C (Note 2)
LV	ABC	80°C
-	OPGW & OHEW	30°C (Design)
-	ADSS	40°C (Design)
-	Stay Wires	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. For existing Hard-drawn Copper (HDCu) mains, submit a request for rating to Ratings@ausgrid.com.au.

2.9 Strength factors for various components

2.9.1 Strength reduction factors for various components shall be applied in accordance with Table 13.

Table 13 - Component Strength Factors

Part of Overhead Line	Component	Limit State	Strength Reduction Factor (Φ)
Timber pole structures	Poles	Strength	0.60
		Serviceability	0.34
Timber crossarm not preserved by full length treatment	Crossarms	Strength	0.85
		Serviceability	0.48
Fibre-cement pole structures	Poles	Strength	0.75
		Serviceability	0.3
Fibreglass Composite Structures (design based primarily on testing)	Poles or crossarm	Strength	0.75 (Note 1)
		Serviceability	0.3 (Note 1)
Concrete structures	Poles	Strength	0.9
		Serviceability	0.3 (Note 2)
Steel structures	Poles or crossarms	Strength	0.9
Stays	Cable members	Strength	0.80
	Anchors	Strength	0.40
Conductors	Conductors	Strength	0.70
	Conductors	Serviceability	0.50
Fittings and pins - forged or fabricated	Insulators or fittings	Strength	0.80

Fittings – cast	Fittings	Strength	0.70
Fasteners	Bolts, nuts, washers	Strength	0.90
Porcelain or glass insulators	Insulators	Strength	0.80
Synthetic composite suspension or strain insulators	Insulators	Strength	0.70
		Serviceability	0.40
Synthetic composite line post insulators	Insulators	Strength	0.9 (max. design cantilever load)
		Serviceability	0.4
Foundations relying on strength of soil - conventional soil testing (Note 3)	Poles	Strength	0.9 (Note 6)
Foundations relying on strength of soil - empirical assessment of soil (Note 4)	Poles	Strength	0.8 (Note 6)
Foundations designed to yield before structure failure (Note 5)	Poles	Strength	1.0 (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 13 shall apply.
2. Reinforced and prestressed concrete poles shall exhibit a 'no-crack' criteria for serviceability / sustained loads in accordance with the manufacturer's load / deflection pole performance
3. Testing methods may be Cone Penetration Test (CPT), trial pits or other standardised tests (refer to AS/NZS 7000).
4. Soil information from Ausgrid's GIS would be considered suitable to meet the criteria of 'empirical assessment'.
5. For designs up to and including 11kV, only intermediate structure footings may be designed to 'yield before structure failure'. The ϕ-factor of 1.0 shall not be used for deviation angle structures (greater than 10°) or termination structures as pole footing yield is unacceptable at these locations.
6. The ϕ-factor is equivalent to the Geotechnical Reduction Factor for foundations.

3 Conductors and Cables

3.1 Conductor selection

3.1.1 The selected conductors shall comply with the requirements of Clause 1.

3.1.2 Conductors (including overhead earth wires) shall be selected from the list of Ausgrid preferred conductors (refer to the AML and Annexure A) in accordance with the following factors:

- The operating context – including network safety requirements (for example, bushfire risk), network reliability / resilience requirements, and compatibility with existing adjacent electrical infrastructure.
- The environmental context - including environmental conditions (for example coastal, rural, heavily polluted, urban), lightning exposure, vegetation / flora and fauna (for example, significant / heritage trees, bird migration, wildlife).
- Electrical properties – including required electrical current rating (including expected future requirements) and fault current capacity - refer to Clause A2.
- Mechanical properties - including span lengths, conductor tensions and sag limitations, conductor weight, and resulting structural requirements (particularly important for reconductoring a feeder using existing structures) – refer to Clause A3.
- Life cycle costs – including capital costs (for example, conductors and fittings, construction time), operating costs (for example, line / pole / pole top equipment access, switching / access permit earthing, HV live line work), maintenance costs (for example, vegetation management) and end of life replacement / disposal.

3.1.3 New SWER or 11kV insulated (HV ABC) systems shall not be constructed.

3.1.4 Overhead line earthing point and lightning protection requirements for high voltage conductors (11kV and 22kV) shall be assessed in accordance with NS126.

3.1.5 Overhead line earthing system and overhead earth wire requirements for sub-transmission conductors (33kV, 66kV and 132kV) shall be assessed in accordance with NS135.

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

3.2 Streetlighting circuits

3.2.1 New overhead dedicated streetlighting circuits shall be avoided where reasonably practicable

3.2.2 Existing dedicated streetlighting circuits shall be removed where reasonably practicable in conjunction with conversion of spans to LV ABC or replaced with LV ABC where it is not reasonably practicable to remove them.

3.2.3 Refer to NS119 and NS124 for further details.

3.3 Sub-transmission conductors

3.3.1 Sub-transmission overhead lines shall employ a single conductor per phase.

3.3.2 Any proposed use of bundled (dual) conductors shall be managed in accordance with NS181 and shall:

- Be limited to a few spans for reconstruction of existing lines (for example, a termination section) unless conversion to a single conductor cannot achieve required ratings.
- Be a horizontal bundle arrangement.
- Have conductor spacers installed in accordance with standard construction drawing 231652 or the manufacturer's recommendations, considering conductor size, tension, wind conditions and vibration damping requirements.

3.3.3 Sub-transmission conductor selection shall include an assessment of compliance with all of the following criteria in addition to the requirements of Clause 3.1 (also refer to NS135):

- Voltage support and line regulation is maintained within specified limits.
- Line losses are maintained within specified limits.
- Transposition structures required to achieve those voltage and line loss limits.

3.4 Aerial warning markers

3.4.1 New overhead lines and structures shall be assessed for inclusion of aerial warning markers in accordance with Australian Standard AS3891.1, AS3891.2 and Civil Aviation Guidelines where:

- Overhead lines encroach into a legitimate domain of aircraft.
- Aircraft are known to operate in the vicinity of overhead lines, including low-level flying (for example, aircraft used for agricultural or similar purposes, planes operating from waterways, helicopter landing sites).
- Aircraft are likely to be used for firefighting (including collecting water).
- An overhead line crosses another overhead line in an area where the lower line is subjected to aerial inspections by Ausgrid or another authority (for example, Essential Energy, Endeavour Energy).
- A waterway crossing exists, is being modified or is being built (refer to Clause 8.11.3).

3.4.2 Temporary or permanent aerial warning markers may also be required on existing or new lines at locations where conductor clearances may be breached, including the following circumstances:

- Transport and logistics locations where high / extendable vehicles are used or may be climbed (refer to Clause 8.2.2).
- Construction, mining or earthmoving sites.
- Locations where agricultural machinery or spray irrigator systems are used.

3.4.3 Aerial warning markers (where required) shall comply with AS3891.1 and AS3891.2.

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

3.4.5 The aerial warning marker assessment shall include:

- Modelling of the overhead line to assess the impact on structures and conductors of the additional wind load and weight of the aerial warning markers.
- Determination of the conductor height above ground level by modelling the overhead line at 5°C under still air conditions
- Comparison of structure heights and conductor heights above ground level against the requirements in either or all of AS3891.1, AS3891.2 and Civil Aviation Guidelines.
- Consultation with stakeholders / affected parties.

Note: 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.

3.4.6 Refer to Annexure D for further details.

3.5 Bird diverters

3.5.1 Overhead lines shall be assessed for inclusion of bird diverters in areas:

- With a high-level of bird activity, for example wetlands.
- Frequented by birds with large wingspans.
- Identified in environmental impact assessments.

4 Conductor Tension, Creep and Stringing

4.1 General requirements

4.1.1 Overhead line conductor stringing shall comply with the requirements of Clause 1.

4.1.2 Within a termination section, span lengths should be:

- Kept to a similar length where it is practical to do so, considering the terrain, property boundaries, required ground clearance or other factors.
- No greater than double the ruling span, or less than half of the ruling span.
- No greater than double the shortest span within any termination section on tight-strung lines.

4.1.3 Through-termination constructions shall be used to isolate any spans that do not comply with Clause 4.1.2 except for circumstances where design calculations demonstrate that they are not required.

4.2 Design tensions

4.2.1 Overhead lines shall not be designed unnecessarily tight as elevated stringing tensions increase mechanical loads on poles and foundations and may require additional vibration damping. Lower stringing tensions shall be specified in areas with loose sands or soft clays to limit pole embedment depths to reasonable levels (refer to Clause 5.2 for further detail).

4.2.2 Where reasonably practicable, the sag of a super-circuit shall align with (but not exceed) the sag of the sub-circuit at the ‘Everyday’ temperature case (refer to Table 11).

4.2.3 Sub-circuits shall not be designed with a higher stringing tension than super-circuits where the two circuits are of the same conductor type (for example, AAC and AAC).

4.2.4 Where different conductor types are used for sub-circuit and super-circuit (for example, AAC and ACSR/GZ), the sub-circuit may be of a higher tension than the super-circuit to account for different sag characteristics of the different conductor types.

4.2.5 Conductor tension shall be specified as a percentage of the conductor’s Ultimate Tensile Strength (UTS) or Conductor Breaking Load (CBL), referenced at 5ºC in still air.

4.2.6 For LV ABC conductor, the stringing tension shall not exceed 10% UTS. The stringing tension shall be limited to a maximum of 6% UTS if services are required within the section under tension.

4.2.7 For HV covered conductor:

- CCT stringing tensions shall not exceed 10% UTS and spans shall not exceed 120m in length.

- CCSX stringing tensions shall not exceed 20% UTS – span length is only limited by ground clearance requirements.

4.2.8 For bare conductors, maximum design tensions, and specification of armour rods / grips, vibration dampening and clamping arrangements shall be assessed in accordance with AS/NZS 7000:2016 Table Y1.

4.2.9 For CCSX conductors, spiral vibration dampers shall be installed in accordance with standard construction drawing 250145 where the conductor:

- Is in an area unprotected from wind (for example, flat / treeless plains or river crossings), or
- Stringing tension exceeds 15% UTS, or
- Span lengths are greater than 100m.

4.3 Conductor Creep

4.3.1 Conductor creep shall be calculated by use of a linear or non-linear conductor model with reference to the limitations (refer to Clause C4.9).

4.3.2 Conductor creep shall not be allowed for where an existing conductor is being re-tensioned.

4.3.3 Stringing charts shall clearly distinguish between new conductor tensions that allow for future creep (known as the 'initial' conductor phase), and existing conductor (or pre-stressed conductor) tensions for conductors that have already crept (known as the 'final' conductor phase).

4.3.4 'Final' sags shall be used when determining clearances.

4.4 Conductor Stringing

4.4.1 Stringing tension tables should be provided with the following information (where required by the construction activity being performed):

- Conductor sags for stringing with sight battens/boards.
- Wave sagging times (3 return waves).
- Conductor tensions for tensioning with a dynamometer.

This information shall be provided for a range of ambient site temperatures which line workers will select from on the day of tensioning and generally 5ºC to 40ºC (in 5ºC increments)

Note: some items may not be required where the construction activity is a routine activity (for example, a straight-through pole change-over, or like-for-like conductor replacement on existing poles).

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 34 - Example Stringing Table

5 Poles

5.1 General requirements

5.1.1 The selected poles shall comply with the requirements of Clause 1.

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

5.1.3 The use of poles not included in the AML shall be managed in accordance with NS181.

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

5.1.5 Pole steps shall be installed in accordance with NS128.

5.1.6 Timber poles shall not be painted. Non-timber poles shall only be painted following approval by Ausgrid. Proposals to paint non-timber poles shall be managed in accordance with NS181.

5.2 Foundations

5.2.1 Pole foundations shall be designed / assessed using the Ausgrid Pole Embedment Calculator (PEC) to match the tip strength capacity and height of the pole.

Note: The PEC will not provide a solution for all assessment cases – expert advice shall be sought in circumstances where the PEC does not provide a solution.

5.2.2 Foundation design may be performed by a qualified Civil/Structural engineer or foundation design software assessed and approved by Ausgrid. In these circumstances foundations shall be designed in accordance with AS/NZS 7000:2016 and a certified plan of the design shall be provided to Ausgrid before construction commences.

5.2.3 Foundation designs shall include an assessment of additional embedment depths required for poles likely to be excavated for installation of cable transitions from underground to overhead (UGOH) or earthing equipment when the pole is first commissioned, or where it is reasonably foreseeable that excavation for these purposes is likely to occur. The assessment shall include factors such as:

- Cable and/or conduit bending radii.
- Trench / excavation orientation and dimensions.
- Differences in backfill materials (around the cable compared to the pole).
- Construction methodology / sequencing and temporary support requirements.

5.2.4 The construction methodology and temporary support requirements shall also be assessed prior to excavation when new UGOH's are proposed to be installed on existing poles, particularly when the actual embedment depths of the pole are unknown. Refer to standard construction drawing 256262.

5.2.5 For overhead lines designed to a standard pre-dating AS/NZS 7000:2010, poles installed to Ausgrid's standard embedment depth will have adequate footing strength for working loads in medium bearing strength soils (300kPa/m^2).

5.2.6 The use of concrete piles and rag-bolt or pile mounted steel poles (excluding streetlighting columns) shall be managed in accordance with NS181.

5.3 Pole positioning

5.3.1 Poles shall be positioned in accordance with NS128 and NS167, including assessment of the following outcomes.

Table 14 – Pole positioning outcomes

Desirable outcomes (where practical)	Undesirable outcomes (where practical)
- In urban areas, poles are positioned in line with alternate lot boundaries and with minimal impact to house frontages and aesthetics. - Forces and deviations on structures are minimised. - For bare mains, road crossings are minimised. - When using LV ABC, deviating across narrow roads to avoid vegetation, buildings or other clearance issues. - Span lengths are kept reasonably similar. - Coordinated with road lighting requirements. - Vegetation clearing requirements minimised. - On undulating ground, placed on the tops of ridges, or on shoulders' either side of a gully. - Where earthed, adequate clearances from telecommunications earths (refer to NS116). - Good operational access to poles, especially for poles with switches and other plant. - Reasonably prevents means of unauthorised access to parts of the pole above normal ground level.	- Mains or services crossing private property. - Aesthetics / views from houses obstructed, especially where there is pole-mounted plant. - Spans lengths less than 10m. - Within 1.5m from existing driveways or blocking gateways or access tracks on rural properties. - Deviating across roads more often than is necessary, particularly with LV bare mains. - Impeding the vision of motorists or where likely to be struck by errant vehicles, for example, sharp corners, or the outside radius of a tight curve. - At the bottom of gullies (uplift and foundation risks). - Swampy ground or loose sand (foundation risks). - Close to the top of embankments (foundation risks). - Excavation is difficult due to ground conditions (for example, rocky ridges). - Numerous or sensitive underground services nearby (for example, congested footpaths, major fibre cable). - Difficult or restricted access (for example, poor quality access tracks, steep embankments, crops, heavy vehicular traffic, median strips, behind locked gates).

5.3.2 Poles (or other support structures) shall not be positioned within transmission line easements (refer to Clause 8.10.2).

5.3.3 Easements, leases and rights of way shall be established in accordance with NS143

5.3.4 The pole alignment and setback for each specific site shall meet all of the safety and design criteria required by Ausgrid.

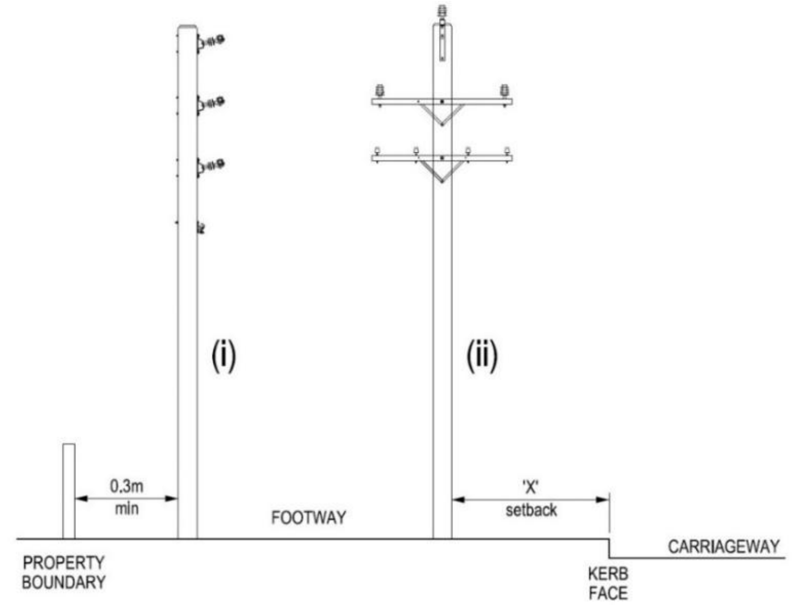


Figure 5 - Pole Alignment / Setback Options

5.3.5 The pole positioning requirements of other organisations and authorities such as Transport for NSW (TfNSW) shall also be assessed. Refer to Table 15.

Table 15 - 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>In addition to requirements in NS167 and NS220, a ‘Clear Zone’ shall be maintained on TfNSW-controlled roads as far as reasonably practicable as per TfNSW requirements (refer to Clause 5.3.6 Table 16). 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. Refer to NS128 and NS130 for utility allocations in various regions as per NSW Street Opening Coordination Council (SOCC).
2. Poles shall be installed at least 300mm from existing services and other in-ground items and there shall 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. Setback shall be calculated from the pole face rather than pole centre.

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 may 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.

5.3.6 Poles on existing TfNSW roads shall be positioned outside of the 'Clear Zone' distances detailed in Table 16 as far as reasonably practicable after assessing Ausgrid's requirements. Poles on new TfNSW roads shall be positioned in accordance with the Austroads Guide to Road Design - Part 6: Roadside Design, Safety and Barriers.

Note: TfNSW may choose to vary from the table for any given site.

Table 16 - 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	6:1 to flat	4:1 to 5:1	3:1 and steeper (Note 3)
≤ 60	< 750	3.0	3.0	Note 3	3.0	3.0	3.0
	750 – 1500	3.5	4.5	Note 3	3.5	3.5	3.5
	1501 – 6000	4.5	5.0	Note 3	4.5	4.5	4.5
	> 6000	5.0	5.5	Note 3	5.0	5.0	5.0
70 – 80	< 750	3.5	4.5	Note 3	3.5	3.0	3.0
	750 – 1500	5.0	6.0	Note 3	5.0	4.5	3.5
	1501 – 6000	5.5	8.0	Note 3	5.5	5.0	4.5
	> 6000	6.5	8.5	Note 3	6.5	6.0	5.0
90	< 750	4.5	5.5	Note 3	3.5	3.5	3.0
	750 – 1500	5.5	7.5	Note 3	5.5	5.0	3.5
	1501 – 6000	6.5	9.0	Note 3	6.5	5.5	5.0
	> 6000	7.5	10.0 (Note 2)	Note 3	7.5	6.5	5.5
100	< 750	5.5	7.5	Note 3	5.0	4.5	3.5
	750 – 1500	7.5	10.0 (Note 2)	Note 3	6.5	5.5	4.5
	1501 – 6000	9.0	12.0 (Note 2)	Note 3	8.0	6.5	5.5
	> 6000	10.0 (Note 2)	13.5 (Note 2)	Note 3	8.5	8.0	6.5
110	< 750	6.0	8.0	Note 3	5.0	5.0	3.5
	750 – 1500	8.0	11.0 (Note 2)	Note 3	6.5	6.0	5.0
	1501 – 6000	10.0	13.0	Note 3	8.5	7.5	6.0

		(Note 2)	(Note 2)				
	> 6000	10.5 (Note 2)	14.0 (Note 2)	Note 3	9.0	9.0	7.5

Notes:

1. Table 16 was originally sourced from the 2010 version of the Austroads Guide to Road Design – Part 6: Roadside Design, Safety and Barriers which has been superseded by the 2024 version of the Guide. The 2024 version of the Guide has withdrawn the quantified 'Clear Zones' concept in favour of a risk assessment process for the design of new roads. The information in Table 16 has been retained for continued reference for designing overhead lines on existing roads.
2. Alternate Clear Zone distances may be required by TfNSW or other road authorities.
3. Fixed objects (poles / structures) shall not be present in the toe of these slopes (change in angle to the horizontal at the bottom of the slope).

5.3.7 Table 16 shall not apply where poles are or will be installed behind a guard rail or other barrier.

5.3.8 The TfNSW requirements do not necessarily take precedence over Ausgrid requirements however they shall be assessed along with all Ausgrid's other required design criteria as they apply to each situation.

5.4 Timber poles

5.4.1 The tip-load capacity (to withstand an overturning bending moment) of existing and new timber poles shall be assessed. Refer to NS146 for further details on altering loads on timber poles.

5.4.2 The tip-load capacity of existing reinforced timber poles shall also be assessed against the capacity of the reinforcement, including the construction and maintenance loading in accordance with Clause 2.6. Refer to NS146 for further details on altering loads on reinforced timber poles.

Note: additional loading shall not be applied to poles reinforced with Ausmose Oz-C splints.

5.4.3 The ultimate tip strength (kN) equation that shall be applied for a new solid round timber pole is:

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

where:

- **k** is the factor accounting for load duration, degradation, shaving, immaturity and processing. A value of 0.8 shall be applied when assessing in-service timber poles.
- **f'b** is the characteristic strength in bending (MPa). A value of 100MPa shall be applied for strength class S1 timber poles and a value of 80MPa applied for strength class S2 timber poles (refer to Table F1 in AS/NZS 7000).
- **D** is the ground line diameter of the pole (m).
- **h** is the tip height of the pole above ground (m).

For additional information regarding timber poles, refer to AS/NZS 7000 Annexure F.

Note: The combined bending moment and compressive strength may be a limitation for timber poles supporting very heavy plant items (refer to Clause 7.3 for examples). Some design software may not be capable of calculating the combined bending moment and compressive strengths for timber poles.

5.4.4 For existing timber poles, the nominal capacity of the pole when it was new shall be applied. The design load and strength reduction factors shall also be applied as if it is a new structure.

5.4.5 For existing timber poles, the nominal capacity shall be determined from either:

- The 'ultimate strength' based on the pole disc details where a pole disc is installed (refer to NS128), or
- The ultimate tip strength equation in Clause 5.4.3 where a pole disc is not installed, or the pole disc does not include pole working strength or ultimate strength details.

5.4.6 Ausgrid may not accept the risk of a loading increase on an existing timber pole. This, combined with other factors (for example, pole condition, equipment condition), may warrant replacement of the pole.

5.5 Manufactured poles

5.5.1 The extent of deflection on the above ground length of manufactured poles shall be assessed. If pole raking is required, refer to NS128.

5.5.2 Deflection limits shall be applied to manufactured poles approved for use by Ausgrid (refer to the AML) in accordance with Table 17.

Table 17 – Manufactured Pole Deflection Limits

Pole Type	Maximum Total Deflection	Ultimate Tip Load Applied
Prestressed concrete poles	4%	50%
Reinforced concrete poles	6%	50%
Steel poles	4%	50%
Fibre-reinforced concrete poles (Note: both limits shall be applied)	5%	50%
	15%	100%

Note: The percentages have been calculated prior to the application of load factors.

6 Stays

6.1 General requirements

6.1.1 Stay arrangements shall comply with the requirements of Clause 1.

6.1.2 Stay arrangements shall be used when the permissible design load limits of a pole are exceeded. For timber poles, a minimum ultimate pole strength of 32kN (8kN working strength) is required.

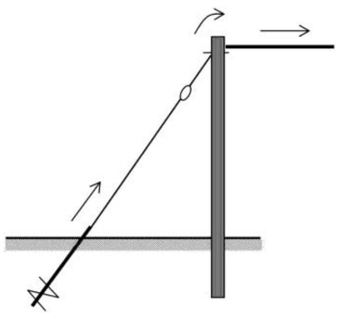
6.1.3 Stay arrangements shall be avoided where it is reasonably practicable to achieve this outcome. Fully self-supporting angle or termination poles shall be installed when the permissible design load limits are not exceeded.

6.1.4 Stay arrangements shall not be used for new overhead lines designed for Security Level II or III unless approved in accordance with NS181. For all existing Ausgrid assets, the use of stay arrangements shall be assessed on a case-by-case basis.

6.1.5 Existing stay arrangements should be removed (where reasonably practical) in association with network augmentation or replacement works.

6.1.6 Stay arrangements (where required) shall be designed for the full applied load rather than just the portion by which the load exceeds the pole capacity. It shall not be assumed that the pole and the stay arrangement share the load. Ausgrid may approve stay arrangements which share the resultant conductor tension between the pole which is stayed and the stay wire.

6.1.7 Stay arrangements shall balance the static conductor loads between the stay (including the pole or ground stay / anchor) and the main structure requiring support. The effect of offsetting stays away from the resultant force direction shall be assessed. The offset angle ‘α’ shall not exceed 45º.



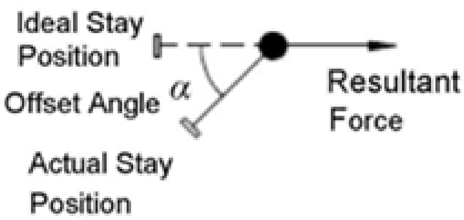


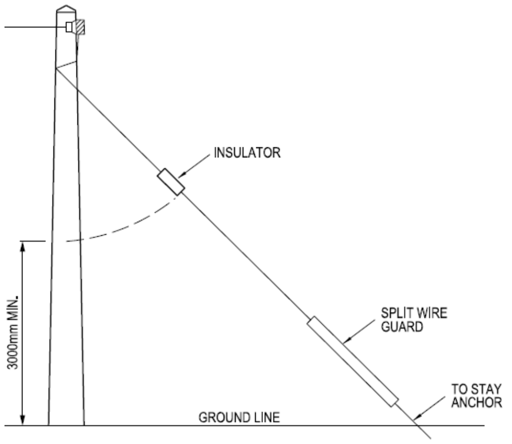
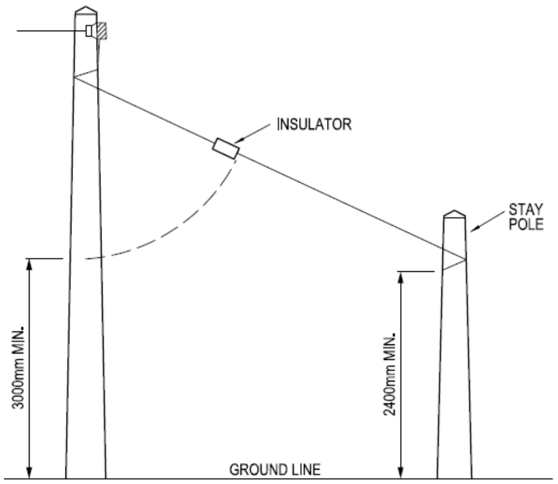
Figure 6 - Stay Loading and Offsetting

6.1.8 Stay wires shall be attached as high as practicable on the pole and shall not be earthed.

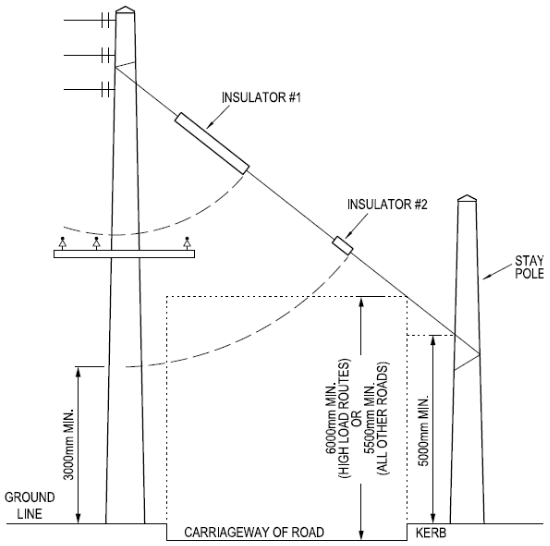
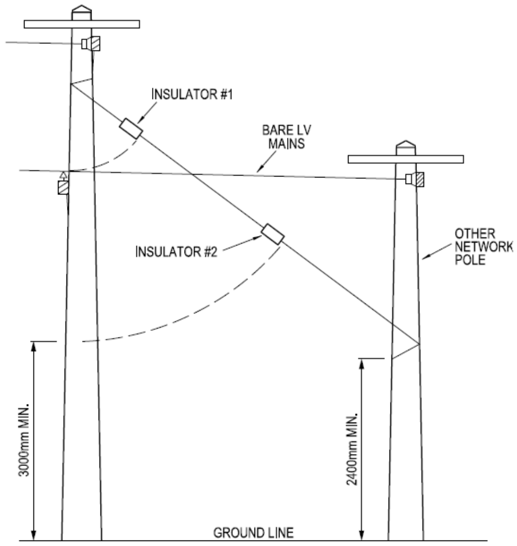
Note: some existing stay arrangements may be earthed (for example, where stay tensions exceeded available stay insulator ratings, or where there are no power circuits or attachments near the stay wire).

6.1.9 Stay insulators shall be installed on stay wires where the stay wire passes through circuits or is located near other circuits, or where other attachments are located on the stay pole. The insulator shall be installed in the stay wire in such a way that the bottom (ground side) of the insulator shall be 3.0m above groundline (minimum) in the event of a stay wire failure as shown for different arrangements in Table 18. Refer to Ausgrid standard construction drawings for additional details.

Table 18 – Stay Insulator Placement

Application	Stay Insulator Placement
Ground stays	
Aerial stays (with stay pole)	

<table>
<tr>
<td>Aerial stay with the stay wire crossing a road

Note: refer to Table 12 for stay wire temperature,</td>
<td>
</td>
</tr>
<tr>
<td>Aerial stay with the stay wire connected to another network pole, and with the stay wire passing between the centre phases of LV bare mains.</td>
<td>
</td>
</tr>
</table>

6.1.10 Stay insulators shall be selected in accordance with Table 19 and Ausgrid standard construction drawings. A 300kN polymeric insulator shall be used where the stay load exceeds the ultimate tensile strength capacity of the porcelain (GY-type) insulator.

Table 19 - Stay Insulator Types

Circuit Voltage Above Insulator	**Insulator Type**	**Ultimate Tensile Strength Capacity (kN)**	**Wet Power Frequency Flashover (kV)**
11kV	GY2	71	15
33kV	GY3	222	20
66kV &132kV	Polymeric long-rod (eye-eye)	300	275

6.1.11 Sight board, guard and barrier requirements for stay arrangements in non-public locations or rural areas shall be assessed where stay wires are likely (reasonably foreseeable) to be affected by people, vehicles / machinery, livestock / animals or floods. Guards shall not be positioned close to a fence in a way that could entrap or injure stock (cattle, horses etc) - refer to standard construction drawing 265972. Stakeholders shall be consulted.

6.2 Load cases

6.2.1 Stay arrangements shall comply with all load cases in Clause 1.5. This includes assessment of construction and maintenance sequencing and the need for temporary stay arrangements under construction and maintenance load cases.

6.2.2 Stay arrangements shall also comply with all load cases in Clause 1.5 in situations where a network pole is stayed to another network pole with an aerial stay wire. The whole stay arrangement (that is, the network poles, their foundations and the stay wire) shall be assessed.

Note: a 'network' pole is any pole which supports Ausgrid electrical, communications or lighting assets.

6.2.3 For all stay arrangements, the pole and foundation shall be capable of withstanding the failure containment load with one stay removed and all phase conductors intact (under the failure containment load case weather conditions of Clause 2.5). Additionally, the pole and stay combination shall be capable of withstanding the normal failure containment load case of one-third of conductors broken (in accordance with Clause 2.5).

6.3 Selecting stay arrangements

6.3.1 The stay arrangement shall be selected based on the full applied load and situational factors associated with the pole location. Refer to standard construction drawing 265974 for the general arrangement stays.

6.3.2 Poles shall be stayed using either of the following arrangements:

- Ground stay arrangements (refer to Clause 6.4), or
- Sidewalk stay arrangements (similar to ground stay arrangements - refer to Clause 6.4), or
- Aerial stay arrangements (refer to Clause 6.5).

6.4 Ground and Sidewalk stay arrangements

6.4.1 Ground stay arrangements shall be used in rural applications. Sidewalk stay arrangements shall be used where there is insufficient space for a ground stay arrangement (for example, semi-rural / urban areas, or where restrictions on placement exist due to footpaths).

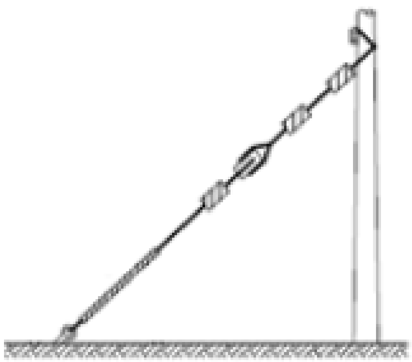


Figure 7 – Ground Stay Arrangement

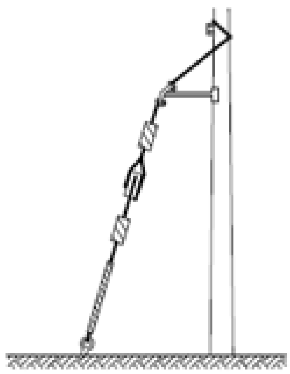


Figure 8 – Sidewalk Stay Arrangement

6.4.2 Where practical, ground and sidewalk stay arrangements shall not be installed in frequented areas such as:

- Footpaths, road reserves, cycle ways, or other locations where members of the public are likely to come into contact with the stay wire (trip or electric shock hazards).
- Areas where horses are ridden or livestock are mustered (for example, stock yard access ways, farm gates).

6.4.3 Ground and sidewalk stay arrangements shall be avoided in areas prone to flooding where debris may accumulate on or against the ground stay arrangement.

6.4.4 Stay wires for ground stays shall be installed at an angle of 45° to the ground where reasonably practicable. The stay angle can be increased to a maximum of 60° where staying space is limited. Common stay wire installation angles for sidewalk stays are 0° to 20°, noting that site conditions may limit an angle being applied to a sidewalk stay (refer to standard construction drawing 520399).

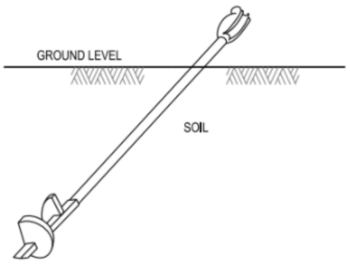
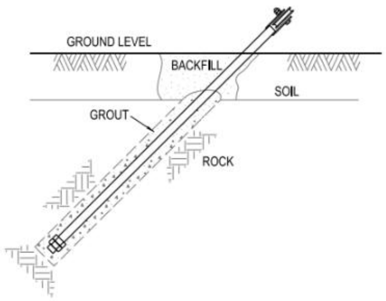
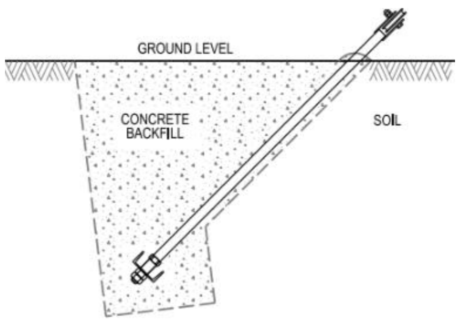
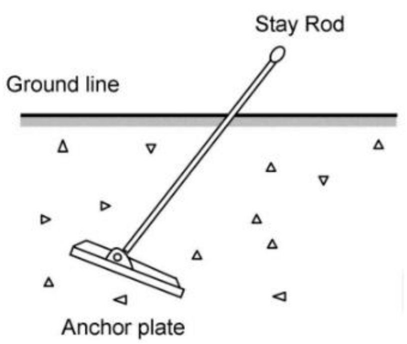
6.4.5 Galvanised steel components (stay wires and termination fittings) on ground anchors and sidewalk stay anchors shall be protected from corrosion by preventing soil coverage and/or pooling of water around the components at ground line. Refer to standard construction drawings.

6.4.6 Ground anchors shall be selected and installed in accordance with the following:

- The approved anchor types in Table 20, and
- For screw anchors, the requirements within the PEC, and
- Standard construction drawings.

Note: The stay anchor rod shall be aligned with the direction of the stay wire.

Table 20 – Ground Anchor Selection

Anchor Type	Application	Anchor General Design
Screw anchors	**Used for ground stays & sidewalk stays.** Used for most soil types.	
Rock anchors	**Used for ground stays only.** Used in bedrock and cemented sand where screw anchors cannot be driven to the required depth, and excavation of rock is impractical for a mass concrete anchor.	
Mass concrete anchors	**Used for ground stays only.** Used in very poor soil or where drainage is poor e.g. swampy areas, loose sand or to avoid interfering with underground services.	
Pivoting (tipping) plate anchors	**Used for ground stays only.** 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. **Note:** their use shall be approved by the NS181 Network Standard variation process.	

6.4.7 The stay wire for ground stay arrangements shall be selected in accordance with standard construction drawing 265974.

6.4.8 The stay wire for sidewalk stay arrangements shall be 19/2.00 galvanised steel wire in accordance with standard construction drawing 520399. The maximum stay wire capacity that shall be applied for various stay wire angles is shown in Table 21Table 21 - .

Table 21 - Stay Wire Capacity for Sidewalk Stays

Steel Stay Wire Size	Maximum Applied Tip Load (kN) At Stay Wire Angle θ				
	0°	5°	10°	15°	20°
19 / 2.00	13.8	17.1	20.9	24.5	27.8

6.5 Aerial stay arrangements

6.5.1 Aerial stays shall be used where ground stays are unsuitable, for example, crossing a roadway and most urban areas. Aerial stay structures include stay poles, stay piles and other Ausgrid network poles (refer to standard construction drawing 271409).

6.5.2 Foundations for support structures shall be designed in accordance with Clause 5.2. Stay piles may require assessment by a civil / structural engineer.

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

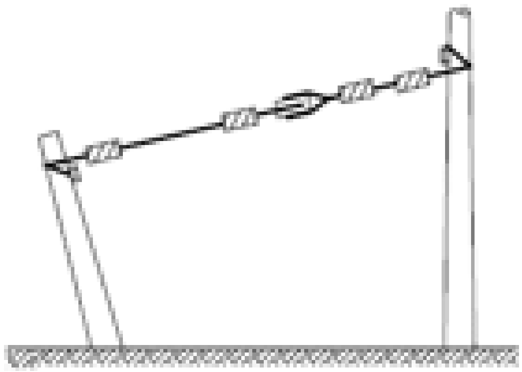


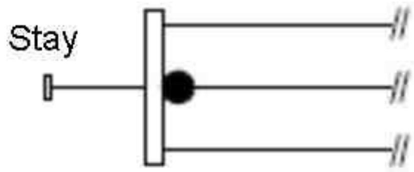
Figure 9 – Aerial (Pole) Stay Arrangement

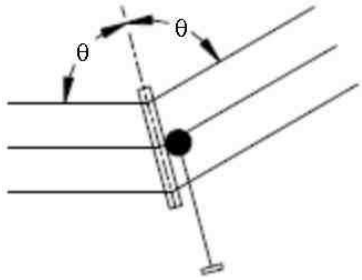
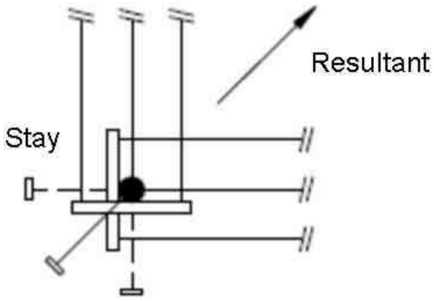
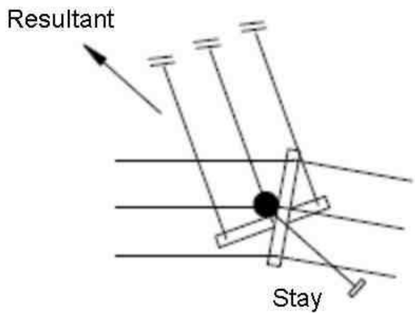
6.5.4 The stay wire load and tension for pole stay arrangements shall be assessed – contributing factors include the angle of the stay to ground and the stay wire attachment height.

6.5.5 The stay wire for pole stay arrangements shall be selected in accordance with standard construction drawing 265974. Stay positioning

6.5.6 Single stays shall be positioned in accordance with Table 22.

Table 22 - Positioning Single Stays

Pole Construction	Stay Position	General Position Of Stay
Termination Pole	Position the stay on the opposite side of the attached circuit.	

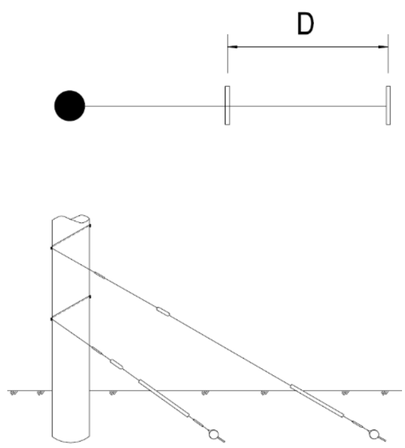
Line Deviation Pole	Position the stay on the opposite side of the bisector of the deviation angle.	
Corner Or Heavy Deviation Pole	**For a single stay** Position the stay on the opposite side of the resultant force direction. **For a double stay** Position a stay on the opposite side of (aligned with) each circuit.	
Complex Pole	Position the stay on the opposite side of the resultant force direction.	

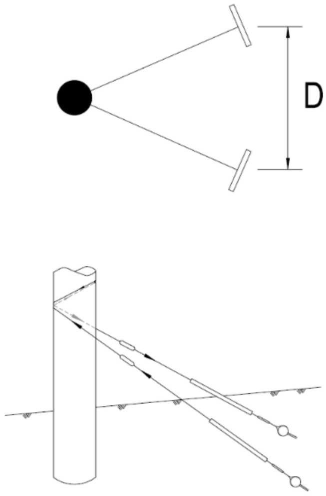
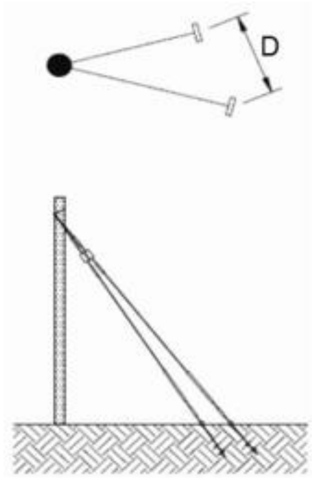
6.5.7 Twin stay arrangements shall be used where stay tensions exceed the capacity of a single stay.

6.5.8 Twin ground stays shall be positioned in accordance with standard construction drawing 269243. Alternative twin ground stay arrangements are shown in Table 23.

Note: 'D' should generally be greater than 2.0m for screw anchors.

Table 23 – Positioning Twin Stays

Stay Construction	Stay Position	General Position Of Stay
Aligned Stays (uneven lengths)	Stays are positioned in the same resultant force direction at different heights and are different lengths.	

Angled Stays (even angles and lengths)	Stays are positioned at equal angles from the bisector of the resultant force direction at the same height and are the same length.	
Angled Stays (uneven angles and lengths)	Stays are positioned at different angles from the bisector of the resultant force direction at the same height and are not the same length.	

7 Pole-top Construction

7.1 General requirements

7.1.1 Pole-top construction shall comply with the requirements of Clause 1.

7.1.2 The tension limits of the pole-top construction shall not be exceeded (including fittings and eyebolts / eye-nuts – refer to standard construction drawings 520331 and 520324).

7.1.3 The pole-top construction type shall be selected based on factors similarly used for conductor selection (refer to Clause 3.1.2) and standard construction drawings. Pole top construction shall be reasonably consistent along a line where practicable.

7.1.4 The use of flat pin construction on sub-transmission lines shall be minimised and only used where there is no reasonable alternative (refer to NS135).

7.1.5 Private attachments on Ausgrid poles shall comply with NS183 and NS232 (telecommunications cables).

7.1.6 Inclusion of an intermediate delta structure shall be assessed where midspan phase clearances cannot be achieved at transitions from vertical to horizontal pole-top construction. Conductor positions shall be assessed at each structure to achieve required mid span clearances if an intermediate delta structure cannot be used.

7.1.7 Clearances between multiple bridging conductors on the same pole (for example, between over/under-built circuits) shall be assessed, including:

- The risk of wildlife flashover if bridging conductors are required over the top of the crossarm for all three phases. Advice shall be included in design drawings for these circumstances.
- Using bridging insulators to maintain clearances.

- Using a composite fibre crossarm in lieu of a steel crossarm if the mechanical strength is adequate for the following circumstances:
  - near highly vegetated areas, or
  - on conductive poles in bushfire prone areas, or
  - on conductive poles with a higher risk of wildlife interactions.

7.2 Crossarms

7.2.1 The selected crossarms shall comply with the requirements of Clause 1 and the design load cases in Clause 1.5 (particularly the construction and maintenance load case). Particular attention shall be given to construction and maintenance loads (Q) which are likely to be imposed on the crossarm.

7.2.2 Crossarms shall be selected in accordance with standard construction drawings and the AML.

7.2.3 The use of crossarms not included in standard construction drawings or the AML shall be managed in accordance with NS181.

7.2.4 Crossarm lengths shall be chosen to meet design requirements such as midspan separation.

7.2.5 Composite fibre crossarms shall be used. Timber or steel crossarms shall only be used when a composite crossarm of the correct length or drilling pattern as shown in standard construction drawings is not available.

7.2.6 Predrilled holes and approved support brackets shall be used to mount composite fibre crossarms and for attachments to the crossarm. Additional holes shall only be drilled (where required) in accordance with manufacturer instructions. Requirements may differ between manufacturers.

7.2.7 For new timber crossarms, the following parameters shall be applied:

- Strength group = S2 (unseasoned).
- Stress grade = F17
- Fibre stress (bending) = 42MPa.
- Crossarm dimension (depth and width) of 100mm x 100mm or 100mm x 150mm (depending on the standard construction drawing used).

7.2.8 Existing timber crossarms shall be regarded as seasoned when they have been in service for more than 5 years and are located more than 10km from the coast. The following parameters shall be applied for existing crossarms:

- Strength group = SD2 (seasoned).
- Stress grade = F27
- Fibre stress (bending) = 67MPa.
- Crossarm dimension (depth and width) of 90mm x 90mm or 90mm x 140mm (nominally 10mm less than unseasoned crossarms).

7.2.9 Steel crossarms shall be used where the strength of composite fibre crossarms or timber crossarms is insufficient including, but not limited to, the following circumstances:

- 11kV termination structures for large conductors and long or high-tension spans.
- Sub-transmission feeders (on intermediate and termination structures, or in accordance with standard construction drawings).

7.2.10 Steel crossarms shall not be used in the following circumstances:

- On LV bare distribution lines.
- On HV distribution lines without assessment of insulation coordination.

Note: Sub-transmission insulation levels do not require assessment or change when steel crossarms are included in standard construction drawings.

7.3 Pole-mounted plant

7.3.1 In addition to the requirements of this Network Standard, pole-mounted plant shall be assessed as follows:

- For pole mounted substations and transformers - in accordance with NS122. Considered as very heavy plant.

- For pole mounted voltage regulators (HV and LV static compensators) – in accordance with standard construction drawings. HV regulators are considered as very heavy plant.
- For pole mounted switches (reclosers, sectionalisers and auto-links, air break / enclosed load break switches, links, line fuses) – in accordance with standard construction drawings.
- For pole mounted capacitors – in accordance with standard construction drawings.
- For pole mounted batteries – in accordance with NS293. Considered as very heavy plant.

7.3.2 Table 24 shows approximate weights and effective wind areas for plant installed on Ausgrid poles.

Table 24 - Weight and Effective Area of Pole Mounted Plant

Plant (Voltage)	Capacity	Approximate Weight (see Note 1)	Approximate Effective Area	
			Face	Side
Transformers 100kVA and greater. (11kV)	100kVA	765kg	0.89m²	0.54m²
	200kVA	1055kg	1.03m²	0.62m²
	400kVA	1700kg	1.22m²	0.74m²
Voltage Regulators (11kV – each can)	110kVA	820kg	0.88m²	0.88m²
	220kVA	1215kg	1.06m²	1.06m²
Voltage Regulators (LV)	1 phase (each)	40kg	0.36m²	0.22m²
	3 phase	120kg	1.08m²	0.22m²
Reclosers (11kV / 33kV)	Nulec N Series	350kg exc VT	0.58m²	0.42m²
	Intellirupter 11kV	460kg	1.79m²	0.34m2
	Intellirupter 33kV	475kg	1.79m²	0.39m²
	Noja 11kV	100kg	0.22m²	0.16m²
	Noja 33kV	150kg	0.34m²	0.25m²
	FuseSaver	6kg	N/A	N/A
ABS	Various	80-135kg	N/A	N/A
Enclosed Load Break	Schneider	300kg	0.91m²	0.87m²
Batteries	Ecostore v1 (each)	550kg	1.7m²	1m²
	Ecostore v2	1100kg	2.29m²	1.59m²
	Pixii	680-800kg	1.49m²	1.97m²

Notes:

1. Major component weights (excluding 11kV voltage regulators) only have 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. Voltage regulator, recloser, sectionaliser and battery weights include the major components and may include control cabinets, mounting brackets, external VT's, primary and secondary cables.

3. Installation of Ecostore v1 batteries has ceased – information included for reference purposes only. Installation includes the face area of one unit plus the side area for two units due to the three-phase pole top arrangement.

4. Ecostore v2 batteries face dimensions are for the battery only; side dimensions are for the battery (1.22m^2) and EcoVAR LV statcom inverter (0.37m^2). The weight includes the EcoVAR inverter.

5. Ecojoule Pixii battery weight depends on battery type / configuration and includes the air-conditioning attachment.

6. FuseSaver assets are mounted on the conductor, not the pole.

8 Conductor Clearances

8.1 General requirements

8.1.1 Conductor clearances shall comply with Clause 1 and the minimum clearance requirements in the following Clauses for:

- All new overhead lines, and
- Major reconstruction of existing overhead lines.

8.1.2 Additional clearance shall be allowed when:

- It is reasonably foreseeable that a future underbuilt circuit will be constructed on the pole, or
- When special circumstances apply, 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).

8.1.3 Any proposal to design a lesser clearance shall be managed in accordance with NS181. Clearances shall not be reduced beyond the requirements of AS/NZS 7000 under any circumstances.

8.1.4 Covered conductors (for example, PVC insulated, CCT, CCSX) are not considered to be an 'insulated' conductor and shall comply with 'covered' conductor clearances.

8.1.5 Service cable clearances shall comply with the Service and Installation Rules of New South Wales and NS124. Service cables shall not cross waterways (refer to NS268).

8.2 Clearances to ground, structures, buildings and boundaries

8.2.1 Overhead lines shall comply with the minimum clearance distances to ground in Table 25 (refer to **Figure 10**). Maximum operating temperatures shall be applied in accordance with Table 12.

8.2.2 An assessment of additional (extended) clearance requirements shall be performed at locations where high vehicles may be climbed (for example, when unloading stock) or where extendable machinery operates (for example, excavators, front-end loaders, tipper trucks). Also refer to the Clause 3.4 for aerial warning markers. Landowners / business owners shall be consulted to determine foreseeable work operations in these circumstances.

8.2.3 Overhead lines shall comply with the minimum clearance distances to structures, buildings and easement boundaries in Table 26 (refer to **Figure 11**). Conductor blowout conditions shall be applied in accordance with Table 11.

8.2.4 Dimensions D and E shall not be assumed 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.

Figure 10 – Conductor Clearances to Ground

Table 25 - Minimum Clearances - 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)

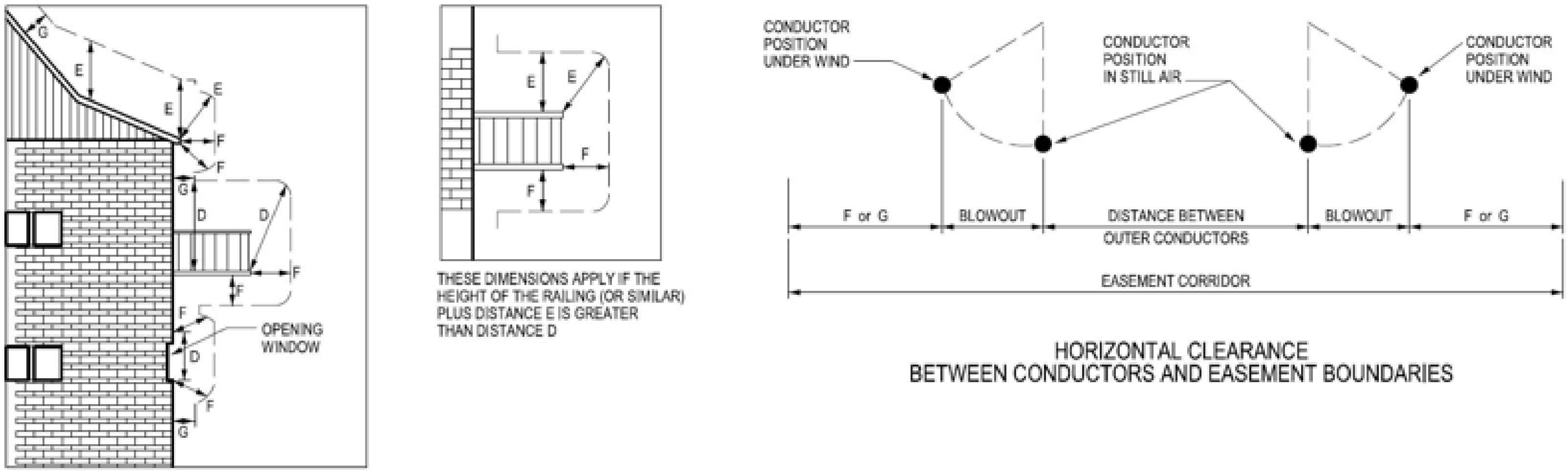


Figure 11 – Conductor Clearances to Structures, Buildings and Easement Boundaries

Table 26 - Minimum Clearances - 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

8.3 Clearances to inter-span poles

8.3.1 Overhead lines shall comply with the minimum clearance distances to inter-span poles in Table 27 (refer to Figure 12). Where practicable, new unattached short height inter-span poles shall not be installed.

8.3.2 Existing inter-span poles causing violations of the conductor clearance distances in Table 27 shall be replaced with a full height pole with all circuits attached.

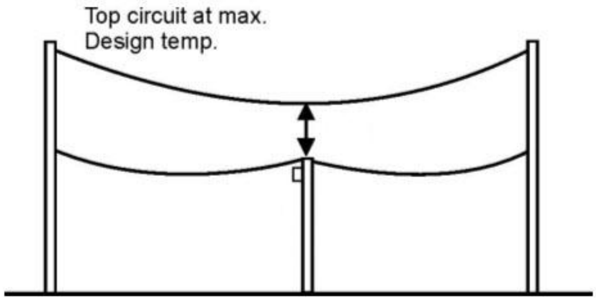


Figure 12 - Conductor Clearances to Inter-span Poles

Table 27 - Minimum Clearances - Inter-span Poles

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

8.4 Clearances for the same circuit on the same support structure

8.4.1 Overhead lines shall comply with the minimum clearance distances for the same circuit on the same support structure in Table 28 (refer to Figure 13).

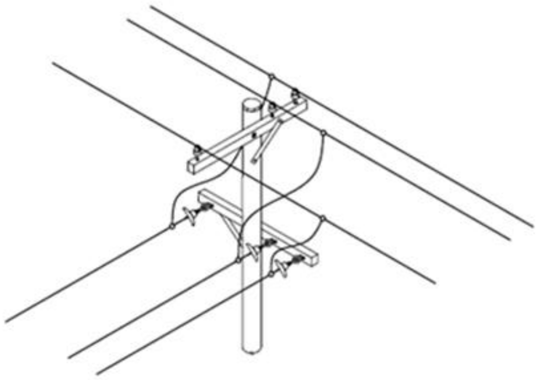


Figure 13 - Conductor Clearances for the Same Circuit on the Same Support

Table 28 – Minimum Clearances - Same Circuit on the Same Support

Lower Circuit		Upper Circuit			
		LV bare or covered (m)	LV insulated (LV ABC) (m)	22kV, 12.7kV SWER, 11kV Bare / CCT / CCSX (m)	33kV (m)

	LV bare or covered	0.6 (Note 1)	0.3 (Note 3)	-	-
	LV insulated (LV ABC)	0.3 (Note 1)	0.3 (Note 1)	-	-
	22kV, 12.7kV SWER, 11kV Bare / CCT / CCSX	-	-	0.75 (Note 2)	-
	33kV	-	-	-	0.75 (Note 2)

Notes:

1. This separation represents a circuit conductor spacing.
2. The 0.75m separation represents the crossarm 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 shall 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, including open LV links.

8.5 Clearances for different circuits on the same support structure

8.5.1 Overhead lines shall comply with the minimum clearance distances for different circuits on the same support structure in (refer to Figure 14):

- Table 29 where the upper circuit is operating at sub-transmission voltages, or
- Table 30 where the upper circuit is operating at distribution voltages.

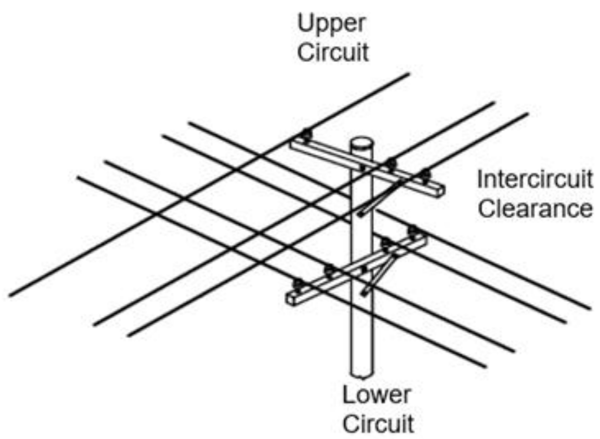


Figure 14 - Conductor Clearances for Different Circuits on the Same Support

Table 29 – Minimum Clearances - Different Circuits on the Same Support (Sub-transmission Upper Circuit)

		Upper Circuit					
		132kV bare		**66kV bare**		**33kV bare or covered**	
		LL	**Non-LL**	**LL**	**Non-LL**	**LL**	**Non-LL**
		m	**m**	**m**	**m**	**m**	**m**
Lower Circuit	**132kV bare**	2.5	2.4	-	-	-	-
	66kV bare	2.5	2.4	2.5	1.5	-	-
	33kV bare or covered	2.5	2.4	2.5	1.5	2.5	0.9
	22kV, 12.7kV SWER, 11kV bare, covered or insulated	2.5	2.4	2.5	1.5	2.5	0.9
	LV bare or covered	2.5	2.4	2.5	1.8	2.5	1.2

	LV insulated (LV ABC)	2.5	2.4	2.5	1.8	2.5	1.2
	Other conductive cables	2.5	2.4	2.5	1.8	2.5	1.2
	Other non-conductive cables	2.5	2.4	2.5	1.8	2.5	1.2

Table 30 – Minimum Clearances - Different Circuits on the Same Support (Distribution Upper Circuit)

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

Notes for Table 29 and Table 30:

1. ‘LL’ = Live line area including all new lines. ‘Non-LL’ = Non live line area or existing line built to older spacings.
2. 11kV or 22kV circuits shall not be installed on the same structure as a 12.7kV SWER circuit.
3. New insulated 11kV circuits (HV ABC) shall not be installed on the Ausgrid network.
4. 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.
5. Figures in brackets represent LV circuit separation at the structure when the different circuits share the same support structures and the same span.
6. 22kV and 11kV circuits may be installed on the same structure where minimum circuit clearances can be achieved.

8.5.2 All LV circuits which share the same support structures, and the same span, shall be LV ABC. Existing LV bare or covered conductors shall be replaced.

8.6 Clearances for unattached conductor crossings

8.6.1 Overhead lines shall comply with the minimum unattached crossing clearance distances for different circuits on different support structures in (refer to Figure 15):

- Table 31 where the upper circuit is operating at sub-transmission voltages, or
- Table 32 where the upper circuit is operating at distribution voltages.

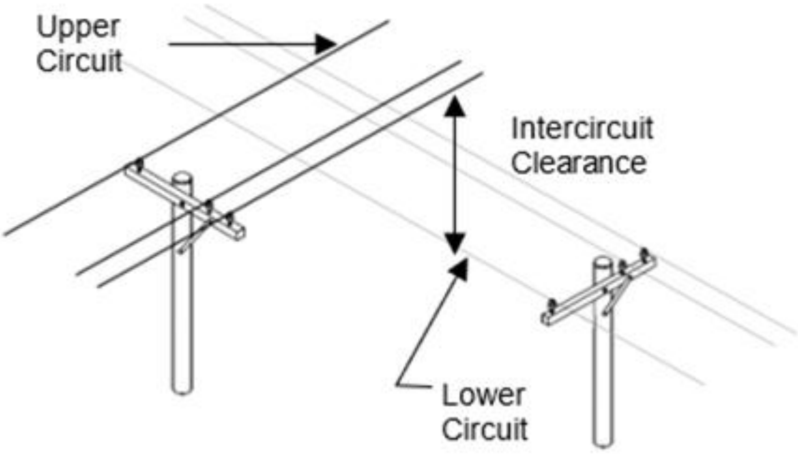


Figure 15 – Conductor Clearances for Unattached Crossings

Table 31 – Minimum Clearances – Unattached Crossings (Sub-transmission Upper Circuit)

		Upper Circuit			
		Wind condition	132kV bare	66kV bare	33kV bare or covered
			m	m	m
Lower Circuit	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
		Wind	1.5	0.8	0.5
	22kV, 12.7kV SWER, 11kV bare or covered	No wind	3.0	2.5	2.0
		Wind	1.5	0.8	0.5
	LV (any)	No wind	3.0	2.5	2.0
		Wind	1.5	0.8	0.5
	Other conductive cables	No wind	3.0	2.5	2.0
		Wind	1.5	0.8	0.5
	Other non-conductive cables	No wind	3.0	2.5	2.0
		Wind	1.5	0.8	0.5

Table 32 – Minimum Clearances – Unattached Crossings (Distribution Upper Circuit)

		Upper Circuit					
		Wind condition	11kV insulated	22kV, 12.7kV SWER, 11kV bare or covered	LV (any)	Other conductive cables	Other non-conductive cables
			m	m	m	m	m
Lower Circuit	11kV insulated	No wind	1.5	-	-	-	-
		Wind	0.4	-	-	--	

	22kV, 12.7kV SWER, 11kV bare or covered	No wind	1.5	1.5	-	-	-
		Wind	0.4	0.5	-	-	-
	LV (any)	No wind	1.5	1.5	1.0	-	-
		Wind	0.4	0.5	0.4	-	-
	Other conductive cables	No wind	1.5	1.5	1.0	0.6	0.4
		Wind	0.4	0.5	0.4	0.4	0.2
	Other non-conductive cables	No wind	1.5	1.5	1.0	0.4	0.4
		Wind	0.4	0.5	0.4	0.2	0.2

Notes for Table 31 and Table 32:

1. The above clearances may be increased due to local factors or to meet safe approach distances required for construction, operation and maintenance.
2. 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.

8.6.2 Weather conditions (wind and ambient temperatures) shall be applied in accordance with Table 33 when assessing minimum clearances for unattached conductors.

Table 33 - Weather Conditions for Determining Unattached Conductor Clearances

Condition	Upper Circuit	Lower Circuit	Clearance
No Wind	Maximum operating temperature	15°C	Refer to **'No Wind'** conditions in Table 31 and Table 32
Low wind (100Pa) only on lower circuit	35°C	35°C	Refer to **'Wind'** conditions in Table 31 and Table 32
High wind (500Pa) only on lower circuit	35°C	35°C	Fixed clearances as per Electrical Safety Rules

8.7 Clearances between parallel conductors, spans and circuits

8.7.1 Overhead lines attached to the same support structures and sharing the same span shall comply with the minimum clearance distance requirements of AS/NZS 7000:2016 Clause 3.7.3 to prevent contact or electrical flashover (under foreseeable operating conditions) between any conductor in the span and:

- Other conductors on the same circuit, and
- Other conductors on adjacent circuits or overhead earth wires.

8.7.2 Where conductors for different circuits are attached to the same support structures and share the same span, the circuits shall be attached to the support structures in accordance with Clause 8.7.1 such that:

- If the circuits have different operating voltages, the lower voltage circuits are placed below circuits operating at higher voltages.
- If the circuits have the same operating voltages, the circuits meet the minimum clearance distances.
- Where vertical construction is used (irrespective of operating voltages), the circuits meet the minimum clearance distances.

8.7.3 Mid-span conductor separation k factors shall be applied in accordance with Table 3435.

Table 3435 – Mid-span Conductor Separation k Factors

Line Component	Apply to	
	LV-22kV	33kV-132kV
Extremely turbulent wind conditions (for example, gullies, ridges, cliffs)	0.6	0.6

Bushfire prone area – vegetation category 1	0.6	0.6
Bushfire prone area – vegetation category 2	0.5	0.6
Bushfire prone area – vegetation category 3	0.5	0.6
Bushfire prone area – buffer	0.4	0.6
For all bushfire categories with CCSX, CCT, or HVABC	0.4	N/A
Fault currents up to 4,000 A	0.4	0.6
Fault currents 4,000 A and up to 6,000A	0.5	0.6
Fault currents above 6,000A	0.6	0.6
All other circumstances	0.4	0.6

8.8 Clearances to telecommunication lines

8.8.1 Overhead lines shall comply with the minimum clearance distances to telecommunication lines and equipment in accordance with;

- NS201 for clearances between Ausgrid-owned ADSS cables and associated equipment and other Ausgrid assets.
- NS232 for clearances between Ausgrid's assets and third-party communications cables and equipment.

8.8.2 The minimum clearance distances above telecommunication lines shall be assessed with;

- The power line super-circuit operating at maximum design temperature, and
- The telecommunication sub-circuit operating at 15°C.

8.8.3 Any proposal to attach telecommunication lines and equipment to poles with circuits operating at 66kV or 132kV shall be managed via the NS181 Network Standard Variations process.

8.9 Clearances for railway crossings

8.9.1 Overhead lines crossing railways shall be approved by the railway corridor management group responsible for the railway.

8.9.2 Structures supporting overhead lines crossing railways shall not be located within railway property (where reasonably practicable). Assess relocation requirements for existing support structures within railway property when redesign of existing railway crossings is being undertaken.

8.9.3 Overhead lines shall comply with the minimum clearance distances for railway crossings in Table 36 (refer to Figure 16).

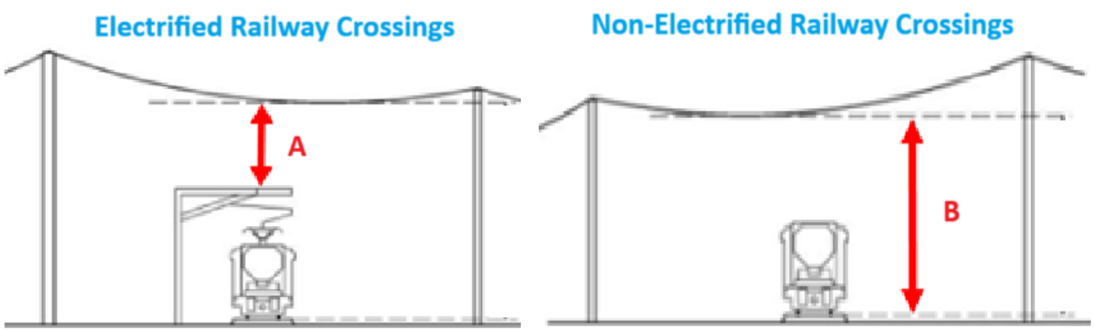


Figure 16 – Clearances for Railway Crossings

Table 36 – Minimum Clearances - Railway Crossings

Dimension	Application	LV Insulated or Bare	22kV, 12.7kV SWER or 11kV	33kV	66kV or 132kV
		m	m	m	m
A (Note 1)	Clearance above 1500V DC conductors / supports	Not allowed	3.7 (4.5)	3.7 (4.5)	4.5 (6.0)
B (Note 2)	Over non-electrified railway tracks	7.7 (9.45)	8.6 (10.45)	8.6 (10.45)	9.6 (11.25)

Notes:

1. The clearances in brackets indicate clearances required from supporting structures with walkways in accordance with ARTC EEG-00-01.
2. Clearances over mainline non-electrified railway tracks in accordance with ARTC EEG-00-01. The clearances in brackets indicate clearances required for non-electrified tracks in yards, sidings and balloon loops.

8.9.4 Overhead lines crossing railways shall also comply with the minimum clearance distances required by other railway network Regulations, Codes, Agreements or railway corridor management group including, but not limited to:

- Requirements for Electric Aerials Crossing Transport for NSW Infrastructure, TS 03773:1.0.
- Requirements for Electric Aerials Crossing ARTC Infrastructure, EEG-00-01.

8.9.5 Overhead lines with clearances less than the minimum clearances distances in – but which exceed the clearance distances required in accordance with Clause 8.9.4 shall be managed in accordance with NS181.

8.9.6 Electrolysis risks associated with stray DC currents from the railway system shall be assessed, particularly when installing below-ground metallic infrastructure such as earthing systems and steel or reinforced concrete structures close to the rail corridor. Refer to NS270 and 'T HR EL 12002 GU Electrolysis from Stray DC Current' (Transport for NSW TS 03676:0.0) for further information.

8.10 Clearances for transmission under-crossings

8.10.1 Ausgrid overhead lines beneath transmission lines shall be designed (including distribution line profiles with conductors at 15°C) and approved in consultation with the transmission network operator responsible for the transmission line (for example, TransGrid).

8.10.2 Support structures shall not be positioned beneath transmission lines – a termination structure shall be installed on either side of the transmission line easement. Overhead lines and support structures shall be positioned 15m (minimum) from transmission structures.

8.10.3 Overhead lines beneath transmission lines shall comply with the minimum clearance distances in Table 37 under normal conditions and fault conditions (refer to Figure 17).

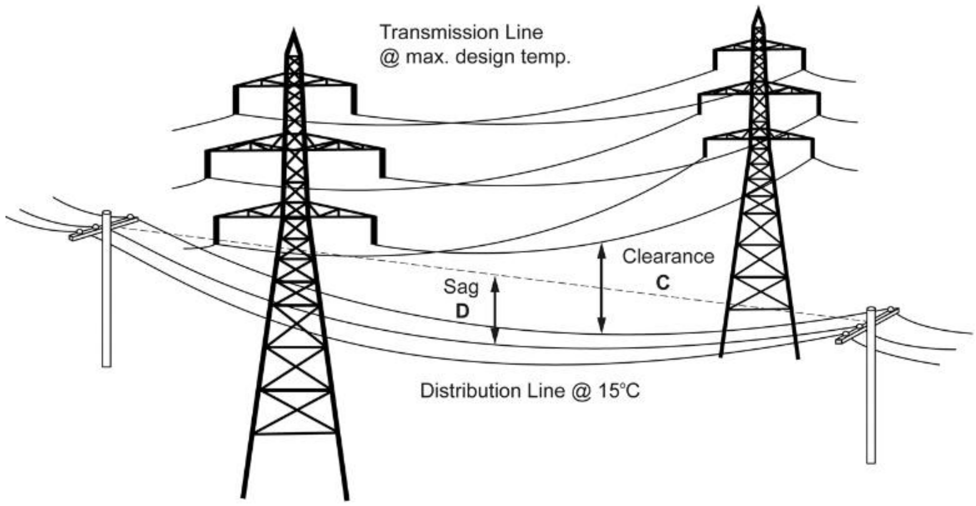


Figure 17 – Clearances for Transmission Under-crossings

Table 37 - Minimum Clearances - Transmission Under-crossings

<table>
<tr><th></th><th colspan="6">Upper Circuit</th></tr>
<tr><th rowspan="4">Lower Circuit</th><th colspan="2" rowspan="2"></th><th>132kV</th><th>>132 – 275kV</th><th>>275 – 330kV</th><th>>330 – 500kV</th></tr>
<tr><th>m</th><th>m</th><th>m</th><th>m</th></tr>
<tr><th rowspan="2">Ausgrid Circuits and Cables
- All voltages</th><td>No wind</td><td>3.0
(2.4)</td><td>4.0
(2.8)</td><td>5.0
(3.8)</td><td>6.0
(5.2)</td></tr>
<tr><td>Wind</td><td>1.5</td><td>2.2</td><td>2.6</td><td>3.6</td></tr>
</table>

Notes:

1. The clearances exceed those provided for in AS/NZS 7000 (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 in Table 37 may be increased due to local factors or to meet safe approach distances during the construction, operating or maintenance phases of the overhead line.
4. 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

8.10.4 High voltage induction hazards shall be assessed for the construction, operating and maintenance phases of the overhead line. Refer to ISSC 32 Guide for Network Providers to Provide Information to the Construction Industry for Working Near Overhead Power Lines.

8.11 Clearances for navigable waterway crossings

8.11.1 Overhead lines crossing navigable waterways shall be designed and constructed in consultation with, and with the approval of, the authority or landowner responsible for the waterway (for example, Transport for NSW, Department of Lands) or other impacted entities and in accordance with:

- The “Boaters’ guide to electricity cables crossings of NSW navigable waters”, and
- NS268.

8.11.2 Overhead lines crossing navigable waterways shall comply with the minimum clearance distances in Table 38 (refer to Figure 18).

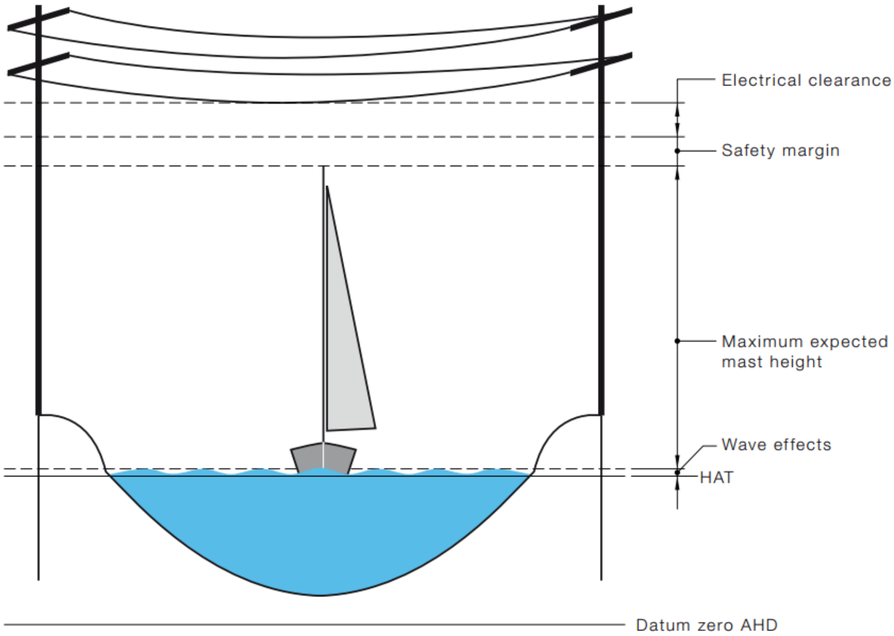


Figure 18 – Clearances for Navigable Waterway crossings

Table 38 – Minimum Clearances for Navigable Waterway Crossings

Circuit Voltage	Uninsulated Conductor Clearance
≤ 33 kV	300mm
66 kV to 132 kV	800mm

8.11.3 Overhead lines crossing navigable waterways shall be subjected to a risk assessment in accordance with Clause 1.4 and NS268 (for Ausgrid approval). Risk treatment options include, but are not limited to, the following:

- Warning signs, signage lighting on both sides of the waterway (refer to NS268).
- Coloured marker balls and/or coverings attached to conductors (refer to Clause 3.4).

8.11.4 Waterway crossing signs shall be designed in accordance with NS268 and standard construction drawing 252151.

8.11.5 Any excavation or filling activities undertaken in association with the crossing shall be approved by the responsible authority or landowner.

8.12 Clearances to streetlights

8.12.1 Overhead lines shall comply with the minimum clearance distances to streetlights:

- Under ordinarily expected worst combinations of weather conditions and current loadings, and
- After the streetlight has been attached into position on the support structure.
- Refer to the Ausgrid Electrical Safety Rules (ESR) for minimum safe working distances during construction, maintenance, replacement or repositioning of streetlights in proximity to exposed mains and apparatus:

8.12.2 Overhead lines shall comply with the minimum clearance distances to streetlights not attached to the same pole as the overhead lines in Table 39 (refer to Figure 19).

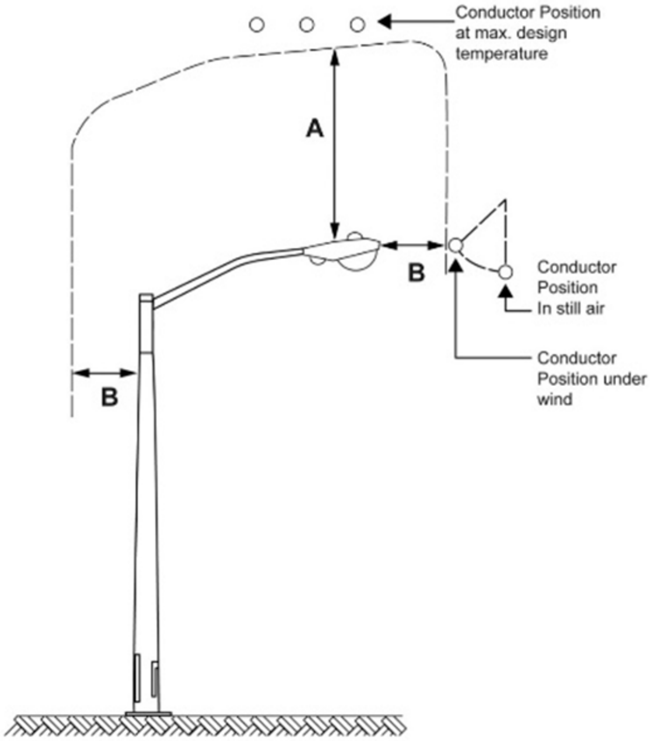


Figure 19 – Clearances to Streetlights Not Attached to the Same Pole

Table 39 – Minimum Clearances - Streetlights 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

8.12.3 Overhead lines shall comply with the minimum clearance distances to streetlights attached to the same pole as the overhead lines in Table 40 (refer to Figure 20).

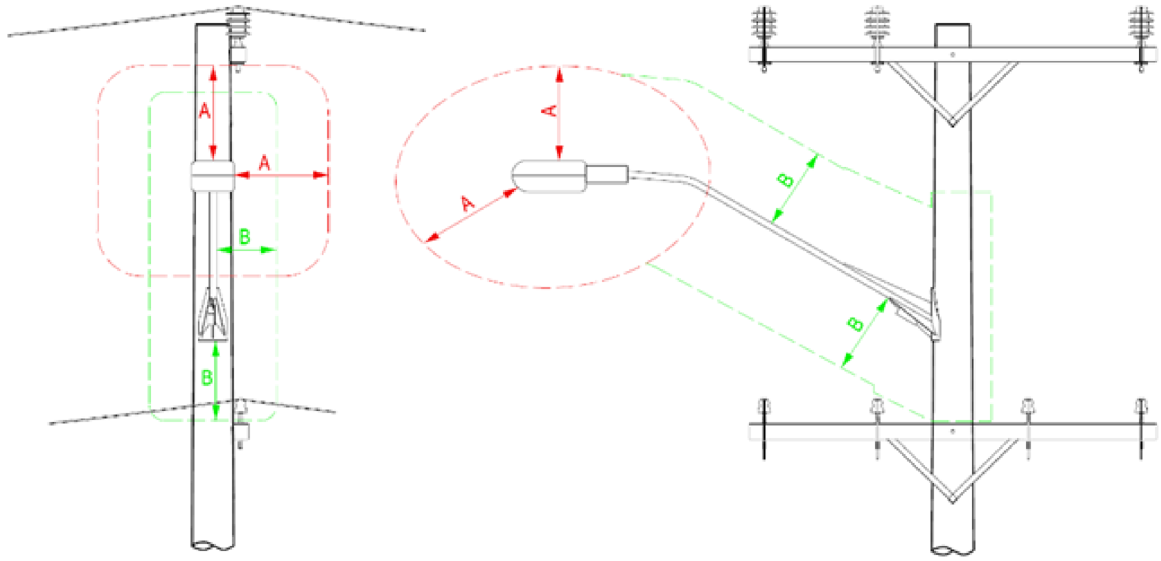


Figure 20 – Clearances to Streetlights Attached to the Same Pole

Table 40 - Minimum Clearances - To Streetlights (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

8.12.4 Additional clearances shall be applied in accordance with the dimensions shown in brackets in Table 40 where live line techniques are used on 11kV to 33kV overhead lines.

8.13 Clearances to vegetation

8.13.1 Overhead lines shall comply with the minimum clearance distances to vegetation in accordance with NS179.

8.13.2 A risk assessment shall be performed in accordance with Clause 1.4 and NS179 when the minimum clearance distances in NS179 cannot be achieved. The risk assessment shall determine whether the overhead line meets the 'Exception' criteria in accordance with NS179. Approved Exceptions shall be documented and recorded in Ausgrid's ERP system.

8.13.3 Vegetation clearances to meet the requirements of NS179 shall be established prior to new or refurbished overhead lines being put into service, including any lesser vegetation clearing required by risk assessments for allowed Exceptions.

8.14 Clearances to swimming pools

8.14.1 Overhead lines shall comply with the minimum clearance distances to existing swimming pools in Table 41 (refer to Figure 21).

8.14.2 New swimming pools shall not be constructed closer than the minimum clearance distances to overhead lines in Table 41.

8.14.3 This Clause does not apply to the separation between existing pools and existing overhead lines. Violations of the minimum clearance distances in Table 41 between existing pools and existing overhead lines shall be referred to Ausgrid Mains Engineering for a site-specific risk assessment.

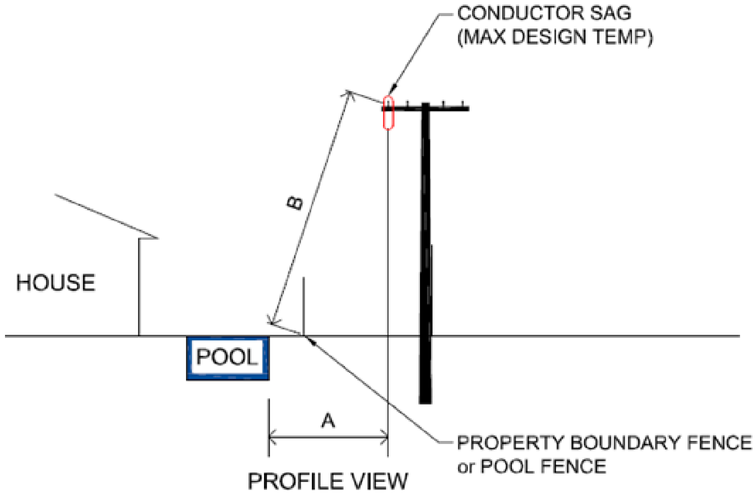


Figure 21 – Clearances to Swimming Pools and Pool Surrounds

Table 41 - Minimum Clearance - To Swimming Pools

Dimension	Location	Insulated service (Note 1)		LV		11kV	33kV and above (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 surface within the extent of 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.
3. Measurement 'B' is the minimum safety clearance regardless of the pool location within a property, unless an additional pool fence or barrier is installed.

Annexure A: Conductors

A1 Preferred conductor types and application

A1.1 Preferred bare conductor types

Table 42 – Preferred Bare Conductors and Application

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 to criteria in NS109 and NS125. • For new HV mains (standard conductor), except where use of CCSX is warranted. • Has good conductivity and low weight. • Limitations: AAC's lower strength means that it is not suitable for very long spans (ACSR, AAAC or SC/AC may be preferable).	MERCURY (7/4.50)	Normal line segments
		PLUTO (19/3.75)	For 11kV main feeder 'trunk' from a substation, or for 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 - 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. • Has greater strength than AAC, but inferior conductivity. • Risk of steel strand corrosion in coastal areas, 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.	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 HDCu mains.	N/A	N/A
SC/GZ (**S**teel **C**onductor – **G**alvanised)	Obsolete — refer to Clause 3.1.6. SC/GZ 3/2.75 shall be the minimum conductor size for repairs (to reduce the risk of conductor failure if struck directly by lightning).	N/A	N/A
SC/AC	Rarely used - may be required where AAC / AAAC strength is insufficient or where ACSR would suffer from corrosion.	N/A	HV water crossings, long spans

(Steel conductor, aluminium coating)			

A1.2 Preferred insulated / covered conductor types

Table 43 – Preferred Insulated and Covered Conductors and Application

TYPE	APPLICATION	NOMINAL SIZES	TYPICAL APPLICATION
LV ABC **LV Aerial Bundled Conductor** (Hard Drawn Aluminium)	**LV Distribution** • Refer to NS109 and NS125 regarding criteria for use of bare LV conductor or LV ABC. **Limitations:** • Unsuitable for long spans—not suitable for tight stringing.	95mm²	Normal single dwelling residential areas.
		150mm²	Commercial/industrial areas.
		2 x 95mm²	Where loads are likely to exceed 280A. Parallel at 100m (max.) intervals.
CCSX Covered Conductor – Semiconducting Screen – XLPE Covering	**HV Distribution** • Preferred covered conductor type. **Limitations:** • CCSX is more costly than bare AAC but cheaper than CCT and shall not be used unless warranted for the site conditions. • Weight and wind loading is greater than for bare conductors and may cause excessive loading on structures.	CCSX25 25mm² aluminium-coated steel	Rural light loads, replacement of small steel bare wire.
		CCSX62 62mm² ACSR	Normal feeder segments.
		CCSX159 159mm² AAAC	Main feeder 'trunk' from a substation, or to supply large loads.
CCT **C**overed **C**onductor – **T**hick (AAAC 1120)	**HV Distribution** • Obsolete and shall only be used for repairs or minor modifications to existing CCT mains. Refer to NS126 regarding criteria for use of bare HV conductor or covered conductor. **Limitations:** • 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.	80mm²	Spur lines, rural areas with light loading.
		120mm²	Normal feeder segments.
		180mm²	Main feeder 'trunk' from a substation, or to supply large loads.

A2 Electrical properties and ratings

A2.1 Bare conductor electrical properties and ratings

Table 44 - Bare Conductor Electrical Properties and Ratings

Material	Conductor Name	Cross-Sectional Area (mm²)	Strands (No. /Diameter)		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
	ALMOND	34.36	6/1/2.50		0.975	74	133	144	179	183	230

Material	Conductor Name	Cross-Sectional Area (mm²)	Strands (No. /Diameter)		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	APPLE	49.48	6/1/3.00		0.677	89	167	180	225	229	290
(1350)	BANANA	77.31	6/1/3.75		0.433	111	221	235	298	301	384
AS3607	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	*(*)*	*9.43*	*3/2.00*		*20.0*	*17*	*30*	*33*	*40*	*41*	*51*
Refer to Clause 3.1.5		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
AS1222.1		58.07	7/3.25		3.3	44	85	92	116	117	148
SC/AC			7/2.59	7/.102	4.986	85	156	168	209	214	269
			7/3.25	7/.128	1.576	109	209	223	281	285	361
			7/3.75	7/.148	1.11	N/A	N/A	267	338	342	435

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

A2.2 Insulated / covered conductor electrical properties and ratings

Table 45 – Insulated and Covered Conductor Electrical Properties and Ratings

Material	Conductor Name	Cross-Sectional Area (mm²)	Strands (No. /Diameter)		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
11kV CCSX EN50397	CCSX25	25	7/2.12 ACS		3.500	74	92
	CCSX62	62	6/1/3.37 ACSR		0.536	208	266
	CCSX159	159	19/3.26 AAAC		0.200	382	512
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 2.8.
2. Ausgrid's 'Ratings & Impedance Calculator' contains the up-to-date current rating data.

Standard Input Parameters are -

Conductor temperature: As required Windspeed: 0.6m/s

Emissivity: 0.6	Solar absorptivity: 0.8
Summer day/night - ambient 35° C	Summer day - Solar radiation intensity: 1000
Summer night - Solar radiation intensity: 500	Winter day – ambient: 25° C
Winter day – solar radiation intensity: 1000	Winter night – ambient: 10° C
Winter night - solar radiation intensity: 0	

3. For further information on rating, contact Ausgrid's ratings group via your Ausgrid Representative or Ratings@ausgrid.com.au.
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.

A3 Mechanical properties

A3.1 Bare conductor mechanical properties

Table 46 - Bare Conductor Mechanical Properties

Material	Conductor Name	Strands (No. /Diameter) Metric (mm)	Strands (No. /Diameter) Imperial (inches)	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)
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

Material	Conductor Name	Strands (No. /Diameter)		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)						
		37/2.75		219.80	19.30	83.90	1.990	108	17
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 Refer to Clause 3.1.6 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
SC/AC		7/2.59	7/.102	36.83	7.77	45.69	0.245	159	13.0
		7/3.25	7/.128	58.07	9.75	69.90	0.387	157	12.9
		7/3.75	7/.148	77.28	11.30	86.90	0.515	157	12.9
	Earth wire	7/3.66	7/.144	73.55	10.97	84.78	0.579	160	12.9

(*) 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.

A3.2 Insulated / covered conductor mechanical properties

Table 47 – Insulated and Covered Conductor Mechanical Properties

Material	Conductor Name	Strands (No. /Dia.) Metric (mm)	Strands (No. /Dia.) Imperial (inches)	Cross-Sectional Area (mm^2)	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)
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
11kV CCSX EN50397	CCSX25	7/2.12 ACS		25	11.80	-	-	31.50	0.247	159	13
	CCSX62	6/1/3.37 ACSR		62	15.8	-	-	18.6	0.340	80	19
	CCSX159	19/3.26 AAAC		159	21.8	-	-	42.0	0.642	64	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 46 and Table 47 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 46 and Table 47:
   - 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.

Annexure B: Design Documentation

B1 General requirements

The Design documentation shall be provided in accordance with NS104 for auditable substantiation. 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.

The design documentation in the following Clause shall also be provided to facilitate redesign and emergency restoration repairs to the overhead lines during their service life. Where the section of line is short, is wholly on public roads, or on a single property, Ausgrid may vary some of the above requirements. A Design Brief will indicate if any of these requirements have been varied.

B2 Pole strength check sheet

A pole strength check sheet shall be provided to facilitate design auditing regardless of the design software used. All design checks and calculations supporting the summary sheet shall be provided.

B3 Line schedule

A list of all structures shall be provided, showing structure numbers, 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.

B4 Property schedule

A property schedule shall be prepared where easements are to be acquired, or lands are to be purchased. The schedule shall include details of:

- Lot and DP numbers of all affected properties.
- The name of the owner of all affected properties.
- The postal address of the owner of all affected properties.
- The contact phone number or email address of the owner of all affected properties.
- Details of the nature of the interest to be obtained for all affected properties.
- Any agreements made with the owner of any affected properties such as access conditions, disposal of vegetation removed during line construction etc.

B5 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 on the plan.

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 survey-accurate cadastral information, and any access routes.

B6 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.

B7 Overhead design files

Relevant overhead design files (from the overhead line design software package used), and digital terrain survey file shall be submitted along with the drawings and other information discussed above.

B8 Environmental documentation

Project specific documentation including EIAs, approvals, licences and permits, issue specific management plans, and construction environmental management plans (CEMPs).

B9 Earthing design

Earthing design documentation shall be provided in accordance with NS260.

B10 Blowout plan

A blowout plan view shall 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 shall be shown in accordance with the blowout load case in Clause 8.2.

B11 Foundation designs

Pole foundation design documentation shall be provided in electronic form for all poles being replaced or being modified.

Annexure C: Overhead Line Design Software

C1 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/NZS 7000 & 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 shall 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 assessment criteria for distribution lines allows for assumptions and approximations to be accepted to perform 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 assessments 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 shall also be developed using finite element analysis.

C2 Process for software approval

Whilst the design of sub-transmission and distribution lines can be performed manually, Ausgrid requires that the design shall be 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.

C3 Design submission requirements

The Designer is responsible for the production of a design in accordance with Ausgrid Network Standards (including NS104) 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.

C4 Design Software Requirements

C4.1 Limit state design

The software shall allow for the design of overhead lines based on limit state principles for serviceability and strength limit state for the various line components in accordance with Clause 1, Clause 2 and as per AS/NZS 7000.

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.

C4.2 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 shall be structurally checked and analysed in accordance to limit state philosophies.

It is requested that all structural assessment be completed within the software however Ausgrid will consider other forms of calculation assessment 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 2 and AS/NZS 7000.

Typical structural components include, but are not limited to, cross arms, conductors, insulators and stays. Strength assessments with respect to limit state design are required on all components.

C4.3 Weather case conditions

The software shall have the capability of implementing all weather cases which will be used for particular design load checks to be performed.

Multiple weather cases shall 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 2.

It shall 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.

C4.4 Load case conditions

The software shall have the capability to simulate all load conditions from Clause 2. There shall be a mapped link from the load case to the corresponding weather case.

A complete load tree for the structure shall be provided including 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.

A definition of load factors shall be included and shall explain exactly what they apply. An example diagram clearly showing the load definitions is desirable (such as a Tee-off).

Construction and maintenance loads

The supports shall be able to be assessed 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., in accordance with Clauses 2.6, 6.2 and 7.2.

Failure containment loads

The supports shall be able to be assessed for all failure containment and broken wire cases in accordance with Clause 2.4. The loads shall be able to be configured and assessed for worst case scenarios.

Loads from the supported conductor

The software shall have demonstrated capability to address the load factor requirements.

C4.5 Wind direction

The direction of the wind acting onto the structure and the conductors shall act to ensure that the worst-case wind loading is being assessed at the structure. There shall 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 shall 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 2.

Synoptic and downdraft wind

- For 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.
- For longitudinal direction – apply full longitudinal wind load on the conductors, insulators, fittings and support, together with corresponding deviation loads and all relevant vertical loads.

- For oblique (or yawed) wind (refer to AS/NZS 7000 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.

Tornado wind (where required applicable to high security level lines – (see AS/NZS 7000 Appendix B)

- 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.
- 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.

C4.6 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 shall be considered as permanent dead loads and are a desirable addition to the software.

C4.7 Strength reduction factors and load factors

The software shall allow for Strength Reduction Factors and Load Factors to be input in accordance with Clause 2. All corresponding calculations shall factor the loads according to this setting and the load equation.

C4.8 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 the actual span or finite element analysis of the wire system should be used in the software. For distribution lines with span lengths greater than 250 metres and all sub-transmission lines, the actual span or finite element analysis of the wire system should be used.

The software should have 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.

C4.9 Materials

The material libraries within the software shall 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 shall reflect the material that is being delivered as part of the design.

Pole design

The structure orientation shall 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:

- A finite element analysis approach shall be performed for strength checks on concrete, steel and timber poles and lattice tower structures.
- Concrete poles shall include the bending moment capacity data from the concrete pole supplier.
- Where required the software shall have the capability to assess the strength of steel sleeved, flanged and base mounted poles.
- For timber poles, the software shall have the capability to enter 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 finite element analysis. A pole tip load analysis is acceptable for these poles.

For Multi-pole structures:

- the software shall have the capability 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 shall have the capability 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 shall be able to be set, including install tension, modulus of elasticity and weight.
- When using stays, the pole shall be assessed at the stay attachment point as well as ground level.

Conductors

The software shall be capable of modelling all homogeneous and bi-metallic conductors used on Ausgrid's network.

Damage and failure limits of conductors shall be able to be assessed in accordance with the table in Clause 2.9.

Metallurgical creep shall be assessed 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 shall make sag and tension calculations for cables in their initial and final creep conditions.

The cable model shall consider the following:

- Conductor diameter, mass, drag coefficient, calculated breaking load when calculating conductor vertical and horizontal sag-tension.
- tension/damage limits of the conductors are not exceeded during load case assessments.

The stringing table output shall indicate whether or not a creep temperature offset has been applied.

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

Insulators

The software shall be able to model insulators as either strain termination clamps, suspension arrangements (including horizontal line posts), and where required, 2-part braced post insulators.

Insulators shall have mechanical stresses including tensile, compressive and cantilever loadings from conductor tension and weight of fittings assessed against allowable strength ratings. It shall be possible to implement insulator strength reduction factors in accordance with the table in Clause 2.9.

For sub-transmission design and distribution design over 250m, horizontal line post insulators shall be modelled using interaction and capacity load curves supplied by the manufacturer. The software shall enable the interaction capacity data to be entered and assessed.

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

Insulator length and swing shall be assessed by the software.

C4.10 Clearances

The software shall enable clearance assessments 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.

C4.11 Survey and terrain modelling

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

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

The software should have the following functionality:

- Separate feature codes to be allocated to above ground obstacles so that separate clearance assessments 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. A clearance assessment to tinned surfaces shall be able to be calculated.

Alignments

Design alignments shall 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.

C4.12 General software requirements

The software should have a profile view showing a ground clearance line. A plan and 3D view is desirable, as is the capability to output a design in a Google Earth file format.

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

C4.13 Additional desirable criteria

The software should functionally meet the following requirements:

- Modelling of bundled cables,
- Pole deflection checks,
- Coordinate system selection,
- The capability 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 view.

Annexure D: Aerial warning markers

D1 General requirements

D1.1 Aerial warning markers attached to overhead lines or structures (or a combination of both) provide a visual warning to pilots of aviation risks associated with those overhead lines or structures. Aerial warning markers (for example, rotating markers or flag markers) may also be installed as a visual warning of overhead line risks at locations where high / extendable vehicles are operated or may be climbed (refer to Clauses 3.4.2, 8.1.2 and 8.2.2).

D1.2 Aerial warning markers for aviation risks shall comply with the following Clauses.

D1.3 A risk assessment shall be performed in accordance with Clause 1.4 if the overhead line or structure does not meet the following aerial warning marker requirements but it poses a foreseeable risk to aviation (for example crossings of rivers, waterways, valleys or highways).

D2 Certified aerodromes

D2.1 Aerial warning marker requirements shall be assessed in accordance with AS3891.1 if the overhead line or structure is within 30km of a certified aerodrome, or declared Defence Aviation Area, if:

- The overhead line or structure is likely to penetrate the desirable limits to which objects or structures may project into the airspace around the aerodrome (the 'obstacle limitation surfaces'), or
- The overhead line or structure may pose a threat to aircraft operating in or around the aerodrome.

D3 Non-certified aerodromes and other landing areas

D3.1 Aerial warning marker requirements shall be assessed in accordance with AS3891.1 if the overhead line or structure is in the proximity of a non-certified aerodrome or other landing area if (refer to Figure 22):

- The overhead line or structure is likely to penetrate the transitional slope (20%) of any landing area, or
- The overhead line or structure is likely to penetrate the approach and take-off slope (3.3%) of any landing area, or
- The overhead line or structure may pose a threat to aircraft operating in or around the aerodrome or landing area.

Note: A non-certified aerodrome or landing area includes any aerodrome, airfield, airstrip, landing area, water alighting area or helicopter landing site that is not a certified aerodrome, regardless of ownership.

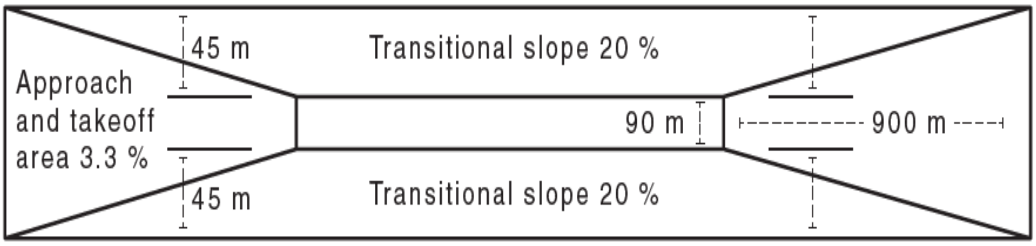


Figure 22 – Non-certified aerodrome or other landing area slopes (Source AS3891.1)

D4 High and long overhead lines

D4.1 Aerial warning marker requirements shall be assessed in accordance with AS3891.1 (including support structures) if the overhead line span is:

- Greater than 90m above the ground, water or ambient vegetation (refer to Figure 23), or
- Longer than 1,500m and greater than 60m above the ground, water or ambient vegetation (refer to Figure 24).

Note: In accordance with AS3891.1, the Civil Aviation Safety Authority (CASA) and Air Services Australia shall be notified of any overhead lines and structures 100m or more above local ground level.

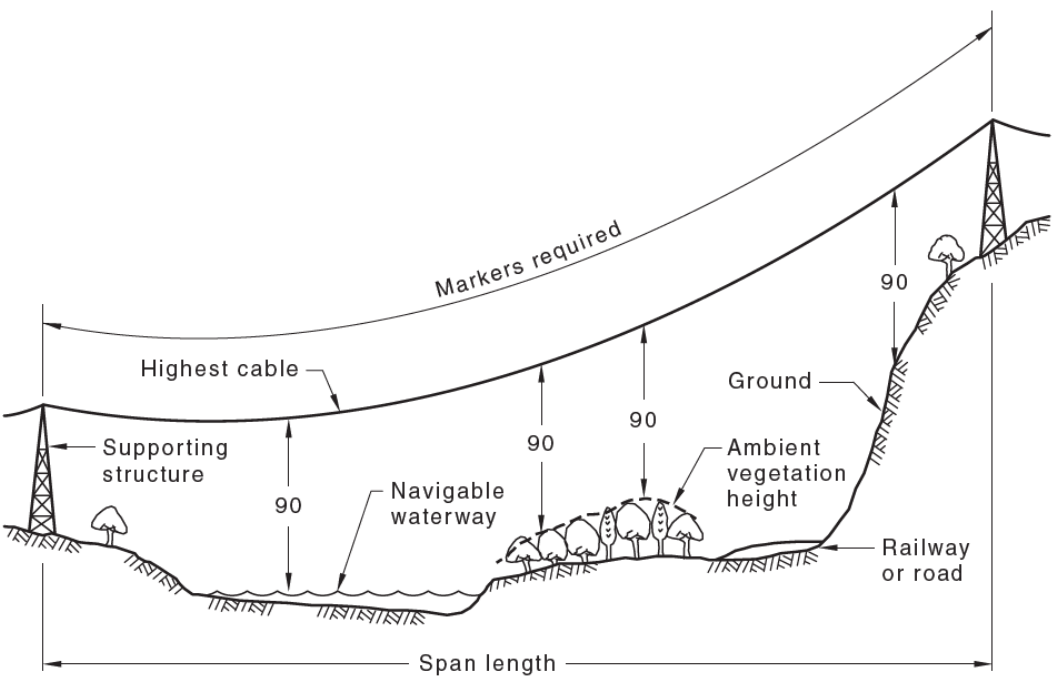


Figure 23 – Span height greater than 90m (Source AS3891.1)

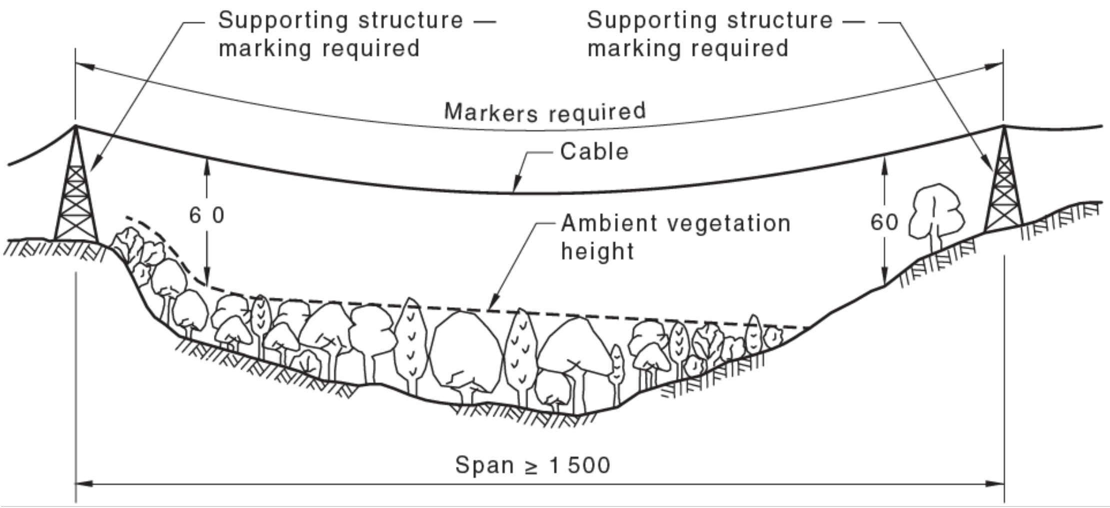


Figure 24 – Span greater than 1500m long and 60m high (Source AS3891.1)

D4.2 Where aerial warning markers are required under these circumstances, overhead lines shall be marked with three-dimensional markers attached to the conductor(s) which are:

- Of alternating colours, one of which shall be white and the other of a colour specified in AS3891.1 to achieve maximum contrast with the background context, and
- Installed at equidistant intervals across the span but not closer than 30m to the supporting structure, and
- Installed at a minimum rate of three markers per 500m of span length (or part thereof) unless mechanical capacity limitations exist in which case a minimum of three markers shall be installed, and
- Installed on the highest conductor in the span (where practicable).

D4.3 Where multiple conductors exist on the structure at the highest conductor height (for example, twin OHEW's or the top phases of a dual-circuit pole line), aerial markers may be staggered longitudinally and alternating between the highest conductors to reduce structural loading impacts of the aerial markers.

D5 Low level aviation operations

D5.1 Aerial warning marker requirements shall be assessed in accordance with AS3891.2 if the overhead line or structure is within areas where planned low level aerial operations occur.

> **Note:** Low level aerial operations are any aviation operation that involves planned flight below approximately 152m (500 ft) above ground level and includes crop spraying, firefighting, mustering, emergency services response, power line inspection, survey, media, parachuting and ballooning operations conducted under an approval, licence or regulations issued by the CASA. They exclude operations due to aircraft or pilot operational emergencies (for example, engine failure, medical incapacitation).

D5.2 Aerial warning markers shall be installed on support structures where an overhead line crosses another overhead line in an area where aerial inspections are performed.

D5.3 The aerial warning markers installed on support structures shall be (refer to Figure 25):

- Circular in shape (not less than 300mm diameter) and Canary Yellow in colour, and
- Installed at the top of the support structure that supports the lower circuit subject to aerial inspection, and
- Installed on the second and third structures from the in-span circuit crossing location, on both sides of the crossing, and
- Installed so that the markers face away from the in-span crossing location so that they are visible for aircraft operating towards that crossing.

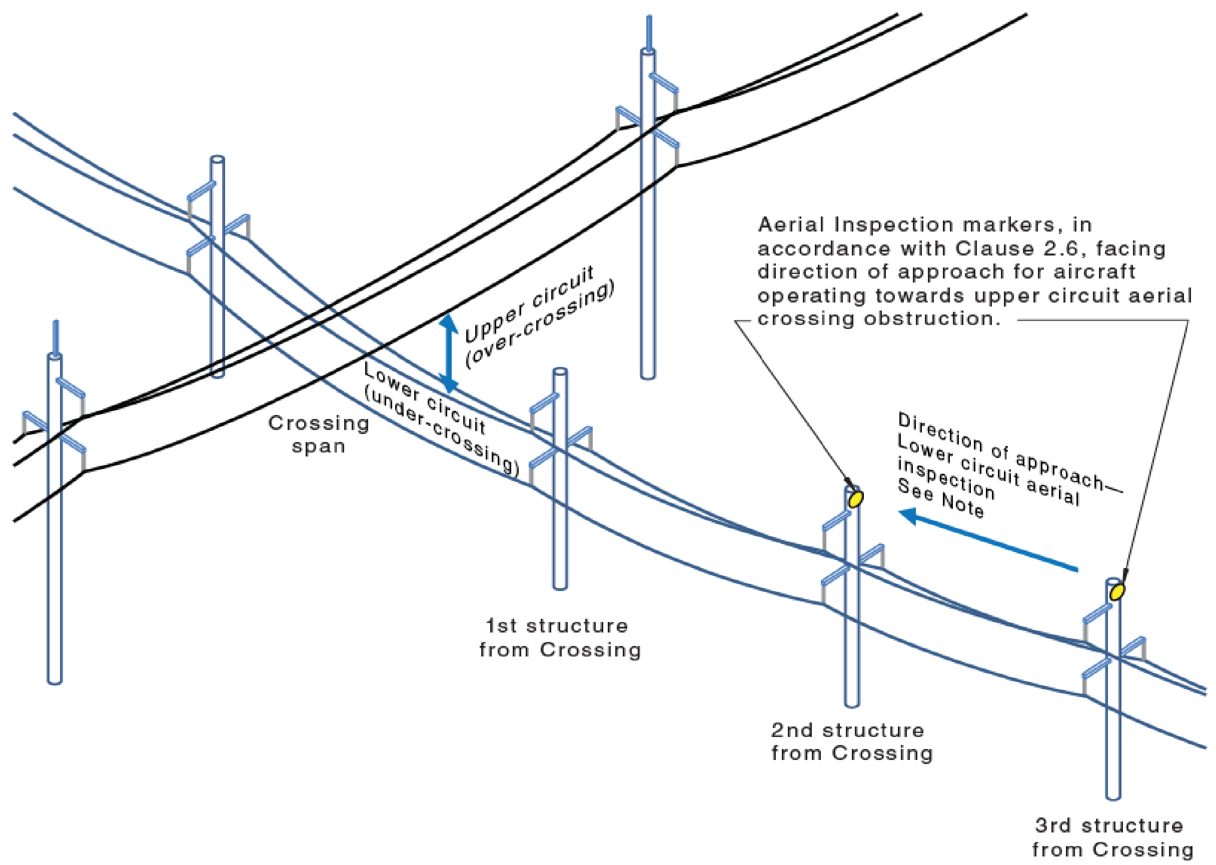


Figure 25 – Aerial warning marker placement for low level operations (Source AS3891.2)

D6 Application

D6.1 Examples of conductor-mounted aerial warning markers used by Ausgrid and their application are shown in Figure 26.

Marker balls in a rural area

Marker balls near an urban helipad

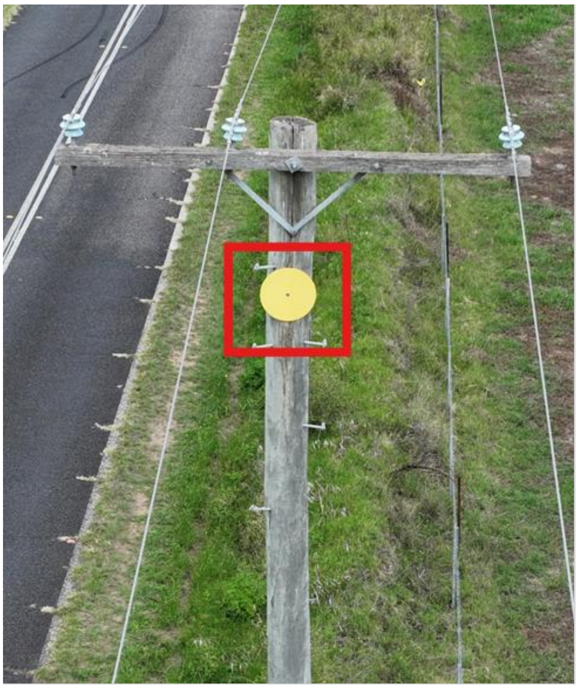
Rotating warning markers in a stock loading area

Rotating and flag markers (Balmoral Engineering)

Figure 26 – Aerial warning markers installed on conductors

D6.2 Examples of aerial warning markers used by Ausgrid on structures are shown in Figure 27.

Triangular markers (superseded type)



Circular markers (current type)

Figure 27 – Aerial warning markers installed on structures