Distribution Overhead Design Standard

AS/NZS 7000 Compliant

Incorporating Limit State Design

Version Number: 3.9

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RESPONSIBILITIES

This document is the responsibility of the Asset Management Team, Tasmanian Networks Pty Ltd, ABN 24 167 357 299 (hereafter referred to as "TasNetworks").

Please contact the Asset Management Systems and Standards Team with any queries or suggestions.

- Implementation All TasNetworks staff and contractors.
- Compliance All group managers.

RECORD OF REVISIONS

Section	Date	Version	Description
ALL	Dec 2017	1.0	Initial Issue
ALL	May 2018	2.0	Various amendments based on first round of comments and trial
ALL	Nov 2021	3.0	Major release
0	Nov 2021	3.1 – 3.7	Various updates to Amendment record
1	Nov 2021	3.1	Minor additions
4	Oct 2021	3.1 – 3.3	MS HVABC and IBIS added
5	Mar 2020	3.1 – 3.3	MS HVABC tables added
6	Nov 2021	3.1 - 3.6	Various additions of poles and foundations: Titan, Busck, Bluescope Steel, Rockla concrete, customer poles, reformatting, Changes for Titan Poles. Corrections to Stobie pole LS strengths and windages, engineering note on strength calc.
7	Mar 2021	3.1 - 3.2	Reformatting, moved some detail of bolt limitations to section 8.3.4
8	Nov 2021	3.1 – 3.7	Added LVABC and MS HVABC limitations, included FRC HV crossarms, added 33kV span/angle limits, added steel bolt limitations, made pole extenders obsolete, amended APL codes. Modified HV FRP crossarm dimensions, strengths, spanning limits
10	Mar 2020	3.1	Minor fixes
12	June 2021	3.1	Poles-N-Wires Software set up
13	Nov 2021	3.1 - 3.6	Updates to Threatened Bird Strategy
14	June 2021	3.1	Updated references due to changes to sections 6, 4 and 8, various fixes
2,3,6	March 2024	3.8	Updated SRF for foundations. Changed minimum sinking depths for 9.5 and 11m poles
2,3,7,8	Feb 2025	3.9	Section 2.3.10 - updated fasteners strength factor. Section 7.4 - added a table showing bolt capacities through hardwood, softwood, and Titan poles at various stay angles relative to the horizontal. Section 3.8 has been updated to include the manual handling option

CONTENTS

SCOPE OF THIS STANDARD

The scope of the *AS/NZS 7000:2016* Standard provides guidance as to when a Limit State Design is to be used and not applied retrospectively to existing lines. The existing network design is based on the ESAA document *C(b)1:1991*. It is expected that all future designs will be done using *AS/NZS 7000* and Section 1.1 of the Standard is repeated here for clarification:

"The *AS/NZS 7000* Overhead Line Design Standard is only applicable to new overhead line designs and is not intended to be retrospectively applied to the routine maintenance, and ongoing life extension of existing overhead lines constructed prior to the issue of that Standard. Such maintenance and life extension work ensures that lines continue to comply with the original design standards and remain safe and 'fit for purpose'.

Where the additional loading does not exceed the foundation or major structural element capacities, it is not necessary to comply with that Standard. Modifications may be made to comply with the Standard applicable to the original design. Major structural elements include poles, lattice tower legs and foundations.

However, where existing overhead lines are proposed to be altered such that elements of the overhead line may be overloaded or overstressed to the original design standard; then the overhead line is required to be assessed by a competent person for compliance with the provisions of the Standard.

The Standard is applicable to overhead lines supporting telecommunications systems or where they are used on overhead lines either attached to the aerial line conductor / earth wire systems, or as separate cables supported by the supports. These telecommunication systems include optical ground wires (OPGWs), optical conductors and all dielectric self-supporting (ADSS) cables.

It is also applicable to overhead line structures supporting telecommunications equipment."

For minor extensions or changes the Overhead Legacy Construction Standard might be used.

SECTION 1 – INTRODUCTION

Version: 3.0

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SECTION 1 - INTRODUCTION

1.1 PRELUDE

This Standard contains the approved design process considerations and detailed standard arrangements for the design of Overhead Distribution assets within the TasNetwork electrical network.

The information contained in this Introduction is intended to provide guidelines on the format, contents and use of the Standard.

TasNetworks may update this standard for the purposes of design improvement and technology advances. It is the responsibility of the designer to ensure the latest TasNetworks' Standard is used for distribution design.

1.2 SCOPE

The Distribution Design Standard for Overhead Distribution applies to the following asset types:

- High voltage overhead lines, i.e. 33kV, 22 kV, 11 kV and SWER
- Low voltage overhead lines
- Pole-mounted plant, e.g. transformers, switches, reclosers, regulators and fuses
- Communications cables on poles (e.g. pilot cables, optical fibres, NBN cables).
- Streetlight bracket attachments.

Overhead materials shall comply with TasNetworks' current periodic contract for distribution equipment and specifications.

For interconnections to other TasNetworks electrical reticulation refer to the following standards:

- Underground cable terminations on poles – for further detail refer to the Distribution Design Standard for Underground System
- Private installations - for further detail refer to the Distribution Design Standard for Planning

The application of this design standard applies for both greenfield and brownfield sites, where the HV and LV reticulation is intended to be overhead. All designs shall be compliant in full with this standard. All noncompliance's are required to receive prior approval from the TasNetworks Planning, Asset Strategy and Asset Engineering Team.

1.3 DEFINITIONS

Term	Definition
AAC	All Aluminium Conductor.
AAAC	All Aluminium Alloy Conductor
AC	Alternating current
ACSR	Aluminium Conductor Steel Reinforced
Action	Force (load) applied to a mechanical system, as well as imposed or constrained deformation or acceleration, e.g. due to wind, ice, loading with weight
Aerial Bundled Cable (ABC)	Two or more cores twisted together into a single bundled cable assembly. Two types of aerial bundled cable are used: Low voltage aerial bundled cable (LVABC) means a cable which meets the requirements of either AS/NZS 3560.1 or AS/NZS 3560.2 as applicable; and High voltage aerial bundle cable (HVABC) means a cable which meets the requirements of either AZ/NZS 3599.1 or AS/NZS 3599.2 as applicable.
Aerial Cable	Any insulated or covered conductor or assembly of cores with or without protective covering, which is placed above ground, in the open air and is suspended between two or more supports
ADSS	All-Dielectric Self Supporting (communications cable-optical fibre) non-metallic
AHD	Australian Height Datum
Al	Aluminium
ALARA	The underlying risk management principle whereby risk is reduced to “as low as reasonably achievable” within a cost benefit framework. Sometimes referred to as ALARP (“as low as reasonably practicable”)
Alignment	Position within a footpath or road reserve relative to the property boundary or kerb
Average Recurrence Interval (ARI)	Or "Return Period", is the inverse of the annual probability of exceeding wind speed, as applied in AS/NZS 1170.2
Blowout	Horizontal sag where a conductor or cable is pushed sideways under the action of wind
Bonding Conductor	Conductor providing equipotential bonding
Bridging	Relatively short, flexible or rigid, bare, covered or insulated leads which electrically connect lines at termination or tee-off point or connect electrically lines to electrical apparatus, also known as 'droppers' or ‘jumpers’
Calculated Breaking Load (CBL)	In relation to a conductor, means the calculated minimum breaking load determined in accordance with the relevant Australian/New Zealand Standard
CBD	Central business district

CCA	Copper chrome arsenate wood preservative
Chainage	The distance from a datum along the centreline of a roadway. This term and offset are used to reference points on roadworks plans.
CL	Centre Line
Clearance	The shortest distance between two objects that may have a potential difference between them
Clearing Time	The time taken for the protective devices and circuit breakers to isolate the fault current
Common MEN System	An earthing system in which the LV MEN system is connected to the HV system earthing. This is used commonly in urban areas where there are numerous interconnected earth rods all meshed together over a wide area and a low resistance to earth can be obtained. See 'Multiple Earth Neutral'.
Component	One of the different principal parts of the overhead electrical line system having a specified purpose Typical components are supports, foundations, conductors, insulator strings.
Compression	Also crimping. The method used to join conductors by compressing a lug or socket onto the conductor(s). Conductors from 16 to 300 mm^2 can be crimped manually or with a battery operated crimping tool but larger conductors require a hydraulic powered compression tool.
Compression, Indent	Lug connection type that deforms the fitting and the conductor by deep indentation. These types of connections are no longer permitted for TasNetworks asset connections
Compression, Hexagonal	Used on stranded conductors by hexagonal dies to uniformly compress the fitting and the conductor
Conductor	Any bare conductor which is placed above ground, in the open air and is suspended between two or more supports
Conduit (Also 'Pipe' or 'Duct')	A pipe or closed passage formed underground or in a structure and intended to receive one or more cables that may be drawn through it
Consumer mains	Wiring complying with AS 3000 owned and maintained by the consumer connected from the service fuses or circuit breaker to the main switchboard of an installation
Consumer Installation	The electrical system owned and operated by an electricity consumer for the purpose of utilising electricity, normally contained within the consumer's premises
Creep (or Inelastic Stretch)	The process where a conductor increases in length over time when under tension in service. This causes an increase in sag in a span of mains
CSA	Cross-sectional area
Cu	Copper
Customer	A person or organisation that has applied for or receives electrical supply from the electricity network
DC	Direct current

Earth (Reference/remote)	Part of the earth considered as conductive, the voltage of which is conventionally taken as zero, being outside the zone of influence of the relevant earthing arrangement.
Earth current	Current that flows from the main circuit to earth or earthed parts at the fault location (earth fault location)
Earth electrode	Conductor which is embedded in the earth and conductively connected to the earth, or a conductor which is embedded in concrete which is in contact with the earth via a large surface (for example foundation earth electrode).
Earth fault	Conductive connection caused by a fault between an aerial phase conductor of the main circuit and earth or an earthed part. The conductive connection can also occur via an arc. Earth faults of two or several aerial phase conductors of the same electrical system at different locations are designated as double or multiple earth faults.
Earth fault current	Current which flows from the main circuit to earth or earthed parts during a fault
Earthing	All means and measures for making a proper conductive connection to earth.
Earthing conductor	Conductor which connects that part of the installation to the earth electrode.
Earthing system	Electrical system of conductively connected earth electrodes, earthing conductors, bonding conductors, or metal parts effective in the same way, for example tower footings, armouring, metal cable sheaths.
Earth potential rise (EPR)	Voltage between an earthing system and reference or remote earth. The rise in potential of the ground in the vicinity of an earth electrode during the passage of a fault current.
Earth rod	Earth electrode consisting of a metal rod driven into the ground.
Earth surface potential	Voltage between a point on the earth surface and remote earth.
Earth wire (Overhead)	A conductor connected to earth at some, or all supports, which is suspended usually but not necessarily above the aerial line conductors to provide a degree of protection against lightning strikes. Note: An earth wire may also contain non-metallic wires for telecommunication purposes
Easement	A strip of land registered on the title deed in the office of the Registrar of Titles allowing access or other rights to a public body or party other than the owner of the parcel of land on which the easement exists.
Electric Field	The electric field is the space surrounding an electric charge and exerts a force on other electrically charged objects. It is expressed in units of volts per meter (V/m).
EMF	Electrical and magnetic field, or electro-motive force
Equipotential bonding	Conductive connection between conductive parts, to reduce the potential differences between these parts

Everyday Tension	The sustained load (continuous force) exerted by conductors under no wind conditions
EWP	Elevated Working Platform
Failure	State of a structure, component or element whose ability to fulfil its purpose is terminated, i.e. in which a component has failed by excessive deformation, loss of stability, overturning, collapse, rupture, buckling etc.
Feeder	A circuit (normally HV) emanating from a substation for distributing electric power.
FOC	Fibre optic cable
Footpath Alignment	A distance relative to the edge of a footpath (usually the property boundary side) used to describe the position of an underground service or pole
Footpath Allocation	A space in the footpath between two alignments designated by the local or public authority in which a pole or underground service may be located
FOS	Factor of Safety – the failure strength or breaking load divided by the maximum design loading
Ground Clearance	The vertical distance between the conductor at its lowest point of sag and ground
FRC	Fibre-Reinforced Composite
GL	Ground Level
GZ	Galvanized
HDC	Hard Drawn Copper
Highest system voltage	Maximum continuous value of phase-to-phase voltage
High Voltage	Electrical potential that is in the range of 1kV to 33kV
HVABC	High Voltage ABC (Refer ABC)
HV Spacer Cable	HV Covered Conductor (unscreened) supported by spacers from a catenary / shield conductor.
Hybrid Underground	Sections of HVABC or HV Spacer and sections of underground cabling in places of high cost for vegetation management.
Insulated Conductor	A conductor surrounded by a layer of insulation which provides resistance to the passage of current, or to disruptive discharges through or over the surface of the substance at the operating voltage, or injurious leakage of current. For clearance purposes a distinction is made between insulated conductors with and without earthed screens operating at voltages in excess of 1000V.
Insulated with earthed screen	Includes aerial bundled cable (ABC) complying with either AS/NZS 3599.1 or AS/NZS 3599.2 as applicable
Insulated without earthed screen	Includes CCT (covered conductor with additional insulation thickness) cable complying with AS/NZS 3675
King Bolt	The main bolt/s affixing a crossarm to a pole

King Bolt Spacing	The vertical distance between king bolt attachment points on a support structure e.g. spacing between crossarms on a pole
kVA	Kilovolt amperes
Laminar Wind	Non-turbulent, smooth wind. When applied to a tight-strung conductor with a speed between approximately 0.5 m/s and 7m/s which results in the excitement of Aeolian vibration frequencies on the conductor.
LS	Limit State
Limit state (electrical)	State beyond which the electrical design performance is no longer satisfied
Limit state (structural)	State beyond which the structure, components and elements no longer satisfies the design performance requirements
Load Case	A compatible set of load arrangements or conditions to be considered in evaluating a structure. e.g. sustained load, maximum wind load, ice load
Load Factor	A multiplying factor in a limit state equation which considers the variability and dynamics of a load, as well as the importance of a structure
Loading conditions	Likely design actions with the defined variable actions and permanent actions for a particular structure analysis
Low Voltage (LV)	Electrical potential in the range of 50 V to 1000 V
LVABC	Low Voltage ABC (Refer ABC)
Magnetic Field	Magnetic field generated by current carrying conductor. The magnetic field strength, H, is expressed in amperes per metre (A/m).
Mains	Main lines or cables of a network connecting various sites - does not include services to individual consumers
Maintenance	Total set of activities performed during the design working life of the system to maintain its purpose
Maximum Design Temperature	The maximum temperature that conductors or cables reach under the influence of load current (excluding fault current) and ambient conditions. In the case of overhead lines, this includes the ambient temperature of the air and solar radiation. In the case of underground lines, this includes the thermal conductivity of the soil and conduits.
Maximum operating temperature	Limiting temperature for electrical clearances
Maximum Wind Tension	The force applied by conductors to a support structure in an intense wind, generally a 3s gust corresponding to the overhead line design period
Mean Equivalent Span (MES)	A theoretical span used to represent the behaviour of a number of spans of varying lengths in a strain section of an overhead powerline, also known as Ruling Span.
MS HVABC	Metallic screened high voltage ABC
Multiple Earth Neutral (MEN)	An earthing system connecting the network neutral conductors to the earth electrodes in customers electrical installations, the electricity authority transformers, and earths at multiple locations on the electricity distribution network and the earths of consumer’s installations.

NBL	Nominal breaking load – see also CBL
NBN	National broadband network
Nominal Voltage	Voltage by which the overhead electrical line is designated and to which certain operating characteristics are referred
NMSHVABC	Non-metallic screened high voltage ABC
OPGW	Optical Ground Wire - an overhead earth wire with internal optical fibres
Optical Conductor	An electrical phase conductor containing optical telecommunication fibres
Overhead Mains	Aerial conductors or cables together with associated supports, insulators and apparatus used for the transmission or distribution of electrical energy
Overhead service line	An overhead line operating at a voltage less than 1000 V generally located between the electricity utility's overhead line and the point of connection to an electrical installation.
Phasing	The relative positions of phases (A, B or C) in a polyphase power system
Pilot Cable	A multicore communications cable, often with steel catenary used for protection signalling and control
Pole	A structure (wood, concrete, steel, composite fibre) supporting conductors and other equipment forming part of the overhead mains
Pole mounted	Plant or equipment that is outdoor type mounted above ground level on one or more poles
Profile	A longitudinal cross section of ground and an existing or proposed powerline used to check clearances and select optimum pole positions
Prospective step voltage	The prospective or open circuit voltage that may appear between any two points on the surface of the earth spaced one metre apart (measured with two driven electrodes and a high impedance voltmeter)
Prospective touch voltage	The prospective or open circuit voltage (measured with a driven electrode and a high impedance voltmeter) which may appear between any point of contact with uninsulated metalwork located within 2.4 m of the ground and any point on the surface of the ground within a horizontal distance of one metre from the vertical projection of the point of contact with the uninsulated metalwork
PSTN	Public switched telephone network
Reliability (electrical)	Probability that an electrical system performs a given electrical purpose, under a set of conditions, during a reference period
Reliability (structural)	Probability that a structural system performs a given mechanical purpose, under a set of conditions, during a reference period. Reliability is thus a measure of the success of a system in accomplishing its purpose
Risk Criteria	Terms of reference by which the significance of a risk is assessed
Risk Event	An event that results in the occurrence of a hazard that impacts upon the asset or group of assets which are being assessed
Risk Treatment	Process of selection and implementation of measures to modify risk

RL (Reduced Level)	The elevations of a point above an adopted datum
Ruling Span (RS)	See Mean Equivalent Span (MES)
Sag	The vertical distance between a conductor and a line joining the two attachment points. Usually, the term refers to the maximum distance within a span at or near the midpoint.
SC	Steel Conductor
SC/GZ	Steel Conductor/Galvanized
Service	The electricity authority's conductors/cable connecting individual customers' installations to the electricity network
Service Fuse	Protection between a service cable and consumer's mains (cf). Takes the form of a fuse up to 100 amps/phase or a circuit breaker above 100 amps/phase. TasNetworks owns these devices.
Serviceability limit state (electrical)	State beyond which specified service criteria for an electrical performance is no longer met
Serviceability limit state (structural)	State beyond which specified service criteria for a structure or structural element are no longer met, typically due to sustained loading
SF	Safety Factor or Factor of Safety, inverse of Strength Factor
Single Wire Earth Return (SWER)	A high voltage system consisting of a single active conductor and using the earth as the return path
Sinking Depth	The depth of a pole below ground – also known as embedment or planting depth
Site Identifier	The means by which a 'Site' is discretely identified, e.g. a pole number or distribution substation number. Identifiers vary amongst supply authorities and are usually constructed according to a protocol.
Soil resistivity	Volume resistivity of the earth in Ohm metres
Span length	The centre-line horizontal distance between two adjacent supports
Special Location	With regard to earthing, this is a 'high risk' area where step and touch potentials need to be minimised. A special location may refer to school grounds, a children's playground, within a public swimming pool area, bus stop, at a popularly used beach or water recreation area, or in a public thoroughfare within 100 metres of any of the above-named locations.
Spreader	An insulating device used to keep conductor phases separated to prevent clashing
Stay	A steel wire that is used to support a pole when the tip load exceeds the pole capacity. The stay may be anchored in the ground or to another pole. Also known as a 'guy'.
Step Potential	The difference in ground surface potential between a person's feet spaced 1m apart. The prefixes 'prospective' and 'effective' are added when considering the open circuit and loaded (or 'effective') circuit cases.

Strain Point	The structure on a pole that supports the tension of a line in both directions, where conductors are terminated, as opposed to an intermediate support. Used to sectionalise a line for electrical isolation or to provide convenient stringing sections. Also known as a 'Shackle Point'. Applies to ‘through terminations’ and ‘dead-ends’.
Strain Section	A section of overhead powerline between fixed strain points or terminations
Strength Factor, or Strength Reduction Factor	A factor in a limit state equation used to derate the nominal strength of a component to a practical design value, considering variability of the material, workmanship, maintenance and other factors. (Inverse of safety factor)
Stringing Table	A table providing stringing tensions and/or sags for a nominated conductor over a range of span lengths and conductor temperatures
Subcircuit	A circuit below another circuit above, e.g. LV mains below 11kV
Supercircuit	A circuit above another circuit below, e.g. 11kV mains above LV
Support	General term for different structure types that support the conductors of the overhead electrical line
Support, intermediate	Support for conductors by pin, post or suspension insulators – not a strain point
Support, suspension	Support for conductors by suspension insulators.
Support, tension or strain	Tension support capable of carrying the total conductor tensile forces in one direction.
Support, terminal (dead-end)	Support for conductors by tension or strain insulators
Surge Diverter (Also ‘Surge Arrester’, ‘Lightning Arrester’)	A device designed to protect apparatus (e.g. distribution transformers, UG cables) and lines from over voltages caused by lightning, switching transients or other similar disturbances.
Switchgear	Electrical equipment used for connecting and disconnecting electrical infrastructure on the network
TFB	Taper Flange Beam
Tip Load	The equivalent mechanical load applied to a pole tip by attached conductors or stays at various attachment heights, as well as wind on the pole/structure
Touch Potential	the difference between the EPR of an earthing system and the ground surface potential at a distance of 1.0m. This is the difference between a person’s hand touching an energised object and their feet which is typically assumed to be 1.0m out from the energised object. The prefixes ‘prospective’ and ‘effective’ are added when considering the open circuit and loaded (or ‘effective’) circuit cases.

Transferred potential	Potential rise of an earthing system caused by a current to earth transferred by means of a connected conductor (for example a metallic cable sheath, protective earthed neutral conductor, pipeline, rail) into areas with low or no potential rise relative to reference earth resulting in a potential difference occurring between the conductor and its surroundings. NOTE: The definition also applies where a conductor, which is connected to reference earth, leads into the area of the potential rise.
Transformer	Static apparatus that uses electromagnetic induction to transform alternating voltage and current in two or more windings at the same frequency but different voltage/current values
Ultimate limit state (electrical)	State associated with electrical failure, such as electrical flashover
Ultimate limit state (structural)	State associated with collapse, or with other forms of structural failure
Ultimate Strength	The maximum load (nominal and actual) which may be applied to a structural component without inducing failure
Underground Cable Termination	A HV or LV cable end fitting or joint, where a cable terminates on a pole or plant item, also known as 'pot head' or 'cable end'.
Uplift	A vertical upward force applied to a structure by attached conductors - generally not desirable for intermediate (non-strain) structure types
Urban Interface	An HV power asset outside normal public thoroughfare with a low frequency of direct contact by a given person.
Voltage	System voltages are classified as: EHV Extra High Voltage – 66 000 volts and above (in Tasmania only) HV High voltage. - Voltages exceeding 1000 volts LV Low voltage – Greater than 50V but not exceeding 1000 volts
Voltage rated	The international system of voltage rating is in the form Uo/U (Um) eg. 6.35/11 (12) kV. Where Uo = rms power frequency voltage to earth of the supply system. Where U = rms power frequency voltage between phases of the supply system. Where Um = maximum rms power frequency voltage between any two conductors for which the component is designed. U is used to describe the component for everyday use e.g. "An 11kV cable".
Wayleave	A written authority that the owner/occupier of a property uses to authorize an electricity authority to construct, maintain and clear vegetation for electrical line installations. Unlike an easement, it is not surveyed and recorded on the Title to the parcel of land.
Weight Span	For a support, means the length of conductor which gives the vertical component of the conductor load and equals the span between the lowest points on the catenary curve of the conductor on either side of that support.

Wind Span	For a support, means the length of conductor which gives the horizontal lateral component of the conductor load caused by wind and equals one half of the sum of the spans on either side of that support.
WS	Working Strength or Working Stress
Working Strength	A nominal maximum working load obtained by dividing the ultimate strength by a safety factor. This value is not relevant to limit state design, but existing poles may be labelled with a working strength.

1.4 ACTS, REGULATIONS AND STANDARDS

1.4.1 Acts and Regulations

There are a number of Acts and Regulations that are to be considered in the development of design work. These include the following:

- Electricity Supply Industry Act 1995;
- Electricity Supply Industry (Tariff Customers) Regulations 2008;
- Electricity Wayleaves and Easements Act 2000;
- Workplace Health and Safety Act 1995;
- Workplace Health and Safety Regulations 1998;
- Occupational Licensing Act 2005; and
- Environmental Management and Pollution Control Act 1994

Changes to the Occupational Licensing Act 2005 that became effective on the 19 January 2009 have required TasNetworks to be compliant with The Occupational Licencing Code of Practice 2013. This code of practice sets the minimum standards for electrical work in Tasmania.

Incorporated into this Code of Practice is the requirement to comply with:

- AS 2067 (Substations and high voltage substations)
- AS/NZS 3000 (Wiring Rules)
- AS/NZS 7000 (Overhead Line Design)
- Any additional obligations imposed by AS 2067, AS/NZS 3000 and AS/NZS 7000 referring to further Australian Standards or documents, including any amendments or revisions of those Australian Standards or documents from time to time

The Code of Practice requires that any person performing electrical work within Tasmania to comply with these Australian Standards.

1.4.2 Applicable Australian Standard and Guides

These standards/guides are common standards to be used by the designer for the purposes of distribution design work. These lists are not exhaustive, number references to standards within this document are for the benefit of the service provider. The current standards at the time of the project shall be used.

AS 1154	Insulator and Conductor Fittings for Overhead Power Lines
AS 1222	Steel Conductors and Stays
AS 1531	Conductors – Bare Overhead – Aluminium and Aluminium Alloy
AS 1604	Specifications for Preservative Treatment
AS 1720	Timber Structures
AS 1746	Conductors – Bare Overhead – Hard-Drawn Copper

AS 1824	Insulation Coordination (phase to earth and phase to phase, above 1 kV)
AS 2053	Conduits and fittings for electrical installations
AS 2209	Timber – Poles for Overhead Lines
AS 3000	Electrical Installations Wiring rules
AS 3008	Electrical installations - Selection of cables
AS 3607	Conductors – Bare Overhead, Aluminium and Aluminium Alloy – Steel Reinforced
AS 3608	Insulators - Porcelain and Glass, Pin and Shackle type - Voltages not exceeding 1000V a.c.
AS 3609	Insulators - Porcelain Stay type - Voltages greater than 1000V a.c.
AS 3865	Calculation of the effects of short-circuit currents
AS 3983	Metal drums for insulated electric cables (and bare conductors)
AS 4202	Insulating covers for insulating purposes
AS 4398	Insulators – Ceramic or Glass – Station Post for Indoor and Outdoor Use – Voltages greater than 1000V a.c
AS 4435	Insulators – Composite for Overhead Power Lines – Voltages greater than 1000V a.c
AS 4436	Guide for the Selection of Insulators in respect of Polluted Conditions
AS 5804	High-Voltage Live Working (All Parts)
AS 6947	Crossing of Waterways by Electrical Infrastructure
AS/NZS 1170.2	Structural Design Action – Wind Actions
AS/NZS 1768	Lightning Protection
AS/NZS 2344	Limits of Electromagnetic Interference from Overhead a.c. Powerline and High Voltage Equipment Installations in the frequency range 0.15 to 1000 MHz
AS/NZS 2373	Electric Cables – Twisted Pair for Control and Protection Circuits
AS/NZS 2947	Insulators - Porcelain and Glass for Overhead Power Lines - Voltages greater than 1000V a.c.
AS/NZS 3599	Electric Cables – Aerial Bundles – Polymeric Insulated – Voltages 6.35/11(12) kV and 12.7/22(24) kV
AS/NZS 3560	Electric Cables – Cross-linked Polyethylene Insulated – Aerial Bundled – for working voltages up to and including 0.6/1(1.2) kV
AS/NZS 3675	Conductors – Covered Overhead – for Working Voltages 6.35/11(12) kV up to and including 19/33(36) kV
AS/NZS 3835	Earth Potential Rise – Protection of Telecommunications Network Users, Personnel and Plant
AS/NZS 3891.1	Air navigation – Cables and their supporting structures – Marking and safety requirements – permanent, marking of overhead cables and their supporting structures for other than planned low-level flying

AS/NZS 4065 Concrete Utility Services Poles

AS/NZS 4325 Compression and mechanical connectors for power cables

AS/NZS 4676 Structural Design Requirements for Utility Services Poles

AS/NZS 4853 Electrical Hazards on Metallic Pipelines

AS/NZS 60479 Effects of current on human beings and livestock

AS/NZS 60305 Insulators for Overhead Lines with a Nominal Voltage above 1000V – Ceramicor Glass Insulator Units for a.c. systems – Characteristics of Insulator Units of the Cap and Pin type

AS ISO 1000 The International system of units and its application

AS/ISO 13822 Basis for Design of Structures – Assessment of Existing Structures

HB 101 (CJC5) Co-ordination of power and telecommunications – Low frequency induction – Code of Practice for the Mitigation of Hazardous Voltages Induced into Telecommunications Lines

HB 102 (CJC6) Co-ordination of power and telecommunications – Low frequency induction – Application Guide

HB 88(CJC2) Unbalanced High Voltage Power Lines. Code of Practice for the Mitigation of Noise Induced into Paired Cable Telecommunications Lines from Unbalanced High Voltage Power Lines

HB 331 Overhead Line Design – supplement to AS/NZS 7000

IEC 60720 Characteristics of Line Post Insulators

IEC 60794 Optical Fibre Cables

IEC 60865 Short-Circuit Currents

IEC 62219 Overhead Electrical Conductors – Formed Wire, Concentric Lay, Stranded Conductors

IEC TR 61597 Overhead Electrical Conductors – Calculation Methods for Stranded Bare Conductors

ENA LLM 01 Guidelines for Live Line Barehand Work

ENA LLM 02 Guidelines for Live Line Stick Work

ENA LLM 03 Guidelines for Live Line Glove and Barrier Work

ENA EG-0 Power System Earthing Guide

ENA EG-1 Substation Earthing Guide

ENA NENS 04 National Guidelines for Safe Approach Distances to Electrical and Mechanical Apparatus

ENA 18-2008 Interim Guideline for the Fire Protection of Electricity Substations

ENA EMF Management Handbook

ESAA D(b)5 Current Rating of Bare Overhead Line Conductors

1.4.3 TasNetworks Standards

DS P PC 01	TasNetworks Distribution Standard Protection and Control
	TasNetworks Work Health and Safety Legislation and its application to Overhead Design

1.4.4 Other Standards

	Austroads: Guide to Road Design Part 6: Roadside Design, Safety and Barriers
	VicRoads Road Design Note 06-03A Roadside Utility Poles

SECTION 2 – DESIGN SUMMARY

Version: 3.2

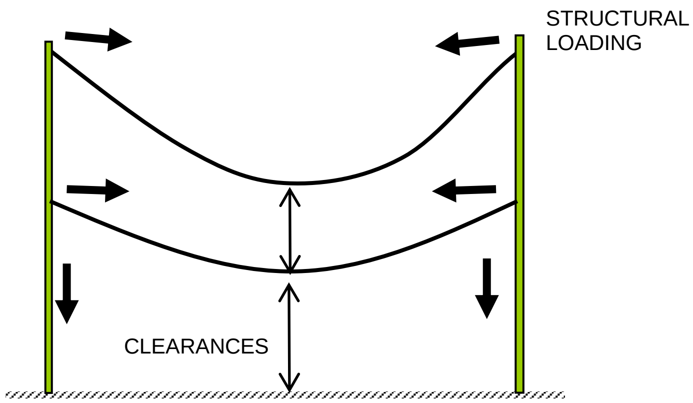
TasNetworks | Powering a Bright Future

SECTION 2 - DESIGN SUMMARY

2.1 GENERAL APPROACH and LIMIT STATE DESIGN

At distribution voltages, overhead line design tends to consist more of structural engineering than electrical engineering. The two main technical aspects to the design of overhead distribution lines are:

1. ensuring that the mechanical load forces do not exceed the strength of the structures or other components, and
2. ensuring that there are adequate clearances—between the conductors and the ground or from other objects in the vicinity of the line, as well as between the various phase conductors and circuits themselves so that clashing does not occur.



The line must comply with these requirements over the full design range of weather and load conditions that could be reasonably encountered—when the line is cold and taut, when at its maximum design temperature and consequently when conductor sag is at a maximum, and under maximum wind conditions.

Current practice for the design of overhead line structural components is to use a 'limit state' design approach as set out in *AS/NZS 7000 Overhead line design*. This limit state approach to overhead design has been used widely in Australia since 1999. It is a rationalisation of the earlier working stress method, which applied a general factor of safety that was somewhat arbitrary in its derivation. Limit state design uses higher, more realistic wind loads wind loads (aligned with *AS1170 Wind code*), but also uses higher, more realistic strengths for structures. Design component stresses are based on the ultimate stress at failure modified by a strength factor which takes into account the material strength variability, durability and reliability required.

The operating conditions to be considered for TasNetworks lines are set out in the following sections, where applicable wind pressures, temperatures and load factors are listed.

2.2 WIND LOADING

An assessment of design wind pressures is necessary to determine the wind loadings to be applied to distribution line components:

- Wind load on the pole element
- Transverse wind load on conductors
- Increase in conductor tension due to transverse load applied by wind action
- Wind load on insulators, cross-arms and other fittings.

2.2.1 Return Wind Period

The likelihood of a line being subjected to a particular wind speed is expressed in *AS/NZS7000* and *AS1170.2* via the wind return period. The wind return period typically associated with distribution lines in *AS/NZS7000* and various Australian utilities is 50 years.

A 50-year return period is equivalent to a 50 year working life for a level I security line, or 25 year working life for level II security (collapse of the line would cause moderately low risk to life or property).

2.2.2 Design Wind Pressures

Table 7.1 of *HB331* lists the design wind pressures relevant to a 50-year return period for various types of equipment and wind regions. The basic wind pressure for region A3 (Tasmania) is 913Pa.

After applying recommended drag factors and rounding, the design pressures applicable to various types of line equipment can be determined:

EQUIPMENT	DRAG FACTOR	DESIGN WIND PRESSURE (Pa)	
		Initial	Rounded
Conductor	1.0	913	900
Wood pole	1.3	1186	1200
Round concrete or steel pole, Stobie pole narrow face	1.0	913	900
Insulators	1.2	1095	1100
Non-round poles, flat surfaces, steelwork, pole-mounted plant, crossarms	1.6	1460	1500

Designers may wish to apply a Span Reduction Factor (SRF) to conductor wind pressures on long spans, recognizing that wind gusts are of limited width and the full pressure is unlikely to apply over the whole of a long span. The SRF on a span of length L may be calculated as follows:

$$SRF = 0.59 + 0.41\, e^{(-L/210)}$$

2.2.3 Limitations of Distribution Design Scope

The above design wind pressures were based on certain assumptions for the majority of distribution lines:

- Structure height above ground is less than 20m
- Required asset design life less than 50 years

- Line does not feed a very critical load (high risk of loss-of-life or significant economic loss)
- Line not installed in a location that can greatly accelerate winds acting perpendicular to the line (e.g. in a valley that funnels the wind or on the crest of a ridge).

<u>Applications outside the above criteria require site-specific determination for design wind pressures in accordance with Appendix B of *AS/NZS7000*.</u>

2.3 LIMIT STATE CONDITIONS AND EQUATIONS

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

INTACT STATE	DAMAGED STATE	FAILED STATE

Serviceability Limit *Ultimate Strength Limit*

2.3.1 General Equation

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

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

where:

φ = the strength factor, which takes into account variability of the material, durability etc.
R_n = the nominal strength of the component
γ_x = the load factor, incorporating the variability of the load, importance of structure, dynamics etc.
W_n = wind load
X = the applied loads pertinent to each loading condition

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

2.3.2 Ultimate Strength (Maximum Wind) Condition

The equation used within TasNetworks, which pertains to loading under short-term wind gusts, with the appropriate load factors applied from section 2.2.2, may be expressed as follows:

$$\varphi R_n > 1.0\, W_n + 1.1\, G_s + 1.25\, G_c + 1.25 Ft_w$$

where:

φR_n = component design strength for limit state condition
W_n = effect of transverse wind load on structure
G_s = vertical downloads due to the self-weight of the structure and fittings

G_c = vertical downloads due to conductors subject to ultimate wind pressure
Ft_W = intact conductor tension loads under ultimate wind conditions

Note that a load factor of 1.25 is applied to conductor tension forces.

2.3.3 Sustained Load Condition

The 'sustained load' is also known as 'everyday load' condition.

$$\varphi R_n > 1.1\ G_s + 1.25\ G_c + 1.1 Ft_e$$

where:

φR_n = component design strength for long duration loads
G_s = vertical downloads due to the self-weight of the structure and fittings
G_c = vertical downloads due to conductors under everyday conditions
Ft_e = effect of conductor loads under everyday conditions

Note that a load factor of 1.1 is applied to conductor tension forces.

The sustained load condition is particularly relevant with timber components, which may deflect or deform under a sustained load. It is normally only a limiting factor on shorter spans in very tight-strung rural lines with steel or ACSR conductors. In the majority of distribution line designs the maximum wind condition will be the determining factor in sizing of structures. Nonetheless, designers should always satisfy themselves that the sustained load condition is satisfied.

2.3.4 Snow and Ice Load Condition

Snow and Ice loads are applicable at elevations greater than 500m. Ice with density 900kg/m^3 is applied above 500m on all conductors but not structures. Temperature is taken to be -5°C.

$$\varphi R_n > 1.0\ S_\gamma + 1.1\ G_s + 1.25\ G_c + 1.1 Ft_{tw}$$

where:

φR_n = component design strength for snow & ice loads
S_γ = snow and ice loads. 'γ' is the return period (50 years).
G_s = vertical downloads due to the self-weight of the structure and fittings
G_c = vertical downloads due to conductors with snow & ice added
Ft_W = conductor tension with snow & ice subject to wind conditions

The thickness of ice on conductors is assumed to be as follows:

0.2 d_c in sub-alpine areas

0.3 d_c in alpine areas

where d_c is the conductor diameter.

The following wind pressures are used:

100 Pa on conductors

130 Pa on round wood poles.

Note that a load factor of 1.1 is applied to conductor tension forces.

The values above have been taken from Table DD1 in AS/NZS 7000. The values in Table DD2 are deemed to be more relevant to transmission lines than distribution lines.

2.3.5 Maintenance Load Condition

$$\varphi R_n > 1.1\ G_s + 1.5\ G_c + 2.0Q + 1.5Ft_m$$

where:

φR_n	=	component design strength for maintenance loads
G_s	=	vertical downloads due to the self-weight of the structure and fittings
G_c	=	vertical downloads due to conductors under maintenance conditions
Q	=	live loads associated with maintenance activities
Ft_m	=	effect of conductor loads under maintenance conditions

Maintenance loads are relevant during construction of a line, where intermediate states of completion of the line can lead to unbalanced loading on fittings and structures.

These would not normally be of concern to distribution network designers, except where designing new constructions from first principles or addressing particular issues with building a line.

2.3.6 Co-ordination of Strength

The design of standard structures should be undertaken to coordinate the relative strength of the components to establish a desired sequence of component failure to minimise overall damage.

2.3.7 Electrical Design Limit States

Three criteria are widely recognised with regard to the electrical design of lines:

a) Clearance for maintenance. Sufficient clearance is to be provided at low wind for maintenance activities (e.g. live-line work). Condition is typically 100Pa at 15°C.

b) Clearance for lightning impulse and switching overvoltages with moderate wind (300Pa at 15°C).

c) Clearance for power frequency withstand at high wind (500Pa at 15°C).

It is expected the above criteria will only be applicable where first principle design is required.

2.3.8 Other Limit States

AS/NZS7000 sets out other limit states that designers may need to check where relevant, such as:

- failure containment or broken wire condition (where one phase conductor breaks on one side of a strain point, so that the loads applied are then out of balance)
- seismic loading
- torsional loading
- maximum wind uplift.

2.3.9 Limit State Parameters

LOAD CASE	WHEN TO CHECK	CONDITIONS			LOAD FACTORS (Refer Table 7.3 *AS/NZS7000*)			
		WIND PRESSURE		TEMP.	WIND LOAD ON STRUCTURE	LONGITUDINAL CONDUCTOR FORCES	VERTICAL LOADS	
							STRUCTURE SELF LOAD	CONDUCTOR
MAXIMUM WIND (ULTIMATE STRENGTH)	ALL SITUATIONS	MAXIMUM	900 Pa nominal Refer Section 2.2.2, Also App B *AS/NZS7000*	15ºC see Note 6	1.0	1.25	1.1	1.25
EVERYDAY (SUSTAINED)	ALL SITUATIONS see Note 1	NIL	0 Pa	5ºC see Note 6	N/A	1.1	1.1	1.25
SNOW & ICE see Note 6	EVEVATION >500m	MODERATE	100 Pa	-5ºC	1.0	1.1	1.1T	1.25
MAINTENANCE / CONSTRUCTION	NO REQUIREMENT TO CHECK FOR STANDARD TN CONSTRUCTIONS see Note 2	LIGHT	100 Pa see Note 4	5ºC See Note 5	1.0	1.5	1.1	1.5 + 2Q see Note 3

Notes:

1. The Everyday/Sustained Load case is normally only a limiting factor on shorter spans in tight-strung rural lines with steel or ACSR conductors. However, designers should always satisfy themselves that this condition is satisfied.
2. Individual structural elements (such as cross-arms) used on TN standard tension structures will be designed to accommodate full termination loads. However, designers may wish to add notes to their design drawings indicating the need for temporary construction stays where required for bracing of the structure itself.
3. 'Q' refers to dynamic loads.
4. Value(s) sourced from Table 7.3 *AS/NZS7000.*
5. Coincident temperature applicable to load condition: location specific for TasNetworks distribution lines
6. Applies for elevations above 500m. Values sourced from *AS/NZS7000* Table DD1, as values in Table DD2 are more relevant to transmission lines than distribution lines. Conductor weight to include ice thickness of 0.2 d_c in sub-alpine regions and 0.3 d_c in alpine regions, where d_c is conductor diameter.

2.3.10 Component Strength Factors

Strength factors for all power line elements within recommended *AS/NZS7000* Table 6.2 range unless otherwise noted.

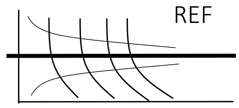
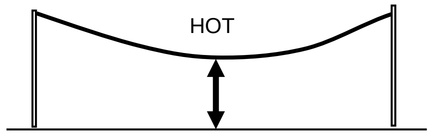
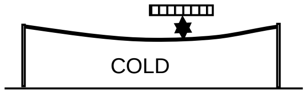
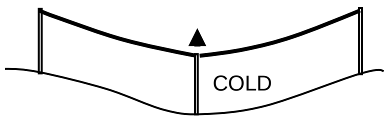
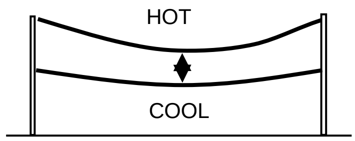
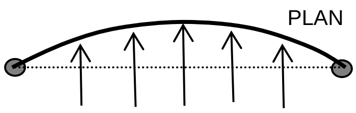
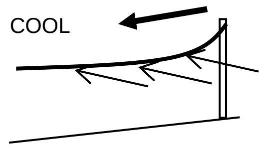
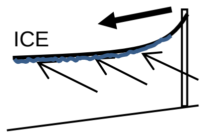
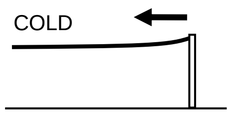
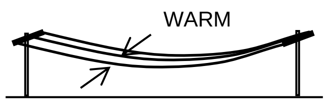
PART OF OVERHEAD LINE	COMPONENT	LIMIT STATE	STRENGTH FACTOR φ
Wood structures preserved by full length treatment	Pole See Note 1	Strength	0.60 ($\Phi*K_d = 0.9*0.667$)
		Serviceability	0.34 ($\Phi*K_d*K_1 = 0.6*0.57$)
	Crossarm	Strength	0.50
		Serviceability	0.40
Wood structures not preserved by full length treatment	Pole	Strength	0.50
		Serviceability	0.30
	Crossarm	Strength	0.50
		Serviceability	0.30
Concrete structures	Pole	Strength	0.9
Steel structures	Pole or crossarm	Strength	0.9
Composite Fibre Structures	Pole or crossarm	Strength	0.75
		Serviceability	0.30
Stays	Cable members	Strength	0.80
	Anchors	Strength	0.40
Conductors		Strength	0.90
		Serviceability	0.50
Fittings and pins—forged or fabricated		Strength	0.80
Fittings—cast		Strength	0.75
Fasteners	Bolts, nuts, washers, stay rods	Strength	0.80
Porcelain or glass insulators		Strength	0.80
Synthetic composite suspension or strain insulators		Strength (short term) Strength (long term)	0.7 0.5
Synthetic composite line post insulators		Strength	0.9 (Max Design Cantilever load)
Foundations relying on strength of soil See Note 2		Strength	0.8

Notes

1. Durability factor K_d lower than 0.85 recommended in *AS/NZS7000* since TasNetworks use S3 and S4 poles which are lower in durability and strength than those used by many mainland states.
2. Values of 0.5, for empirical assessment of soil, and 0.65, where soil testing is carried out, are more usual. The comparatively high value of 0.8 has been adopted to align the results from Brinch Hansen calculations with other simpler, widely-used methods that are less onerous. Refer *HB331:2020* section 10.3.1.

2.4 STANDARD LAYOUT DESIGN TEMPERATURES

The table below shows parameter sets relevant to specific distribution design situations.

SITUATION		TEMP.	WHEN USED	
Standard (Reference) Temperature		5°C	Reference temperature for conductor stringing tables	
Max. Design Temp. (Hot)	Bare, HVABC Cat.	50°C	Checking clearance from ground or objects below the line	
	LVABC	75°C		
	OHEW, Comms	30°C		
Min. Temp. (Cold)		-5°C	Checking clearance from objects above the line	
Uplift		-5°C	Checking for uplift forces, esp. on intermediate structures	
Subcircuit		50°C 15°C	Checking intercircuit clearance—hot supercircuit above and cool subcircuit below	
Blowout (Swing)		15°C	Checking horizontal line displacement (sideways 'sag') under 500Pa wind force (or 350Pa for service cables)	
Max. Wind Condition		15°C	Calculating mechanical forces under maximum wind	
Ice Load condition		-5°C	Calculating mechanical forces with ice on conductor under wind 100Pa.	
Sustained Load Condition		5°C	Calculating sustained mechanical forces and reference temperature for conductor stringing	
Midspan Conductor Clearances		30°C	Checking interphase conductor spacing to avoid clashing	

2.5 ELECTRICAL PARAMETERS

The Basic Insulation Level (BIL) for which the TasNetworks distribution system is designed is:

11kV: 95kV BIL
22kV: 150kV BIL
33kV: 200kV

SECTION 3 – DESIGN PROCESS

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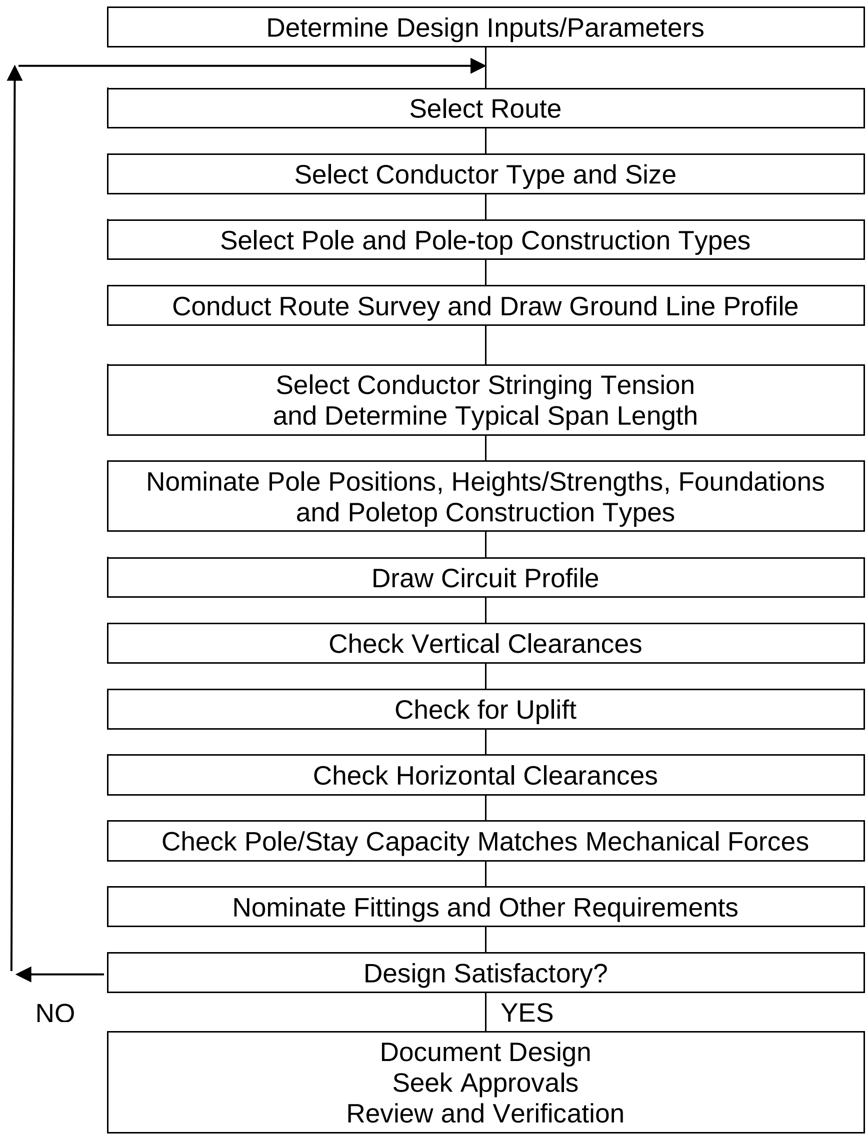
SECTION 3 – DESIGN PROCESS

3.1 OVERVIEW OF PROCESS AND FLOWCHART

The flowchart below shows the *typical* steps in an overhead distribution line design within TasNetworks. Note that the precise steps and their sequence will depend upon the project and the context in which the design is performed. This section concentrates on technical aspects of the overhead line design rather than general network planning, administrative or procedural steps.

The process is iterative, with the designer making some initial assumptions, e.g. as to pole height and size, which may later need to be adjusted as the design is checked and gradually refined. Various options will be tried until a final optimum arrangement that meets all constraints is obtained.



3.2 INPUT PARAMETERS

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

- a planning report, concept, specification or customer request for supply initiating the project
- load details
- any special requirements of customers or stakeholders[1]
- planning requirements, e.g. point of supply and spare capacity in existing network, reliability level, ties to existing circuits, voltage regulation, SWER, 1 ph. or 3 ph. construction, VAR correction, harmonics and disturbing loads, protection considerations, radio reception for remote-controllable plant, budgets, timeframes, phase transpositions
- possible future stages or adjacent developments, road widening or resumptions
- likely future subcircuits or tee-offs
- relevant applicable standards or statutory authority requirements
- coordination with other utilities—'Dial Before You Dig' results
- coordination with road lighting design
- survey plans or base maps
- environmental assessments, ecosystem maps – refer section 13.1
- any site constraints identified, e.g. areas that are flood-prone, under cultivation, difficult to access, exposed to salt or industrial pollution, where large machinery may be operated, high-risk for bushfires, issues pertaining to wildlife, issues pertaining to safety.

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

Financial agreement with customers or management approvals may need to be arranged before commencing work on the design.

[1] These may include property owners/occupiers, indigenous landowners, community groups with a special interest in the site, the local authority, Dept. of Transport and Works, telecommunications carriers, Forestry, Dept. of National Parks, Dept. of Environment and Land Management, Dept. of Harbours and Marine, Airport/Aviation authorities, Railways, other utilities with infrastructure in the vicinity.

3.3 ROUTE SELECTION

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

- property issues, ease of acquisition of easements or wayleaves over private lands
- ease of obtaining approvals from statutory authorities
- community acceptance
- minimising vegetation clearing, wildlife, environmental, EMF and visual impact
- safety issues relating to bushfires, earthing, roads
- access for construction, maintenance and operations
- for low voltage lines, ease of servicing all lots
- compatibility with future development, road widening or realignment
- suitable ground for excavation and pole foundations
- avoiding disturbance to other utilities, e.g. high pressure gas pipeline.

3.4 CONDUCTOR SELECTION

Preferred conductor sizes and types for various applications are presented in section 4.1. Factors influencing selection include:

- voltage
- anticipated load current (for normal and emergency situations) and whether the line segment is 'backbone' or a spur
- voltage drop and regulation
- fault levels and fault current-carrying capacity
- impedance – affects losses and ability of protection to detect and clear faults
- environmental conditions—vegetation, wildlife, pollution or salt spray, bushfire risk, visual impact
- compatibility with existing adjacent electrical infrastructure
- terrain and required span lengths and stringing tension
- mechanical loading on existing structures.

3.5 GENERAL POLE AND POLE-TOP CONSTRUCTION SELECTION

At this stage, the *general* structure type and size should be determined, but precise sizing and selection of type of pole-top construction (e.g. strain or intermediate) will be done later.

Preferred pole sizes and types for various applications are presented in section 6.1.

In general, 11m poles are used for LV lines, 12.5m poles for 11kV or 22kV lines. 14m poles may be used for poles with plant attached or where extra height is needed, e.g. for tee-offs or underground cable terminations, or where poor soil makes deeper foundations necessary. In general, heavier poles are used for dead-ends and line deviations, whereas lighter poles are used for intermediate in-line positions.

It is poor practice to use unnecessarily tall or heavy poles. However, designers should make sensible allowance for any future subcircuits or tee-offs likely to be required, as well as any streetlighting brackets to be attached.

Preferred pole-top constructions are presented in section 8.1.

3.6 ROUTE SURVEY AND GROUND-LINE PROFILING

The line route is 'surveyed' to determine:

- details of existing electricity infrastructure
- terrain and site features, e.g. trees, access tracks, fences, gullies, structures that may be close to the line
- ground line rise and fall along the route.

Ground line profiling may not be necessary for minor projects in urban areas where the ground is reasonably level or has a consistent slope throughout. The designer can check ground clearances by simply deducting the sag in the span from the height of the supports at either end. However, ground line profiling is essential where:

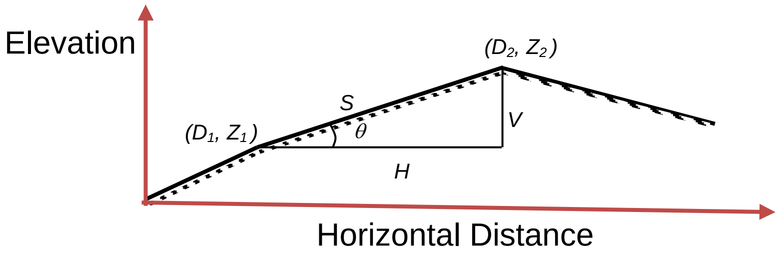
- poles have to be positioned along an undulating traverse
- there is a 'hump' or change in gradient in the ground midspan
- outside of urban areas where spans are comparatively long—say in excess of 80m
- the designer has doubts as to whether required clearances will be met (ground or intercircuit or over some structure such as a streetlight column)
- where uplift on poles is suspected.

The degree of accuracy required will depend upon the circumstances. For many distribution lines, a simple electronic distance measuring device and inclinometer are adequate. Elsewhere, use of a total station, a high-end GPS unit or LiDAR may be warranted.

The route is broken up into segments for profiling, typically corresponding with ‘knee points’ or changes in gradient. Slope distance and inclination measurements for each segment can be converted to chainage and reduced level (RL) values to facilitate plotting as follows:

$H = S \cos \theta$
$V = S \sin \theta$

$D_2 = D_1 + H$
$Z_2 = Z_1 + V$



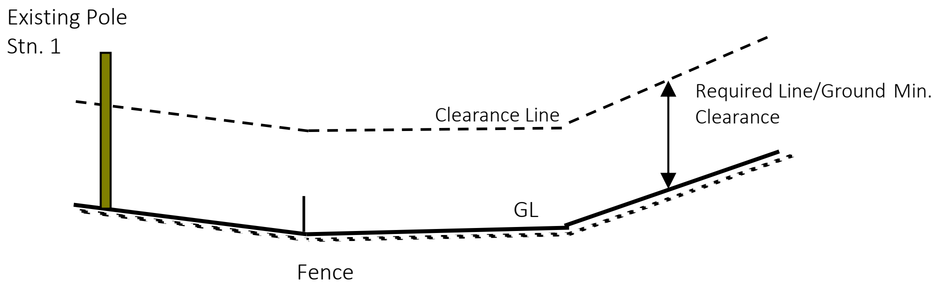
Where the slope angle θ is small (<10°, say), then we may assume H = S for simplicity

A table of the format illustrated below can then be produced. The starting RL can be either a true AHD height measurement or some arbitrary value, e.g. 100m.

Description	S (m)	θ	H (m)	V (m)	Chainage (m)	RL (m)
Station 1					0	100.00
Boundary Fence	40	-3°	40	-2.09	40	97.91
	68	0°	68	0	108	97.91
Station 2	52	+5°	52	+4.53	160	102.44

The data in the Chainage and RL columns can be plotted on graph paper using appropriate scales, e.g. 1:1000 or 1:2000 horizontally, 1:100 or 1:200 vertically. The vertical scale is deliberately larger than the horizontal to exaggerate any slopes and clearance issues. Alternatively, various line design software packages or spreadsheets are available to automate plotting of survey data.

Apart from the ground line, various features and stations may be shown—existing poles, gullies, fences, obstacles, roadways.



A clearance line is then drawn offset from the ground line, according to the minimum vertical clearances that apply (refer section 10). For example, for a bare 11kV line across a field, the clearance line would be 6.7m above the ground line. This line shows the lowest level to which the line may sag under maximum load conditions. The clearance line height may vary along the route, according to the circumstances that apply, e.g. whether along a footpath, over a carriageway, a non-trafficable area or an area where additional clearance is needed for farm machinery.

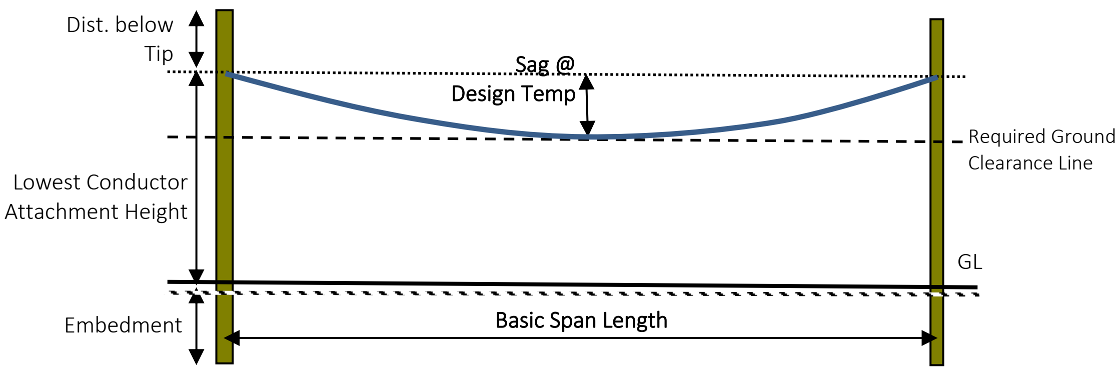
3.7 CONDUCTOR STRINGING TENSION AND TYPICAL SPAN LENGTH

Section 5.1 discusses stringing tensions for various situations and the associated typical span lengths. Designers should not overtension lines – this unnecessarily places very large forces on poles, crossarms, insulators, ties, stays and foundations. Conversely, stringing with insufficient tension can lead to inadequate ground and intercircuit clearance, increased blowout and greater susceptibility to mid-span clashing.

In urban areas, pole positions are often set by the need to position poles on alternate lot boundaries going down the street so that each lot can be serviced, and thus spans are relatively short. In such cases, lower 'urban' stringing tensions should be used. For very short spans, slack stringing should be used.

LVABC is well suited to urban reticulation. It has lesser spanning capability than bare conductors.

In rural areas, longer spans are used. The designer can work out a typical basic span length for the combination of pole, foundation, conductor and stringing tension, as shown below.



The designer should check in Section 8.4 that the pole-top constructions to be used have a spanning capability matching the required basic span length. Also, if there is one circuit above another, e.g. HV over LV mains, intercircuit clearance should be checked for a hot supercircuit over a cool subcircuit.

The spacing between ridges in undulating terrain can also be a factor in determining a suitable arrangement with adequate spanning capability.

3.8 POLE POSITIONING

Firstly, the designer should position poles along the route at any key or constrained locations, e.g. end points, bend points, positions required for supporting street lighting or on alternate property boundaries in urban areas to facilitate servicing each lot.

Locations should be selected for poles carrying switches or plant. Good accessibility is a major issue for these poles. Transformer poles should be placed close to the electrical load centre. Generally, it is best that these are positioned on relatively straight segments of line. Minimising visual impact is also important when selecting transformer sites.

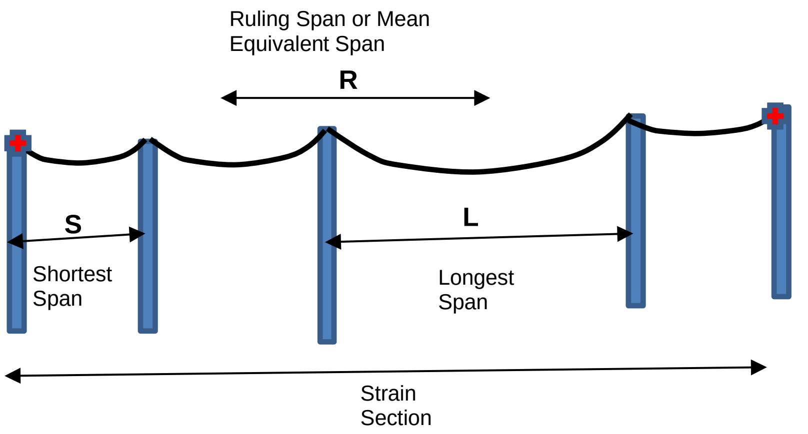
Next, the designer should position poles along the route so that the basic span length is not exceeded. Of course, if there are gullies between poles, the spacing can be increased; if there are 'humps' mid-span, span lengths need to be reduced. Manual handling should also be considered when selecting a span length, noting that the conductor must be manually supported for some cases during construction and maintenance. This is especially necessary where vehicle access is not possible and so ladder work is more likely.

The positions of all the poles can be marked on the ground line profile.

The designer needs to check that all proposed pole locations are suitable, e.g. not in the middle of a gully, an inaccessible area, a steep side-slope, in the middle of a driveway or on a bend in the road where it is likely to be struck by an errant vehicle. **Additional guidance for siting poles is provided in section 6.7**.

3.9 DETAILED POLE, FOUNDATION AND POLE-TOP CONSTRUCTION SELECTION

Strain point (shackle) locations need to be determined. These should be used:
- to isolate electrically different circuits
- to keep very short spans or very long spans mechanically separate, such that all spans in a strain section are of similar length (no span less than half or more than double the mean equivalent [ruling] span length, and on tight-strung lines, the longest span not more than double the shortest span – sometimes called the '2:1 rule')
- to isolate critical spans, e.g. spans over a river, major highway or railway line, to help facilitate repairs or maintenance
- on line deviation angles too great for intermediate constructions
- at locations where there are uplift forces on poles
- at intervals of approximately 8 spans or so. It is helpful if this length corresponds with the output of a conductor stringing work crew for a day. Strain constructions can also limit the length of line affected in the event of wires brought down in a storm. Also, the length of conductor on a drum may be a consideration.



Always ensure:
L < 2 R
S> 0.5 R
Where conductors are strung at 10%NBL or tighter, ensure:
L/S < 2

The span lengths within the strain section should be kept reasonably similar, if possible. Also, the type of pole and pole-top construction used should be kept reasonably consistent, as this gives the line a tidy appearance. The mean equivalent [ruling] spans for each strain section can be calculated. (Refer section 5.14.4.)

The designer will now need to nominate pole strengths and foundation types/sinking depths as a first pass, knowing that these may need to be amended later once tip loads are calculated and checked. Heavier poles will be used at terminations and on larger deviation angles. Pole sinking depths can be determined in accordance with section 6.5.

The designer will need to nominate suitable pole-top constructions for intermediate poles with adequate capacity for the deviation, checking section 8.4 for span/angle capability.

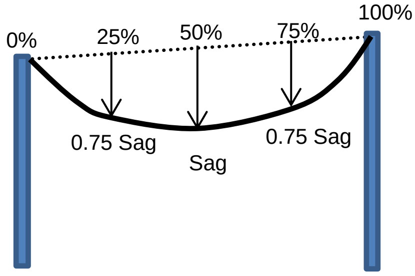
The pole tips and conductor attachment heights should all be marked on the ground line profile. Where circuits are not at the top of the pole, the conductor heights need to be worked out. Note that while the conductor height may be the same as the kingbolt height for a strain construction, this is not the case with pin or suspension constructions. A pin construction typically adds approximately 200mm to conductor height while a suspension construction subtracts approximately 200mm – precise distances depend on the insulator/crossarm/fitting dimensions.

Increased spacings between HV and LV circuits may be used on long spans to prevent problems with intercircuit clearances if necessary. They may also be increased on poles carrying plant or other sites where live line work is likely to occur. The ideal separation between HV and LV circuits for live line work is 2.0m.

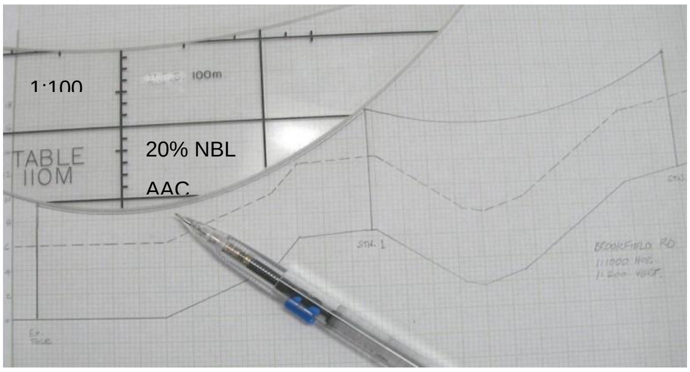
3.10 CONDUCTOR PROFILING

The conductors can now be added to the line profile. This can be done using line design software or manually on graph paper or with CAD.

If working with graph paper, for simple lines over reasonably flat terrain, it may be a simple matter of drawing a line between the two support points, and then projecting vertically downwards at the midpoint by the amount of sag in the span. For improved accuracy, *0.75 x Sag* can be projected down at the quarter-way points in the span, as shown.



For more complex lines and terrain, it is preferable to use a sag template. Details of the template shape can be found in section 5.14.1. The template should be specific to the conductor type (e.g. AAC, SC/GZ), the stringing tension, the MES and the horizontal and vertical scales used. The bottom of the template corresponds to sag at the maximum design temperature. The top of the template may be matched to the minimum design or uplift temperature, -5°C, or 15°C when profiling a cool subcircuit below a hot supercircuit. The datum lines on the template must be aligned with the grid of the graph paper. The template should not be tilted.



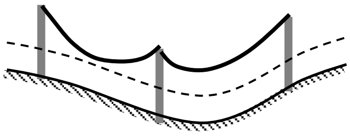
If preparing a profile manually, it is often helpful to generate a table listing the attachment heights and sags in each span, such as the one shown below.

POLE 1	END HEIGHT 1	POLE 2	END HEIGHT 2	CONDUCTOR	TENSION	SPAN	MES	TEMP	SAG
511201	9.85m	E	10.5m	FLUORINE	10%	65m	107m	50°C	0.93m
	8.24m		9.12m	4C 95mm^2 LVABC	10%			15°C	1.36m
								75°C	1.63m
E	10.5m	C	10.5m	FLUORINE	10%	123m	107m	50°C	3.33m
	9.12m		9.12m	4C 95mm^2 LVABC	10%			15°C	4.89m
								75°C	5.84m
C	10.5m	B	10.5m	FLUORINE	2%	12m	12m	50°C	0.25m
	8.97m		8.97m	4C 95mm^2 LVABC	2%			15°C	0.25m
								75°C	0.37m

3.11 CHECKING VERTICAL CLEARANCES

Clearance requirements are detailed in Section 10.

Ground clearance can be checked by ensuring that the 'hot' curve does not fall below the clearance line offset from the ground line. If there is insufficient clearance, the designer may need to:

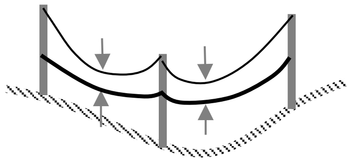


- reposition poles to reduce span length
- increase stringing tension
- increase pole height
- adjust pole positions to try to fit in better with the terrain.

If there is abundant clearance, the designer may try to:

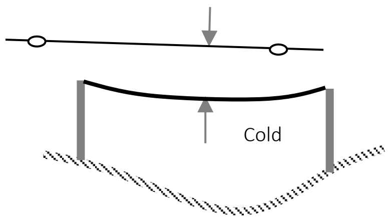
- reposition poles to increase span length, thereby reducing the total number of poles in the line and the associated costs
- reduce pole height.

Where there are long spans with a supercircuit and a subcircuit, intercircuit clearance should be checked. The supercircuit will be drawn at the maximum design temperature and the subcircuit at the 'cool' temperature (refer section 2.4). If there is insufficient intercircuit clearance, e.g. <0.5m between HV and LV mains, the designer may need to:



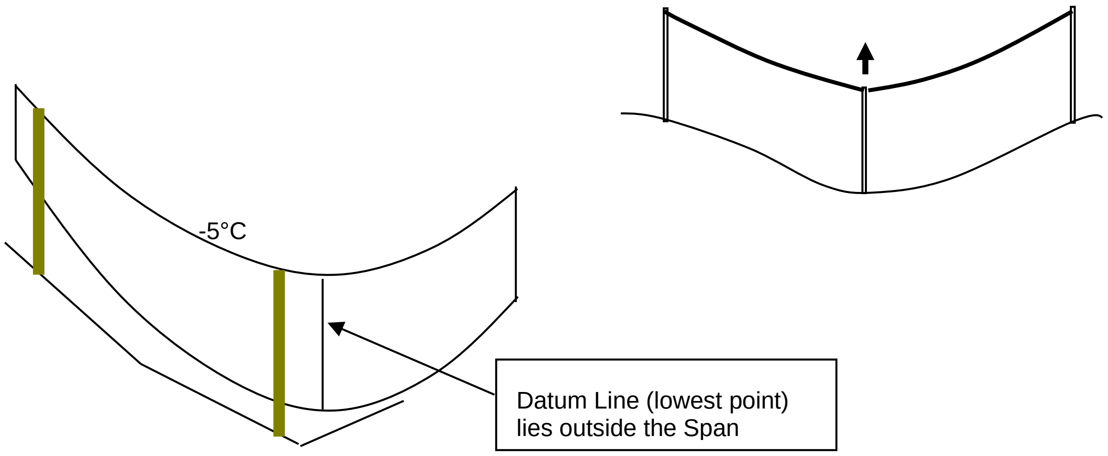
- reposition poles to reduce span length
- increase stringing tension on the supercircuit
- reduce stringing tension on the subcircuit, provided there is adequate ground clearance
- increase the spacing between the supercircuit and subcircuit attachment points on the supporting poles.

For checking clearances from an object above the line, the line temperature should be taken to be -5°C.



3.12 CHECKING FOR UPLIFT

Poles at the bottom of a hill or in a gully are prone to uplift. Under cold conditions, the conductors heading up the slope will become tight and pull upward on structures, causing damage. The -5°C curve is used for this check. Uplift will be evident where the datum of the template (low point of the sag curve) lies outside the span, as illustrated below. Thus, the conductor rises immediately adjacent to the support rather than dropping down.



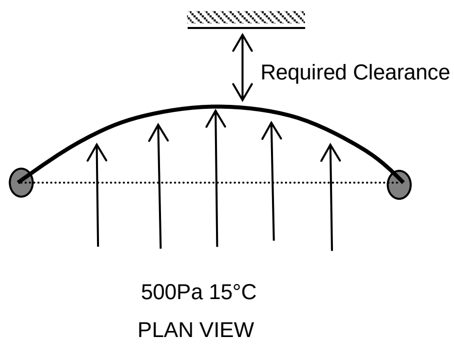
Uplift is generally not a problem if it is on one side of the structure only and offset on the opposite side by a downward force, as may occur with a line with successive spans running down a steep slope. However, if on both sides of an intermediate structure such as a suspension or pin construction,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

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

3.13 CHECKING HORIZONTAL CLEARANCES

The designer should check that there are adequate horizontal clearances between the line and any nearby structures (e.g. flag poles, buildings, bridge columns, streetlight columns) or embankments. **Clearance requirements are detailed in Section 10.** These clearances should be checked for both no wind and blowout conditions.

For aluminium conductors, blowout is typically of a similar magnitude to the sag in a span. Blowout for various conductor types, span lengths and stringing tensions is given in section 5.



Ways of addressing horizontal clearance problems include:

- increasing conductor stringing tension
- reducing span length
- relocating poles to a different alignment
- ensuring that poles are placed in line with any nearby objects, so that there is nil blowout at this point
- using different pole-top constructions, e.g. offset construction
- using insulated cables which may have lesser clearance requirements than bare
- relocating objects affected, where feasible, e.g. streetlights
- increasing line height to skip over the object, where feasible.

3.14 CALCULATING MECHANICAL FORCES

Tip load calculations should be undertaken for each of the poles, particularly dead-ends, strains and deviation angles in the line. For straight-line intermediate poles, it may only be necessary to check those with long spans or large conductors attached.

It is expected that most designers would be using line design software of some type to calculate tip loads. However, if not, conductor tensions can be determined from the tables in section 5. Wind forces on poles can be found in the sections 6.2 and 6.3.

Forces are added as vectors, not scalar quantities unless in the same direction. Section 5.14.9 discusses how this can be done for various pole-top configurations.

When using timber poles, forces should be calculated for both *No Wind* (sustained or everyday) limit state and *Maximum Wind* limit state load cases, although it will usually be the latter that will be most critical. When using steel or concrete poles, analysing stays, pole stakes or pole foundations, only the Maximum Wind limit state load case need be considered.

Forces on stay wires can be calculated. These will depend upon the pole-top load and the angle of the stay wire to ground. The formulae are given in Section 7. For distribution applications, ensure that the stay is designed to take the full load applied and not just the portion by which the load exceeds pole capacity. Do not assume that the pole and stay share load since the pole tip will flex under load whereas the stay anchor is rigid and will immediately be subjected to the full load.

3.15 CHECKING MECHANICAL FORCES AGAINST STRUCTURE STRENGTH

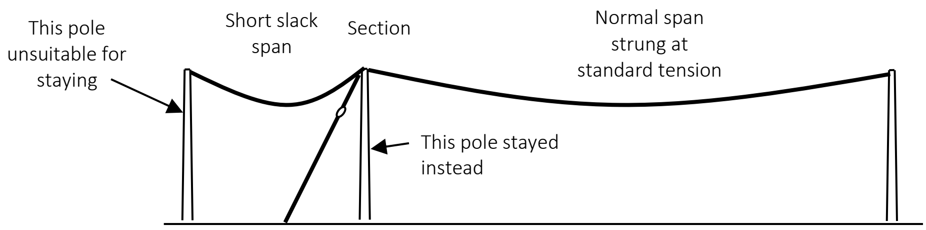
The tip load of each pole is then compared with its capacity, as detailed in sections 6.2 and 6.3.

Where the pole has more than adequate strength, the designer may investigate whether it is feasible to drop down to a smaller size, e.g. from an 8kN to a 6kN working strength. This may mean an adjustment to sinking depth as a consequence, which will affect the profile marginally.

Where the pole has insufficient strength, the design will usually consider increasing pole strength size, or else fitting a stay. Details of stay types, sizing and positioning are given in section 7.

Foundation strength will also need to be checked for each pole by reference to the tables in section 6.5. The designer will need to nominate the embedment depth of the pole and the type of foundation to be used. Adjustments to sinking depth will have an impact on the profile and any significant changes may make it necessary to recheck vertical clearances.

Where space for a stay is restricted or a pole is unsuitable for staying, the designer may reduce stringing tensions, or even use a short, slack span, then staying the next pole along, as shown below.



3.16 NOMINATING FITTINGS AND OTHER REQUIREMENTS

The designer will need to provide additional details concerning things such as:

- fitting of vibration dampers (refer section 8.5.1)
- wildlife proofing (refer section 13.3)
- fitting of aerial markers (refer section 13.4)
- details of clamps, lugs, connectors, sleeves, bridging (refer section 8.5.3, 8.6)
- details of pole-mounted plant, fusing and settings (refer section 9)
- earthing (refer section 11)
- lightning and surge protection
- services and phasing
- vegetation clearing requirements (refer section 10)
- special foundations required in areas of poor soil (refer section 6.5)
- access tracks
- property details, wayleaves and easements.

3.17 DESIGN ITERATIONS

The initial design is 'tweaked' repeatedly until it complies with all regulations and stakeholder requirements and is optimal in terms of cost, reliability and practicality for construction, maintenance and operations.

Whenever poles are moved as the design is 'tweaked', the mean equivalent span for the strain section needs to be recalculated and clearances rechecked.

3.18 DESIGN DOCUMENTATION AND DELIVERABLES

A project design plan or works drawing should be prepared, which should typically include:

- Proposed site and location plan at suitable scale showing electrical infrastructure overlaid on cadastre – refer TasNetworks Design Drafting Standard
- Key dimensions to survey boundaries and peg points, or existing infrastructure as well as other utility infrastructure
- Detailed underground plan and 'Dial Before You Dig' asset information
- Details of terrain, roads, footpaths, access tracks, embankments, retaining walls, vegetation, fences, affected driveways, development staging, fire risk zones, buildings and other relevant features
- Single Line Diagram (schematic)
- Connection diagram
- Schedules giving details of poles, foundations, stays, screw anchor installation torques, poletop constructions, equipment and fittings, conductors and stringing tensions/sags
- Earthing arrangement
- Phasing
- Title block, project drawing register with reviewer and approval sign off
- Relevant notes, warnings, contact details, project numbers and referenced drawings or standards.

This should be accompanied by other elements as applicable, such as:

- Bill of materials or resource estimate
- Contractor Work Order or equivalent project scope/material/schedule
- Safety in Design report, Risk Assessments, earthing safety compliance review
- Environmental impact assessment report
- Line profiles
- Voltage drop calculations
- Tip Load calculations/results or software model files
- Protection settings, reports
- Site surveying
- Manufacturer equipment rating
- Project approvals
- Key project correspondence – letters, emails, offers and acceptance
- Civil/structural details
- Wayleave/easement details (including evidence of easement on title)
- Other approvals, e.g. local authority, road authority, railway authority, vegetation clearing permits, telecommunication authorities where poles are shared
- Completed design QA checklists
- 'Dial Before You Dig' information
- Switching or commissioning plans
- Reports from specialist advisors, e.g. pole inspections, geotechnical test results.

3.19 DESIGN REVIEW AND SAFETY IN DESIGN

The design should be thoroughly checked prior to issue. The designer should ensure that all aspects of the original brief have been addressed. For major projects independent review and verification of the design may be carried out.

The review should always include a consideration of potential safety issues. The *Workplace Health and Safety* Act 2012 requires designers to exercise due diligence and to comply with all relevant safety codes. For simple designs using standard TasNetworks 'building blocks', a simple review may be adequate. However, for large projects or where there is anything out-of-the-ordinary, a formal Safety in Design review may be warranted. Key elements include:

- identifying potential hazards that may arise over the entire life of the infrastructure: during construction, operation, maintenance, decommissioning or recovery
- elimination or minimisation of identified risks
- consultation with construction crews, operators and other stakeholders on potential problems, conflicts or matters needing coordination
- identification of key information to be passed on with the design to constructors and any training that might be required for the site or construction activities.

Refer to the TasNetworks document *"TasNetworks Work Health and Safety Legislation – Application to Overhead Design"* for more detail.

3.20 DESIGN REVIEW AND SAFETY IN DESIGN

Existing HV feeders may have their capacity upgraded by being allowed to operate at a higher temperature than they were originally designed for, e.g. 60°C rather than 50°C.

The line is carefully surveyed by a designer to determine existing conductor sags/tensions and attachment heights on poles. This includes any subcircuits. The ground line profile and any nearby structures are also measured. A profile is prepared for the line at the higher operating temperature and clearances checked. It often turns out that clearances are adequate for the majority of spans; only a few require alteration, typically the longer spans. These may be modified by various techniques, such as:

- changing poletop construction to raise mains slightly e.g. by fitting a poletop raiser
- changing subcircuit construction type or king bolt position to lower subcircuit slightly
- retensioning conductors
- pole replacement
- adding a new mid-span pole.

It may also be prudent to inspect the condition of the line, possibly even conducting a thermoscan, and rectifying any aspects that appear substandard. In some cases, vibration dampers or conductor spacers may be fitted where warranted. Another option is to replace older type connectors.

3.21 SAMPLE TECHNICAL CHECKLIST

The checklist below is a **sample only** and concentrates on technical aspects of overhead design rather than general network planning, procedural or administrative issues. Numerous other elements could be added. Good checklists are an essential part of quality assurance. They need regular updating and should not be static.

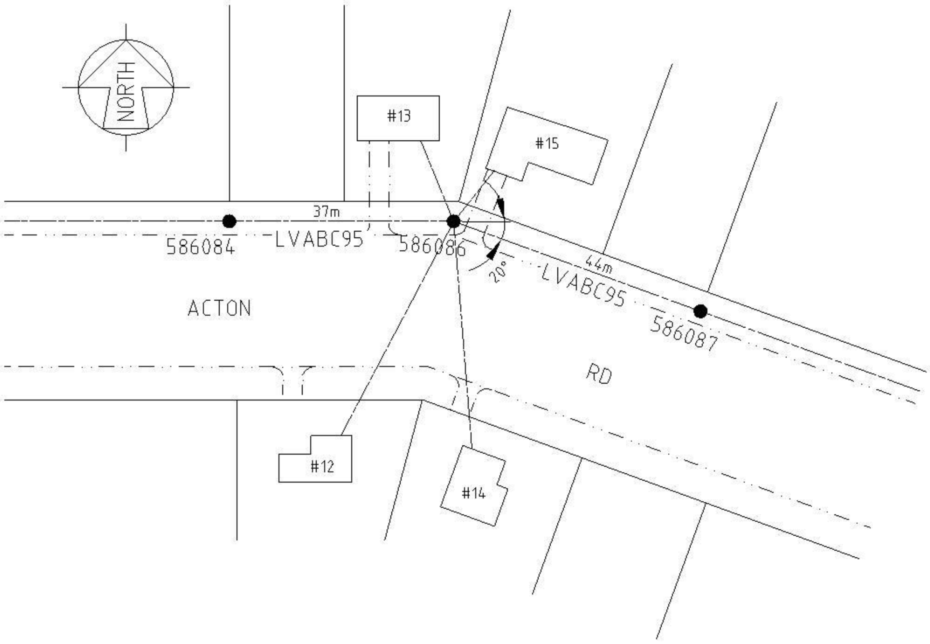
Element	Y, N, NA
PLANNING & COORDINATION	
Brief, stakeholder requirements, budget, timeframes and design parameters reviewed and confirmed	
Schematics – existing/proposed, ties, isolation, reliability, sensitive consumers	
Conductors and plant sized to suit load, voltage drop, fault current etc	
Plant positions optimal, good access	
Compatible with nearby and future development	
No clashes with other services, DBYD	
LINE ROUTE, POLE & STAY POSITIONS	
Base plan shows all relevant details: embankments, walls, gullies, fences and boundaries, trees, easements, survey points, site identifiers, street numbers, property owners, access tracks etc. as applicable	
Access, slopes along and across profile and near poles	
Ground conditions – suitable for excavation, good foundations, drainage, acid sulphate	
Vegetation clearing, bushfires, wildlife, visual impact, EMF, weeds, sediment, protected areas and other environmental issues addressed	
Suitable pole and stay positions: well-spaced, min. hazard to vehicles or livestock, not in gullies or driveways, able to service all lots, coordinated with streetlighting	
Site issues: exposed to high winds, lightning, flooding, crops, land usage and activities in vicinity	
Safety issues addressed	
Pole alignments/setbacks	
POLES	
Suitable type, length and strength for each site	
Existing poles with altered tip loads inspected	
Tip load calculations: Strength of pole, stake or foundation not exceeded nor underutilised	
Suitable foundation types, sinking depths, backfill	
STAYS	
Suitable number, orientation, type, stay wire, insulator, anchor, guard	
CONDUCTORS	
Suitable for environment	
Suitable stringing tensions, sags	

Element	Y, N, NA
Strain sections, 2:1 rule for span lengths, ease of construction and maintenance, critical spans isolated	
Profiling: ground and intercircuit clearances, uplift	
Blowout and horizontal clearances	
Clearances from streetlights, comms cables, other utilities	
POLETOP CONSTRUCTIONS AND FITTINGS	
Span/angle capability	
Spacing between circuits, accessibility, live line	
Crossarm and insulator types suitable	
Phasing	
Bridging, connectors, sleeves, terminations	
Vibration dampers	
Aerial markers	
Wildlife proofing	
EARTHING	
MENs at ends of radials, tee-offs and suitable intervals	
HV earth / LV MEN and comms earth separation	
Cable terminations	
Catenaries of pilot cables, HVABC	
Clearance from Telecommunications and other utilities	
Steel/concrete poles	
HV earths in ‘special’ locations, risk-based study required	
Soil resistivity, deep drilling	
Mitigation measures for step/touch/transfer potential	
SERVICES	
Phasing	
Attachment points on consumer premises, clearance from other services, accessibility	
Routes clear of vegetation, no property crossings	
Adequate ground clearance, e.g. over driveways	
GENERAL	
All relevant notes and information to be conveyed to construction crew	
Protection settings, tap settings on transformers	

3.22 WORKED EXAMPLES

3.22.1 Example 1 – Simple LV Pole Placement

Low voltage pole 586086 has been condemned and requires replacement. It is located on a bend in a suburban street on a 2.150m alignment from RP boundary, or 2.0m behind the kerb. The pole is a 10.5m/4kN WS type, as are the adjacent poles, with approx. 1.7m embedment into the ground, which could be classified as well-drained stiff clay. The mains are 4C 95mm^2 LVABC and the construction on the pole is an angle (double suspension) type. The four 25mm^2 Al/XLPE services emanating from the pole are all in good condition. The sag in the 44m span of mains is measured to be 1.3m (on a sunny, still day with an ambient air temperature of 20°C).



We will replace the pole in the same alignment adjacent to the existing one, 1.0m to the west, say, since replacing it on the east side would put it too close to the driveway to #15. From this new location, the service to #15 will still not cross the neighbouring property. We check 'Dial Before You Dig' records and check this location is clear of underground utility services – if we had concerns about this matter we would add a caution note to our plan and possibly even specify hand sinking or vacuum excavation of the pole hole.

The replacement of the pole adjacent with a similar sized pole will not significantly affect the length of LVABC mains, so there is no need to replace, extend or retension the existing mains. The services to #12 and #13 on the western side of the pole will need retensioning due to the reduction in route length. The services to #14 and #15 on the eastern side of the pole may need replacement due to the slight increase in route length.

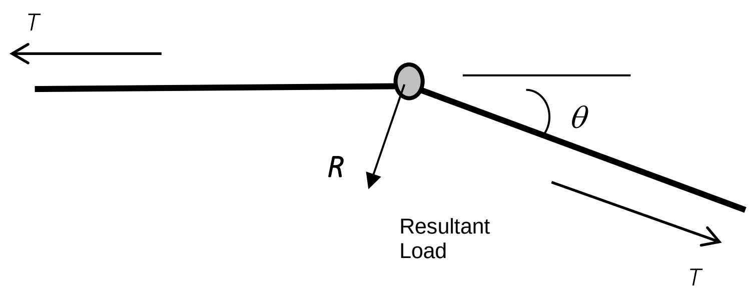
We nominate a new 11m pole for the replacement (this is the standard size according to section 6.1). We will try the lightest pole size initially, 4kN WS 17kN NBL – we can always go up to the next size if this proves unable to withstand the applied load, but the mains are not tightly strung and the deviation angle is modest. According to table 6.2, this has a capacity of 6kN sustained load, 10kN maximum wind LS load, and a self-windage of 1.79kN. Minimum sinking depth is 1.7m.

Where practicable, we try to match the foundation strength to that of the pole. According to section 6.6.3, for the 11/4/17 pole in 'CB' soil and a 'NB' foundation, we need a sinking depth of 1.75m.

We need to determine the tension of the existing mains, using the sag measurement in the 44m span. This can be done with software such as *Poles'n'Wires* or by making use of the stringing tables in section 5. Table 5.9.2 is urban 6%NBL stringing of LVABC for a 40m MES. Let us assume a conductor temperature 5°C above ambient air temperature, as it is sunny and still, i.e. 25°C. According to the table, a 45m span at this temperature and 6%NBL stringing tension will have a sag of 1.19m. Our measured sag is only a little higher than this, so it means the mains are actually a little slacker than 6%NBL stringing tension (actually 5.07%), but we will use 6% for our tip load calculations.

Again, we could use software to calculate the tip load on the pole or we could make use of the tables in section 5 and then apply the formulae in 5.14.8. According to table 5.9.5, for 4C LVABC95 strung at 6%NBL on a 40m span (averaging the spans either side for simplicity), we have the following tensions:

No Wind: 3.51kN
Max. Wind: 9.53kN.



The resultant force, R, is calculated as follows:

$$R = 2\,T\,N\,\sin(\theta/2)$$

In this case, θ = 20°, and N =1.

For the No Wind case, T = 3.51kN, so R = 1.21kN. This is less than the 6kN sustained capacity of the pole.

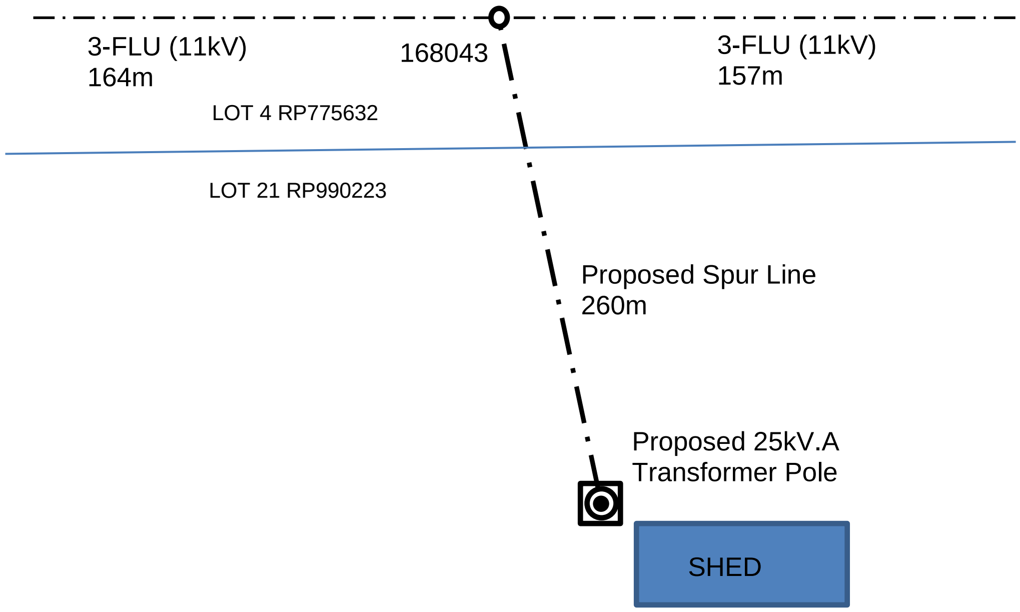
For the Max. Wind case, T = 9.53kN, so R = 3.31kN. Now we need to add the 1.79kN self-windage of the pole to this, giving a total load of 5.10kN. This is also less than the 10kN max. wind LS capacity of the pole, so the pole is adequate and does not need to be upsized or stayed.

We need to check that we have sufficient ground clearance mid-span. The tip height of the new pole will be 11m less the 1.75m embedment, i.e. 9.25m. The LVABC fitting is bolted to the pole 150mm below the tip, so the cable itself will be approximately 300mm below the tip, i.e. at 8.95m. On the adjacent pole, 586077, the LVABC has an attachment height of 8.5m, so the average height of the supports is 8.725m. We subtract the sag@80°C max. design temp. of 1.61m from this, so the mid-span conductor height is 7.115m. This is more than the 5.5m minimum required and so is adequate.

Finally, we need to confirm that the LVABC angle double suspension construction D/LVABC-95/4 is suitable for the span lengths and angle at this site. Checking the table in section 8.4.2, we see that has a max. span of 139m @ 30° and 188m @ 15°, so we are well within its range.

3.22.2 Example 2 – Short Rural 11kV Extension

An application for 3-phase supply has been received for a shed on a rural lot. A 25kV.A transformer will be needed. Supply can be obtained by teeing off an existing 11kV line running through an adjacent dairy farm 260m away. The property owner is willing to grant a wayleave for the new spur to the transformer. The source pole, 168043, is 12m 4kN WS 'MA' species (S4 grade) with an intermediate 11kV construction and 2.0m embedment into the ground, which could be classified as firm clay. The source pole has been inspected and found to be sound below ground. The terrain is flat and open.



We will select FLUORINE (7/3.00 AAAC 1120) conductor for this application. Another option would be 3/2.75 SC/GZ steel conductor, but in this instance AAAC is deemed more suitable because of its corrosion resistance.

We will use full tension (22% NBL) stringing and wonder if we can cover the distance with a single span. Consulting section 5.4.9 for this type of conductor and stringing tension and a 250m MES, we find the sag in a 260m span at the maximum design temperature of 50°C would be 6.25m. This will be excessive for regular height poles and we will not be able to achieve sufficient ground clearance mid-span. Therefore, we will opt for an intermediate pole and use two 130m spans. The MES will be 130m, so we turn to section 5.4.7 for a 150m MES, which is close to 130m, and note that the sag at 50°C in a 130m span would be 2.01m, which will be reasonable and allow us to achieve the necessary ground clearance.

If we wished to be more precise about the sag, we could also note the sag for a 100m MES in the table in section 5.4.6, 2.54m, and then interpolate between the sag values in the two tables:

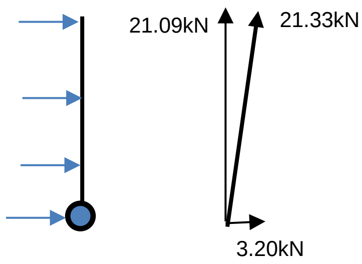
$$\text{Sag} = (150-130)/(150-100) * (2.54 - 2.01) + 2.01 = 2/5 * 0.53 + 2.01 = 2.22\text{m}$$

For the transformer pole, which is also the terminal or dead-end pole, we nominate a 14m heavy type 8kN WS / 33kN NBL. This has a minimum sinking depth of 2.0m (section 6.5.3).

For the intermediate pole, we nominate a 12.5m 4kN WS / 17kN NBL pole, which has a minimum sinking depth of 1.85m.

We now need to calculate tip loads on the various poles. If we have suitable software for this, we would make use of it. In this instance, we will calculate it manually and using the table in section 5.4.12.

On the new transformer pole, the 11kV mains apply a force of 2.86kN sustained and 7.03kN max. wind LS per conductor, i.e. 8.58kN / 21.09kN total. For the max. wind LS case, we also need to include the pole windage, which is 3.20kN according to section 6.2.1, which is at right angles to the conductor force. To add these two together vectorially, we can use the Pythagorean formula:



Resultant = $\sqrt{(21.09^2 = 3.20^2)} = 21.33$kN

Now a 14/8/33 pole has the following capacity according to section 6.2.1:

No Wind: 12.0kN – this is greater than the 8.58kN applied load

Max Wind LS: 20.0kN – this is less than the 21.33kN applied, so we will need to stay the pole.

The load applied to the existing pole 168043 will be very similar to that on the transformer pole, since a tee-off pole is very similar to a terminal pole, the existing 'through' mains cancelling out in terms of their loading. If we wished to be more precise, we could acknowledge that the tee-off is 0.92m below the existing intermediate construction, and so, given the 10m tip height, reduce the loads in proportion. The scaling factor would be (10 – 0.92/10) = 0.908. Also, the wind load on the existing pole is a little smaller, 1.89kN according to section 6.2.2. Thus, our tip loads and capacities will be as follows:

	Strength	*Load*
No Wind:	5.0kN	0.908 x 8.58 = 7.79kN
Max. Wind:	8.78kN	$\sqrt{((0.908 \times 21.09)^2 + 1.89^2)} = 19.24$kN

The pole will definitely need staying. Even if the pole itself had adequate strength, we would need to stay it because of the foundation. According to table 6.6.9, a pole of this type with a natural backfill foundation in soil type 'CC' and 1.85m sinking has a foundation strength of only 4.05kN. With 2.15m sinking, according to 6.6.10, it would have a strength of 5.71kN. With 2.0m sinking, we will be midway between these two values, 4.88kN.

On the new intermediate pole, the sustained load will be nil. The wind span of the pole is 130m, the average of the two spans. Given a conductor diameter of 9mm, the area per conductor will be 130 x 0.009 = 1.17m^2. For 3 conductors and a wind pressure of 900Pa, i.e. 0.9kPa, our total conductor wind load will be 3 x 1.17 x 0.9 = 3.16kN. We add to this the pole wind load of 2.17kN (section 6.2.1) to get a total max. wind load of 5.33kN. This is less than its max. wind capacity of 10.0kN (section 6.2.1).

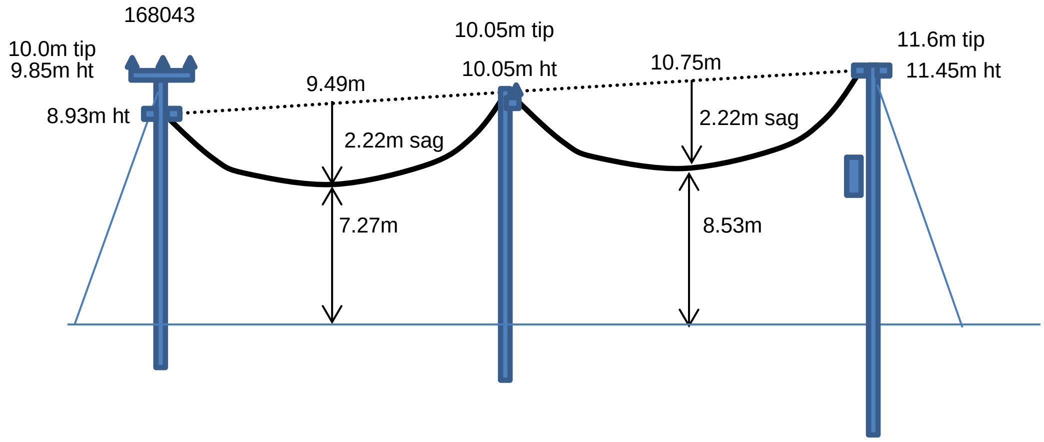
We now need to select foundations for both new poles. For the intermediate pole, consulting table 6.6.4, we note that we can match the foundation to pole strength using an 'EB' foundation of depth 2.45m. The tip of the pole will be at a height of 10.05m.

For the terminal/transformer pole, we will aim for a foundation capable of taking half the max. wind load, i.e. 0.5 x 21.33 = 10.67kN, even though the pole is stayed. We note than an EBW footing with a depth of min. sink + 300mm, i.e. 2.30m has a strength of 10.66kN, so we will nominate 2.40m sinking depth. The tip of the pole will be at a height of 11.6m. If the transformer were 100kVA or more, we would also need to install a breast log or block foundation.

We now need to design the ground stays and consult sections 7.3 and 7.4. For a 45° angle to the ground, the stay wire will need to carry 1.41 times the tip load. On the transformer pole, this will be 30.12kN, slightly less for the existing pole. This can be handled by a 19/2.00 stay wire, insulator and eye bolt. Considering section 7.4, we assess the soil as being poor, class 6. We select a 300mm single blade screw anchor, with an installation torque of 1750N.m and a strength of 60kN.

We need to check the spanning capability of the poletop constructions and consult sections 8.4.5 and 8.4.6. The DE/11/3 construction is suitable for spans up to 202m, so we are well within its capacity. The I/11/3 construction is suitable for spans up to 219m at 0° deviation, so we are well within its capacity.

We need to check that we have sufficient ground clearances and calculate these as shown below. We fist work out conductor attachment heights, then mid-span heights. As it turns out, we are well above the 6.7m minimum ground clearance.

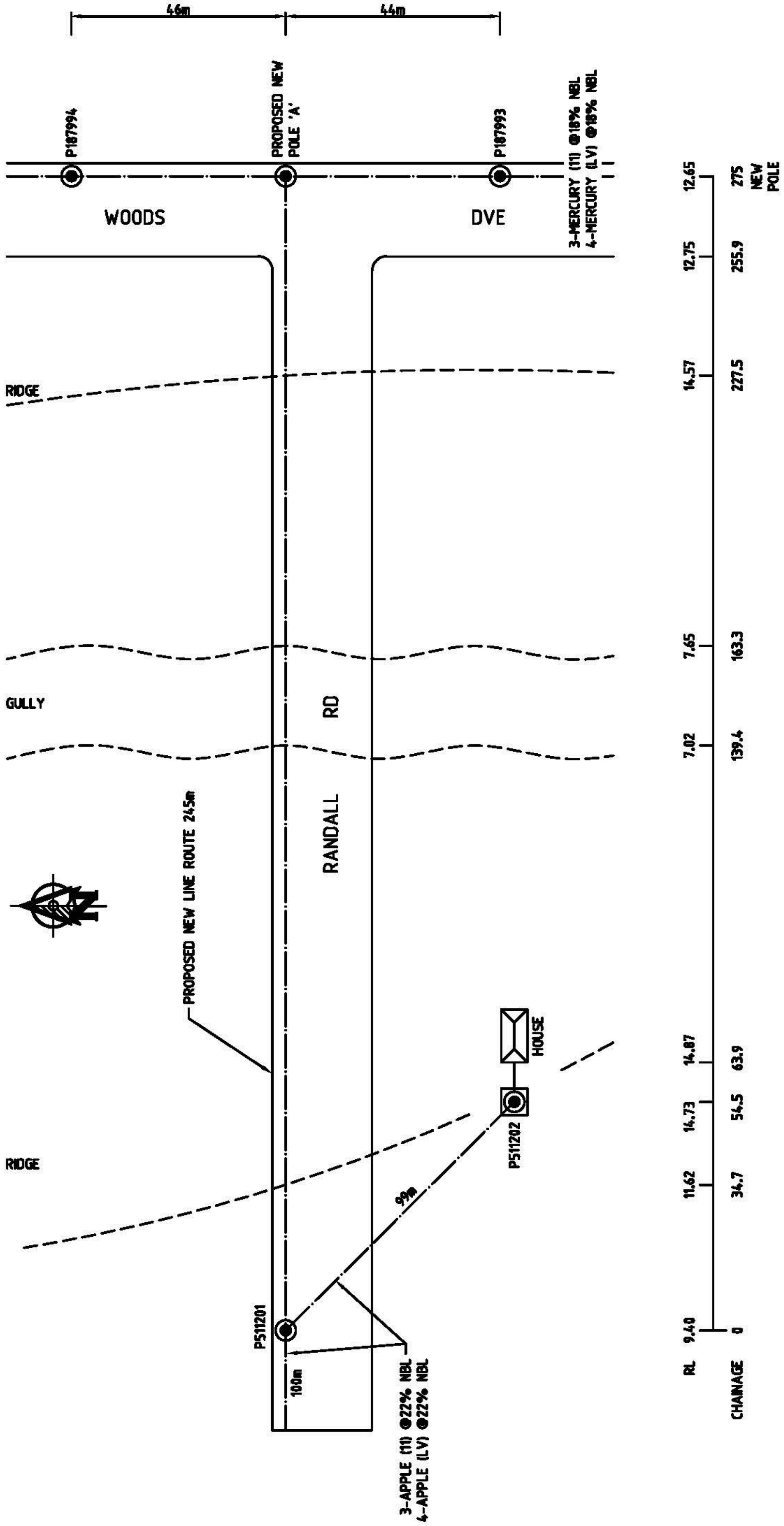


Now that we have the key elements of the design in place, we can turn our attention to some of the fittings and other issues:

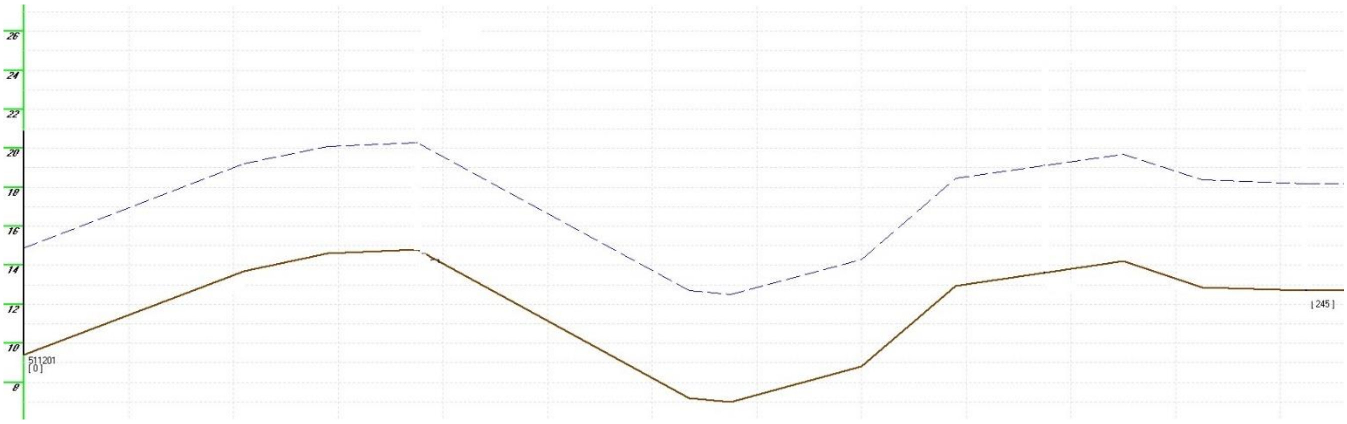
- If there are animals grazing in the paddocks, we may wish to consider fitting rails/guards to the stay wires.
- Given the tight stringing and open countryside, we need to fit vibration dampers to each end of the two new spans of 11kV mains.
- We need to nominate details of the transformer and the service to the shed. The transformer will require separate HV and LV earthing.
- We will require a wayleave or easement to be granted by the owners of Lot 4 giving their consent for the erection of the new spur line over their property and the stay on pole 168043.
- We need to nominate bridging and connection arrangements for the tee-off at P168043.

3.22.3 Example 3 – HV/LV Extension over Undulating Ground

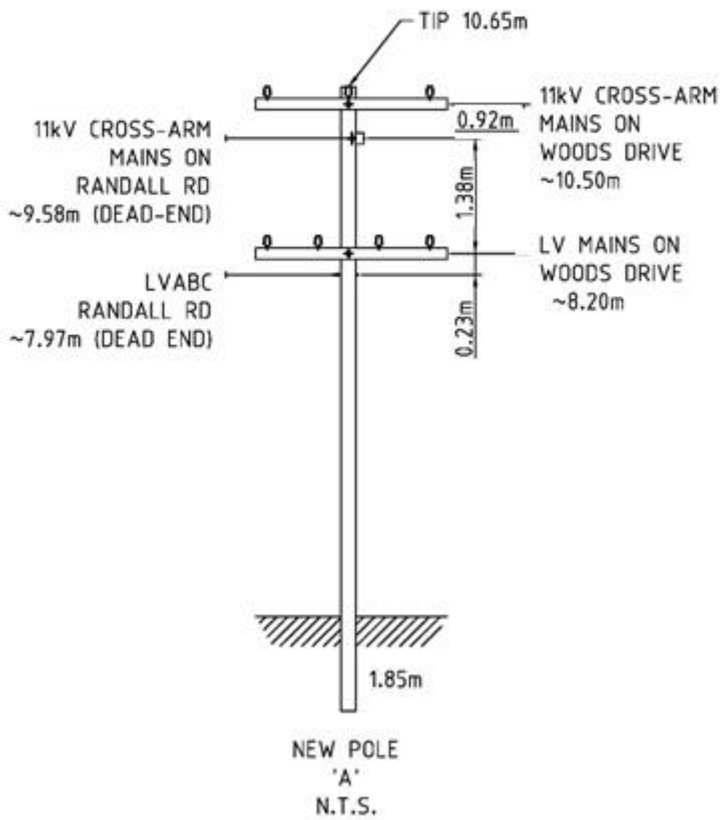
A segment of 11kV/LV line needs to be constructed along Randall Rd to tie together two existing 11kV/LV lines in nearby roads – see site sketch on next page. The planner has specified that the new 11kV mains shall be MERCURY (7/4.50 AAC) and the LV mains 4C 95mm^2 LVABC. On the western end, it is proposed to attach to Pole 511201, a 13.5m 8kN WS species 'ST' (grade S3) with 2.0m embedment depth. The top 11kV crossarm to which the line to the west attaches is at a height of 11.35m, and the LV crossarm to which the line to the west attaches is at a height of 9.05m. The pole has been inspected and found to be sound below ground. The ground is rocky. At the eastern end of the route, a new pole needs to be installed under the existing line in Woods Dve. There is a large rock retaining wall behind the new pole position and no space to install a stay of any type. The ground is undulating and measurements of chainage (starting at P511201) and RL have been made. There is no need for an 11kV switch as the feeder is being reconfigured. However, the LV open point will be at P511201.


46m
44m
P187994
PROPOSED NEW POLE 'A'
P187993
3-MERCURY (11) @18% NBL
4-MERCURY (LV) @18% NBL
WOODS
DVE
RIDGE
GULLY
RD
RANDALL
PROPOSED NEW LINE ROUTE 245m
HOUSE
P511202
99m
RIDGE
P511201
100m
3-APPLE (11) @22% NBL
4-APPLE (LV) @22% NBL
12.65
275
NEW POLE
12.75
255.9
14.57
227.5
7.65
163.3
7.02
139.4
14.87
63.9
14.73
54.5
11.62
34.7
9.40
0
RL
CHAINAGE

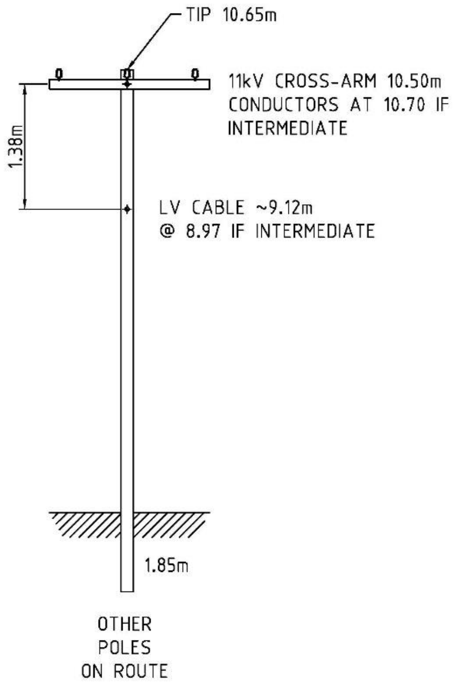
Firstly, we plot the ground profile using a suitable scale, either on graph paper or with software. The vertical scale is exaggerated relative to the horizontal scale. We add a clearance line at 5.5m above the ground line. We can show pole 511201 on the profile. We could even place marks at the attachment points for the new line at heights of 11.35m and 9.05m for the 11kV and LV respectively.



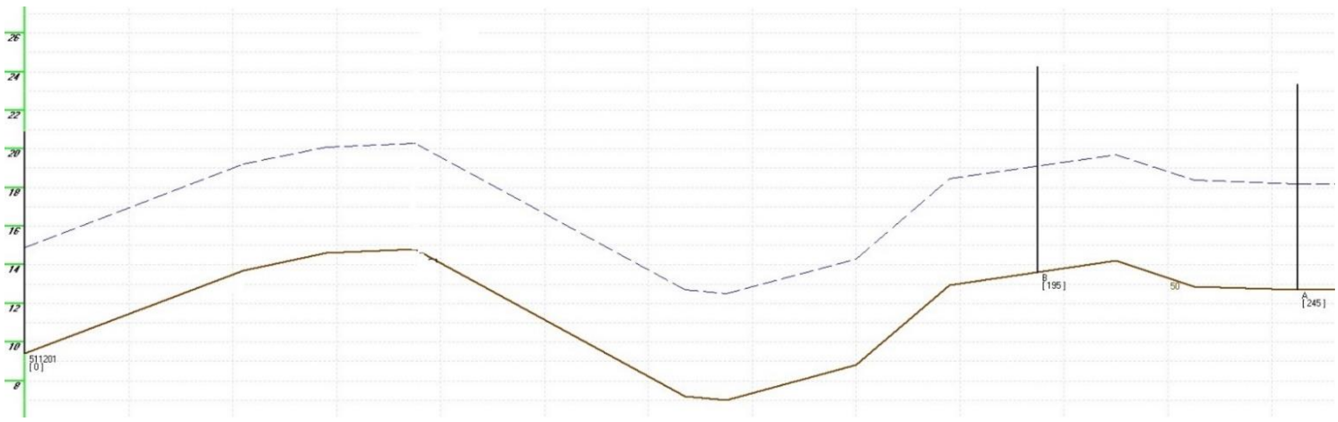
We now give some thought to the new poles we will use. At position 'A' under the existing line in Woods Dv, let us initially propose a 12.5m pole, although we may need to go up a size later if we have difficulty with heights. We will use the heaviest size available, as the pole cannot be backstayed: 8kN WS / 33kN NBL. We can use minimum sinking depth of 1.85m as the ground is rocky and know that the foundation strength will match the strength of the pole. We can sketch out the pole to show conductor attachment heights as shown below.



Other poles along the route can be 12.5m also, at least initially, also sunk 1.85m giving a tip height of 10.65m. The 11kV crossarm king bolt will be at a height of 10.5m and the LV kingbolt 1.38 below at 9.12m. For poles that are not strain poles, we can assume the 11kV mains will be 0.2m above the crossarm kingbolt, i.e. at 11.70m and the LVABC will be suspended 0.15m below the hookbolt, i.e. at 8.97m.



We now consider stringing tensions to be used for the new segments of line. The spanning capability of the line will be set by the LVABC, which can only be strung at a maximum of 10% NBL. There is no point stringing the 11kV mains any tighter than this; it would only add to the pole tip loads. This makes us consider the maximum stringing tension we can apply to the new pole at position 'A' since it cannot be backstayed. It has a maximum wind LS capacity of 20kN. We carry out some quick tip load calculations and find that if we use 10% NBL stringing on the 11k and LV mains, we will exceed this. However, 6% NBL stringing will be within the capacity of the pole provided that the span is of a moderate length. Therefore, we will need to transition from 6% NBL to 10% NBL at a pole near the eastern end of the route. For the moment, we will assume this is the first pole west of 'A', which we will call 'B'.



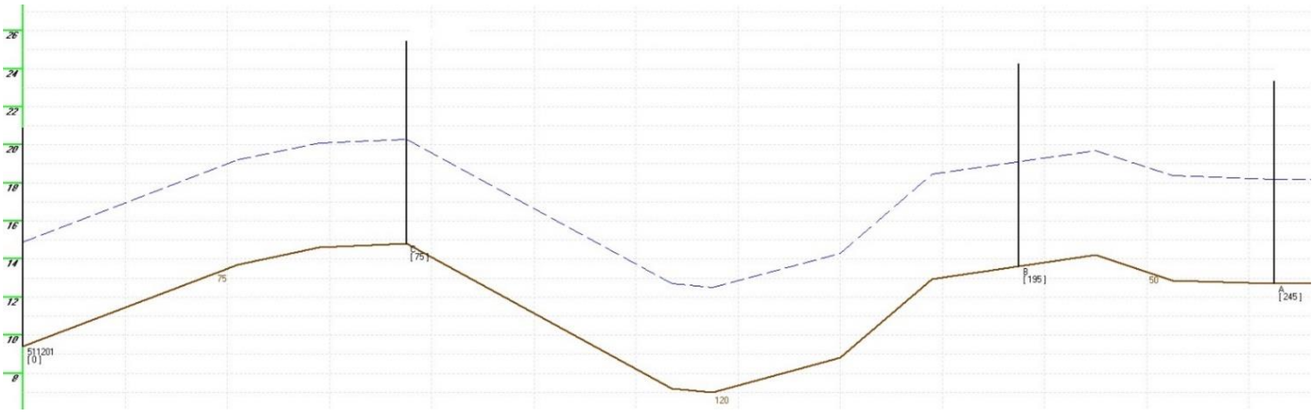
We now consider what the basic span length we could achieve over flat ground would be. Given the LVABC is at a height of about 9m, and we need to keep above 5.5m midspan, we need to keep our sag at the maximum design temperature of 75°C under about 3.5m.

Consulting section 5.9.6, the LVABC 10% NBL 100m MES stringing table, we note that a 95m span has a sag at max. design temp. 75°C of 3.56m. Consequently, if we were traversing flat ground, we would need to position our poles less than about 90m apart. However, with undulating ground, we must use shorter spans where crossing a 'hump' but can use longer spans over a gully.

For 6% NBL stringing, consulting section 5.9.3, we see that we will need to limit the pole spacing to about 70m if on flat ground. Given that there is a definite 'hump' in the ground west of 'A', let us position 'B' just 50m west of A. We nominate an 8kN WS / 33kN type as it is a strain pole, but will review this once tip loads are considered.

This leaves us with a route length of 195m remaining to P511201. This is just over double the 90m basic span for flat ground with stringing at 10%NBL, so it may mean that we need to go to two intermediate poles and three spans. However, we decide to try to use a single intermediate pole and two spans given that there is a large gully which we should be able to cross with a longer than usual span. Also, we have the option of increasing pole length if necessary. We position the intermediate pole 'C' on the crest of the ridge 75m east of P511201. We recognize that we may need to move this back to the west if we encounter problems with clearance on the 'knee points' of the ground line profile. This pole can be a light 4kN WS / 17kN type as it is a straight-line intermediate pole.

The proposed pole positions are shown on the profile below.

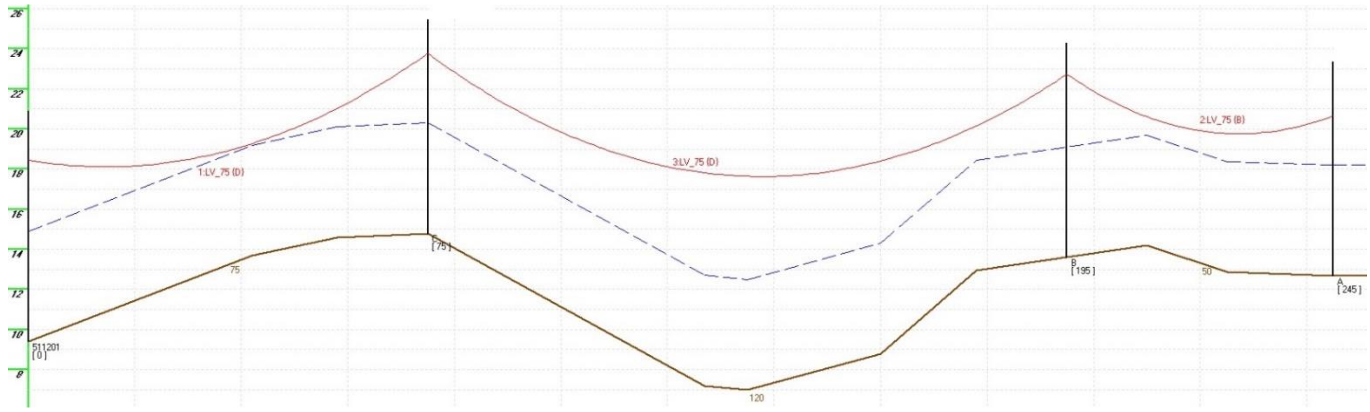


We now need to think about generating a profile for the conductors, so need to determine sags in the various spans. Before we do that, we need to calculate the MES for the two spans strung at 10% NBL.

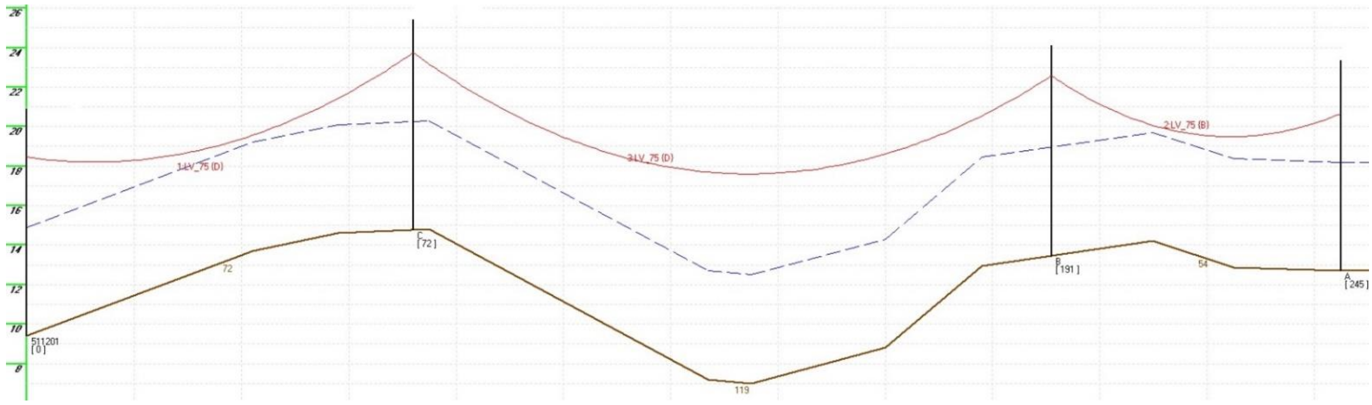
$$MES = \sqrt{[(75^3 + 120^3) / (75 + 120)]} = 105m$$

Initially, we will only consider the LVABC mains at 75°C and check ground clearances. The sag in the 75m span will be 2.18m. In the 120m span, it will be 5.59m. The sag in the 50m span strung at 6% NBL will be 1.78m.

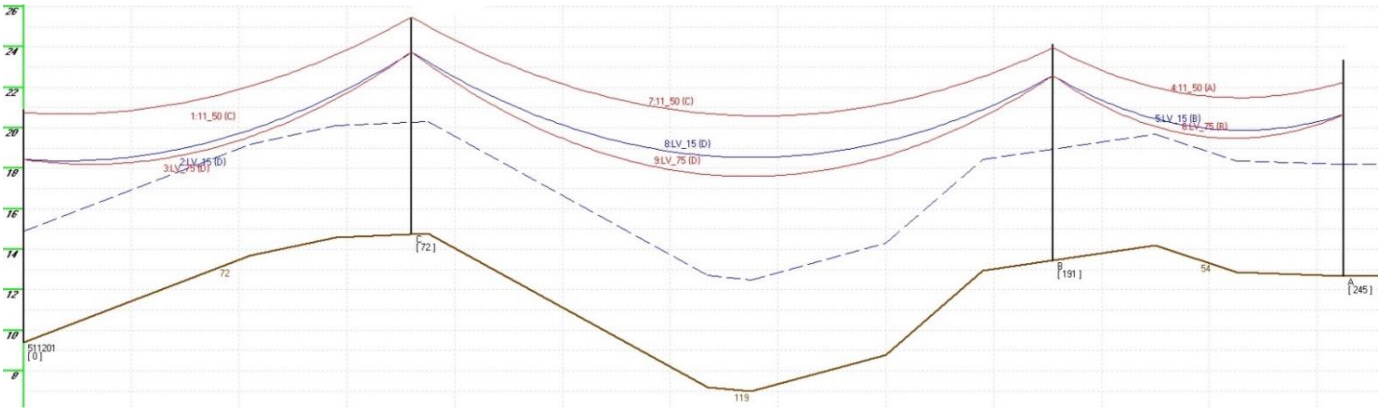
We can now generate a profile for the LVABC at the maximum design temperature.



Our design looks promising – it is clear we do not need any additional poles. However, the conductor profile is in contact with the clearance line in the span between P511201 and Pole 'C'. We will need to either increase the pole height or reduce the span length. We opt for the latter and reduce the span by 3m to 72m. We also not that we have some clearance to spare in the span at the eastern end and so move pole 'B' west by 4m to chainage 191m. Our span lengths from west to east are 72m, 119m and 54m. We recalculate the MES for section strung at 10%NBL at 104m. The 75°C sags in the three spans from west to east are then 2.02m, 5.52m and 2.01m. The profile is redrawn with the new pole positions.



This looks quite workable. The ground clearances are adequate and the spans in the segment strung at 10% NBL are not too dissimilar in length. Therefore, we can now add to the profile the 11kV mains at a maximum design temperature of 50°C and the LVABC at 15°C so that intercircuit clearance can be checked.



The profile appears to be quite satisfactory. All vertical clearances are met and there is no uplift on any of the intermediate constructions. (Strictly speaking, this needs to be checked on a profile for conductors at -5°C, but we can see that we are well clear of any problems with uplift.)

We now check section 8 and verify that all our constructions are within the allowable span/angle range. No problems are found.

We are now ready to calculate tip loads on the various poles, allowing for conductor forces and wind on the pole itself. The results for all poles are summarised in the table below along with the pole strengths for comparison. For pole 511201, we have assumed that the stay on the east side of the pole can be removed, but not the stay to the north west opposite the line extending into private property.

Pole	**Strength** (kN)		**Total Load** (kN)	
	No Wind	Max Wind	No Wind	Max Wind
A	12.0	20.0	5.62@180°	19.27
B	12.0	20.0	4.22@180°	15.90
C	6.0	10.0	0	10.02
511201	12.32	21.62	12.07@270°	12.94

For new pole 'C', the max. wind LS capacity has been exceeded slightly, so we will need to go up a size, to a 6kN WS / 25kN NBL. This has a max. wind LS capacity of 15.0kN.

For new pole 'A', the max. wind LS loading is just within capacity. If the load was much higher we would need to reduce the span length or the stringing tension. Pole 'B' has adequate capacity but could not be downsized without staying.

For P511201, we notice that the No Wind load, 12.07kN, is only just below the No Wind capacity of the pole, 12.32kN, so we decide to leave both existing stays on the pole.

Now we are at the stage of specifying connections and other fittings and auxiliary equipment, then preparing a works plan/drawing to document the design. We may wish to add fuses/links for the transitions of open wire LV mains to ABC. We also nominate vibration dampers for the long span over the gully.

SECTION 4 – CONDUCTORS AND CABLES

Version: 3.3

TasNetworks | Powering a Bright Future

SECTION 4 - CONDUCTORS AND CABLES

4.1 CONDUCTOR SELECTION

4.1.1 Factors Influencing Selection

Designers should consider various factors when selecting conductor size/type:

- Voltage at which to be used, voltage drop and current-carrying capacity (normal, emergency and fault conditions)
- Impedance – affects losses and ability of protection to detect and clear faults
- Preferred conductor sizes within TasNetworks – non-standard conductors should only be used for repairs or minor modifications to existing mains
- Terrain and local environment – affects choice in terms of:
  - spanning capacity
  - loading on existing structures
  - resistance to corrosion
  - need for insulation due to likelihood of contact by wildlife, vegetation, boat masts, structures, probability of bush fire ignition
  - matching existing mains – for single spans or adding an extra phase it is often preferable to match existing conductors.

4.1.2 Preferred Conductors for Low Voltage Mains

LVABC is preferred for all new LV mains. However, it is unsuitable for long spans or tight stringing.

95mm^2 4C	Main LV distributor for residential areas and loads in the range 60A – 200A.
95mm^2 2C	Single phase supply to loads in the range 60A – 200A.
50mm^2 4C	Shorts runs or loads under 60A
50mm^2 2C	Single phase supply for short runs or loads under 60A
150mm^2 4C	Main LV distributor for commercial/industrial areas and loads in the range 200A – 280A.
2 x 95mm^2 4C	For loads in the range 280A – 400A. Parallel at 100m intervals max.

Bare Mains may be used for matching to existing mains or where LVABC is unsuitable.

Mercury	7/4.50 AAC	Standard LV distributors
Fluorine	7/3.00 AAAC	For open-wire streetlighting circuits or longer rural spans

4.1.3 Preferred Conductors for 11kV and 22kV Mains

Bare Mains should be used unless local conditions warrant the use of HVABC.

Neptune	19/3.25 AAC	Main feeder 'trunk', or where fault levels are high
Fluorine	7/3.00 AAAC	Small spurs, rural areas with light loads and low fault levels
	3/2.75 SC/GZ	For rural areas with very light loads and low fault levels where very long spans are required. Do not use in coastal areas prone to corrosion.

HVABC is significantly more expensive than bare mains construction. Therefore, it should only be used where good reason exists, such as where:

- reduced vegetation profiles are required
- there is a significant risk of tree branches or wind-blown debris contacting the mains
- wildlife is likely to initiate faults
- there is a significant risk of mains being contacted by cranes, jibs, boat masts, hang gliders or paragliders
- mains are in close proximity to structures.

HVABC would be unsuitable:

- for long spans (>120m, say)—not suitable for tight stringing
- where existing poles have limited capacity – wind and wind loading is greater than for bare conductors and may cause excessive loading on structures
- for railway crossings.

$35mm^2$	Small spurs, rural areas with light loads and low fault levels
$185mm^2$	Main feeder 'trunk', or where fault levels are high

TasNetworks has discontinued erecting NMS (Non-Metallic Screened) HVABC due to problems that have been encountered in some locations as the cable has aged. MS (Metallic-Screened) HVABC should now be used.

4.2 ELECTRICAL PROPERTIES AND RATINGS

4.2.1 Bare Mains – Metric Sizes

Material	Conductor Name	Strands No./Dia.(mm)	CSA (mm^2)	Equiv. CSA Pure Alum. (mm^2)	DC Resistance @20ºC (Ω/km)	AC Resistance @50ºC (Ω/km)	Nom. Reactance @50Hz (Ω/km)	Current Rating (A)												Fault Rating 1s (kA)
								50ºC Conductor Design Temp.						60ºC Conductor Design Temp.[5]						
								Summer		Winter Normal		Winter Emergency		Summer		Winter Normal		Winter Emergency		
								Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	
AAC (1350)	LEO	7/2.50	34.36	34.0	0.833	0.916	0.377	124	154	206	216	242	250	163	185	229	238	268	275	2.9
	LIBRA	7/3.00	49.48	48.9	0.579	0.634	0.366	153	193	258	272	303	314	202	234	288	300	336	346	4.2
	MARS	7/3.75	77.31	76.4	0.370	0.406	0.351	196	257	342	362	400	417	264	311	381	399	445	460	6.6
	MERCURY	7/4.50	111.30	110.0	0.258	0.282	0.340	239	324	428	454	500	524	327	391	478	501	557	577	9.5
	NEPTUNE	19/3.25	157.60	155.0	0.183	0.201	0.326	289	405	532	568	622	653	402	490	595	627	693	720	13.5
AAAC (1120)	FLUORINE	7/3.00	49.48	42.1	0.601	0.660	0.360	150	190	255	268	298	310	199	230	284	295	331	341	4.2
ACSR/GZ	ALMOND	6/1/2.50	34.36	29.0	.975	1.142	0.378	115	142	191	200	223	231	150	171	212	220	248	254	2.8
	APPLE	6/1/3.00	49.48	41.8	0.677	0.809	0.367	141	179	239	251	280	291	187	216	266	277	311	320	4.0
	BANANA	6/1/3.75	77.31	65.2	0.433	0.540	0.353	181	238	316	334	370	386	244	287	353	368	411	425	6.2
	CHERRY	6/4.75+7/1.60	120.40	105.0	0.271	0.362	0.338	235	321	423	451	495	519	323	388	473	497	551	572	9.7
	RAISIN	3/4/2.50	34.36	17.9	1.59	1.810	0.345	90	112	150	157	176	182	118	135	167	173	195	200	2.1
SC/GZ	1.31GPa min.	3/2.75	17.82	2.6	11.0	12.5	0.700	33	40	53	56	63	65	42	48	59	61	69	71	1.1
HDC (Hard Drawn Copper)		7/1.25	8.59	13.6	2.090	2.289	0.421	70	81	110	114	130	133	89	98	122	126	143	146	1.3
		7/1.75	16.84	26.6	1.060	1.158	0.399	104	124	168	175	197	203	134	150	187	193	218	223	2.4
		7/2.00	21.99	34.7	0.815	0.892	0.391	122	147	198	206	232	239	158	177	220	227	257	264	3.2
		19/1.75	45.70	71.7	0.395	0.433	0.365	184	233	312	327	365	379	244	282	347	361	406	417	6.7
		19/2.00	59.69	93.7	0.303	0.332	0.356	214	276	368	388	431	448	286	333	410	428	478	493	8.8
		19/2.75	112.90	177.0	0.160	0.176	0.330	305	415	547	582	640	670	419	501	612	642	713	739	16.6

Notes:

1. Conductors other than current preferred sizes are included for reference purposes.
2. Current ratings are based on:
   - a wind speed normal to the conductor of 1.0m/s (3.6km/h) for normal conditions and 2.0m/s (7.2km/h) for emergency conditions
   - 30ºC ambient for summer and 10ºC ambient for winter
   - daytime solar intensity of 1000W/m^2 summer, 500W/m^2 winter, albedo (ground reflectance) coefficient of 0.2
   - bare conductor emissivity of 0.85, solar absorption coefficient of 0.85.
3. Fault ratings assume a starting temperature of 50ºC and final temperature of 160ºC for AAC, AAAC and ACSR, 200ºC for HDC, 400ºC for SC/GZ. On feeders with auto-reclosing, some derating may be appropriate.
4. Precise reactance values depend on conductor configuration and phase separation.
5. 50ºC ratings are for standard line designs. 60ºC ratings are provided for information only or for special cases where lines are re-rated.

4.2.2 Bare Mains – Imperial Sizes

Material	Conductor Name	Strands (No./Dia.)		CSA (mm^2)	Equiv. CSA Pure Alum. (mm^2)	DC Resistance @20ºC (Ω/km)	AC Resistance @50ºC (Ω/km)	Nom. Reactance @50Hz (Ω/km)	Current Rating (A)												Fault Rating 1s (kA)
									50ºC Conductor Design Temp.						60ºC Conductor Design Temp.[6]						
									Summer		Winter Normal		Winter Emergency		Summer		Winter Normal		Winter Emergency		
		Metric (mm)	Imperial (in)						Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	
AAC (1350)	LOCUST[5]	7/2.36	7/.093	30.71	30.32	0.938	1.023	0.394	116	142	192	200	225	232	151	172	213	221	249	255	2.6
	GRUB	7/3.00	7/.118	49.42	48.84	0.582	0.636	0.378	154	195	260	274	305	316	204	235	290	302	339	349	4.2
	FLY	7/3.40	7/.134	63.88	62.97	0.452	0.529	0.371	176	227	302	319	354	368	235	274	337	351	393	405	5.5
	WASP	7/4.39	7/.173	106.19	105.32	0.271	0.307	0.355	233	314	415	441	486	509	319	380	464	487	541	560	9.1
	HORNET	19/3.25	19/.128	157.74	155.35	0.183	0.202	0.339	289	405	532	568	622	653	402	490	595	627	693	720	13.5
ACSR/GZ	GOPHER	6/1/2.36	6/1/.093	30.64	25.93	1.089	1.306	0.395	107	132	178	186	208	215	140	159	198	205	231	237	2.5
	FERRET	6/1/3.00	6/1/.118	49.35	41.80	0.676	0.808	0.380	141	179	239	251	280	291	187	216	266	277	311	320	4.0
	MINK	6/1/3.66	6/1/.144	73.54	62.25	0.454	0.570	0.367	177	231	307	324	359	374	237	279	342	357	399	412	5.9
	DOG	6/4.72+7/1.57	6/.186+7/.062	118.70	103.80	0.272	0.356	0.351	234	319	421	448	493	516	321	386	471	494	548	569	9.5
	IBIS	26/3.14+7/2.44	26/.1236+7/.0961	234.07	203.10	0.144	0.177	0.241	321	476	619	667	727	768	461	576	695	737	812	848	21.5
SC/GZ	85/95 TON	3/2.64	3/.104	16.45	2.4	10.32	13.5	0.669	34	40	54	56	64	65	43	48	60	62	70	72	1.1
HDC (Hard Drawn Copper)		7/1.22	7/.048	8.07	12.75	2.188	2.396	0.435	69	79	108	111	127	130	87	95	120	123	140	143	1.2
		7/1.63	7/.064	14.52	22.93	1.231	1.345	0.417	91	107	145	151	170	175	117	129	161	166	189	193	2.1
		7/2.03	7/.080	22.71	35.86	0.787	0.858	0.403	123	149	201	210	236	243	160	180	224	231	261	268	3.3
		7/2.46	7/.097	32.26	50.96	0.535	0.586	0.391	155	191	257	269	301	312	203	231	286	297	334	343	4.7
		19/1.63	19/.064	38.39	60.62	0.446	0.498	0.382	169	211	283	297	332	344	223	255	315	327	368	379	5.6
		19/2.11	19/.083	66.32	104.72	0.270	0.296	0.366	226	294	391	413	458	476	304	355	436	455	509	525	9.8
		19/2.57	19/.101	98.19	155.00	0.182	0.200	0.354	281	377	498	529	583	610	383	456	557	584	649	672	14.4

Notes:

1. Conductors other than current preferred sizes are included for reference purposes.
2. Current ratings are based on:
   - a wind speed normal to the conductor of 1.0m/s (3.6km/h) for normal conditions and 2.0m/s (7.2km/h) for emergency conditions.
   - 30ºC ambient for summer and 10ºC ambient for winter
   - daytime solar intensity of 1000W/m^2, 500W/m^2 winter, albedo (ground reflectance) coefficient of 0.2
   - bare conductor emissivity of 0.85, solar absorption coefficient of 0.85.
3. Fault ratings assume a starting temperature of 50ºC and final temperature of 160ºC for AAC, AAAC and ACSR, 200ºC for HDC, 400ºC for SC/GZ. On feeders with auto-reclosing, some derating may be appropriate.
4. Precise reactance values depend on conductor configuration and phase separation.
5. The conductor designation 'Locust' is sometimes also used to refer to the AAC size 19/.211", i.e. 19/5.36.
6. 50ºC ratings are for standard line designs. 60ºC ratings are provided for information only or for special cases where lines are re-rated.

4.2.3 LVABC Mains

No. of Cores	CSA of Cores (mm^2)	AC Resistance @75ºC (Ω/km)	Reactance @50Hz (Ω/km)	Current Rating (A)				Fault Rating (kA)	
				Continuous 75ºC Conductor		Emergency 100ºC Conductor			
				Summer	Winter	Summer	Winter	1s	3s
2	**50**	0.796	0.0842	205	260	265	300	5.060	2.920
4	**50**	0.796	0.0915	155	195	200	230	5.060	2.920
2	**95**	0.398	0.0783	295	365	350	435	9.620	5.555
4	**95**	0.398	0.0853	235	300	310	355	9.620	5.555
4	**150**	0.257	0.0821	295	430			15.190	8.770

Notes:

1. The CONTINUOUS current rating is to be used for design purposes. The EMERGENCY current rating is to be used for short-term application (8 hours) such as paralleling of LV circuits during switching.
2. Current ratings assume a wind speed normal to the conductor of 1m/s (3.6km/h), solar intensity of 1000W/m^2, summer ambient temperature of 30ºC, winter ambient temperature of 10ºC, solar absorption coefficient of 0.9 and emissivity coefficient of 0.95.
3. The fault current rating is based on an initial temperature of 75ºC and a maximum temperature of 210ºC, the maximum that can be sustained for the nominated time without causing permanent damage.

4.2.4 HVABC Mains

Type	CSA of Cores (mm^2)	Voltage (kV)	Core DC Resistance @20ºC (Ω/km)	Core AC Resistance @90ºC (Ω/km)	Core Inductive Reactance @50Hz (Ω/km)	Catenary DC Resistance @20ºC (Ω/km)	Current Rating (A)				Fault Rating (kA)
							Summer		Winter		
							Day	Night	Day	Night	1s
NMS Non-metallic Screened	**50**	6.35/11	0.641	0.822	0.149	0.239	160			210	4.7
	35	12.7/22	0.868	1.11	0.164	0.239	150	175	185	205	3.3
	150	6.35/11	0.206	0.265	0.125	0.163	370			430	14.2
	185	12.7/22	0.164	0.211	0.127	0.163	395	465	490	550	17.5
MS Metallic Screened (Heavy Duty Screen)	**35**	6.35/11	0.868	1.11	0.157	3.2	135			184	3.4
	35	12.7/22	0.868	1.11	0.165	3.2	135			184	3.4
	185	6.35/11	0.164	0.211	0.119	3.2	354			491	8.1
	185	12.7/22	0.164	0.211	0.125	3.2	354			491	8.1

Notes:

1. All cables are 3-core with catenary. Cables other than current preferred sizes are included for reference purposes.
2. Current ratings assume a wind speed normal to the conductor of 0.5m/s (1.8km/h), solar intensity of 1000W/m^2, summer ambient temperature of 30ºC, winter ambient temperature of 10ºC, solar absorption coefficient of 0.9 and emissivity coefficient of 0.95. For HVABC, the rating is based on a core temperature of 90ºC and catenary temperature of 50ºC.
3. The fault current rating is based on an initial temperature of 90ºC and a maximum temperature of 250ºC, the maximum that can be sustained for the nominated time without causing permanent damage.

4.2.5 Service Cables

Type	No. of Cores	CSA of Cores (mm^2)	Strands (No./Dia.)		Continuous Current Rating (A)	Volt Drop (mV/A.m)		Service for Max. Size of V75 Unenclosed Consumer Mains
			Metric (mm)	Imperial (in)		1 Ph	3 Ph	
Aluminium XLPE	**2**	**25**			125	2.89		
	3	**25**			105	2.59		
	4	**25**			105	2.59	2.31	
HDC V75 Insulated 0.6/1kV	**1**	**10**	7/.135		85	4.42		
	2	**10**	7/.135		80	4.42		
	3	**10**	7/.135		60	4.42		
	4	**10**	7/.135		60	4.42	3.83	
	1	**16**	7/1.70		110	2.83		
	2	**16**	7/1.70		110	2.83		16
	3	**16**	7/1.70		100	2.83		35
	4	**16**	7/1.70		100	2.83	2.45	34
	1	**25**	19/1.35		150	1.74	1.5	70
	1	**50**	19/1.78		210	1.12	0.97	120
	1	**70**	19/2.14		265	0.89	0.77	185
	1	**6.8**	7/1.12	7/.044	65			
	2	**6.8**	7/1.12	7/.044	65			
	3	**6.8**	7/1.12	7/.044	55			
	4	**6.8**	7/1.12	7/.044	55			
	1	**14.5**	7/1.63	7/.064	100			
	2	**14.5**	7/1.63	7/.064	100			
	3	**14.5**	7/1.63	7/.064	100			
	4	**14.5**	7/1.63	7/.064	100			
	1	**22.7**	7/2.03	7/.080	135			
	1	**38.4**	19/1.63	19/.064	180			
	1	**66.3**	19/2.11	19/.083	250			

Notes:
1. Cables other than current preferred sizes are included for reference purposes.
2. Current ratings assume a wind speed normal to the conductor of 0.5m/s (1.8km/h), ambient temperature of 40ºC and a conductor temperature of 75ºC.

4.3 MECHANICAL PROPERTIES

4.3.1 Bare Mains – Metric Sizes

Material	Conductor Name	Stock Code	Strands No./Dia. (mm)	CSA (mm^2)	Nom. Diameter (mm)	Nom. Breaking Load (kN)	Mass (kg/m)	Modulus of Elasticity (GPa)	Linear Expansion Coefficient (/ºC x 10^{-6})
AAC (1350)	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	77.31	11.25	11.80	0.211	59	23
	MERCURY	10.16.15	7/4.50	111.30	13.50	16.90	0.304	56	23
	NEPTUNE	10.16.21	19/3.25	157.60	16.25	24.70	0.433	56	23
AAAC (1120)	FLUORINE	10.16.10	7/3.00	49.48	9.00	11.80	0.135	56	23
ACSR/GZ	ALMOND		6/1/2.50	34.36	7.50	10.50	0.119	79	19.3
	APPLE		6/1/3.00	49.50	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
	RAISIN		3/4/2.50	34.36	7.50	24.40	0.195	136	13.9
SC/GZ	1.31GPa min.	43.89.12	3/2.75	17.82	5.93	22.20	0.140	193	11.5
	Stay Wire	43.89.20	19/2.00	59.70	10.0	70.5	0.473	184	11.5
HDC (Hard Drawn Copper)			7/1.25	8.589	3.75	3.59	0.0769	124	17
			7/1.75	16.84	5.25	6.89	0.151	124	17
			7/2.00	21.99	6.00	8.89	0.197	124	17
			19/1.75	45.70	8.75	18.30	0.413	124	17
			19/2.00	59.70	10.00	23.60	0.538	124	17
			19/2.75	112.90	13.80	43.10	1.020	124	17

Notes:

1. Conductors other than current preferred sizes are included for reference purposes.
2. Conductor data is generally in accordance with Australian Standards. Note that product from various manufacturers may differ slightly from the above data.

4.3.2 Bare Mains – Imperial Sizes

Material	Conductor Name	Stock Code	Strands (No./Dia.) Metric (mm)	Strands (No./Dia.) Imperial (in)	CSA (mm^2)	Nom. Diameter (mm)	Nom. Breaking Load (kN)	Mass (kg/m)	Modulus of Elasticity (GPa)	Linear Expansion Coefficient (/ºC x 10^{-6})
AAC (1350)	LOCUST[3]		7/2.36	7/.093	30.71	7.08	5.38	0.0833	59	23
	GRUB		7/3.00	7/.118	49.42	8.99	8.23	0.1350	59	23
	FLY		7/3.40	7/.134	63.88	10.21	10.32	0.1741	59	23
	WASP		7/4.39	7/.173	106.19	13.18	16.46	0.2902	56	23
	HORNET		19/3.25	19/.128	157.74	16.26	25.27	0.4331	56	23
ACSR/GZ	GOPHER		6/1/2.36	6/1/.093	30.64	7.08	9.36	0.1061	79	19.3
	FERRET		6/1/3.00	6/1/.118	49.35	8.99	14.70	0.1711	79	19.3
	MINK		6/1/3.66	6/1/.144	73.54	10.97	26.62	0.2545	79	19.3
	DOG		6/4.72+7/1.57	6/.186+7/.062	118.70	14.17	32.47	0.3959	76	19.9
	IBIS		26/3.14+7/2.44	26/.1236+7/.0961	234.07	19.88	72.05	0.8135	75	19.5
SC/GZ	85/95 TON		3/2.64	3/.104	16.45	5.69	21.80	0.1295	193	11.5
HDC (Hard Drawn Copper)			7/1.22	7/.048	8.07	3.66	3.44	0.0731	124	17
			7/1.63	7/.064	14.52	4.88	6.10	0.1295	124	17
			7/2.03	7/.080	22.71	6.10	9.45	0.2024	124	17
			7/2.46	7/.097	32.26	7.39	13.75	0.2986	124	17
			19/1.63	19/.064	38.39	7.92	15.76	0.3438	124	17
			19/2.11	19/.083	66.32	10.54	26.92	0.5953	124	17
			19/2.57	19/.101	98.19	12.83	39.55	0.8810	124	17

Notes:

1. Conductors other than current preferred sizes are included for reference purposes.
2. Conductor data is generally in accordance with Australian Standards. Note that product from various manufacturers may differ slightly from the above data.
3. The conductor designation 'Locust' is sometimes also used to refer to the AAC size 19/.211", i.e. 19/5.36.

4.3.3 LVABC Mains

No. of Cores	CSA of Cores (mm²)	Stock Code	Nom. Conductor Diameter (mm)	Nom. Core Diameter Over Insulation (mm)	Nom. Overall Cable Diameter (mm)	Nom. Breaking Load (kN)	Mass (kg/m)	Modulus of Elasticity (GPa)	Linear Expansion Coefficient (/ºC x 10⁻⁶)	Min. Bending Radius (installed) (mm)	
										Core	Cable
2	**50**	10.30.04	8.1	11.2	23.8	14.0	0.350	59	23	70	145
4	**50**	10.30.02	8.1	11.2	28.7	28.0	0.700	59	23	70	160
2	**95**	10.30.03	11.4	14.9	31.8	26.6	0.680	56	23	95	285
4	**95**	10.30.01	11.4	14.9	38.4	53.2	1.350	56	23	95	285
4	**150**	10.30.08	14.2	17.7	45.6	84.0	2.020	56	23	115	460

Notes:

1. Note that product from various manufacturers may differ slightly from the above data.

4.3.4 HVABC Mains

Type	CSA of Cores (mm²)	Voltage	Stock Code	Nom. Conductor Diameter (mm)	Nom. Core Diameter (mm)	Nom. Overall Cable Diameter[3] (mm)	Nom. Catenary Diameter (mm)	Catenary Material	Catenary CSA (mm²)	Catenary Stranding No./Dia. (mm)	Nom. Breaking Load Catenary (kN)	Overall Cable Mass (kg/m)	Modulus of Elasticity Catenary (GPa)	Linear Expansion Coefficient Catenary (/ºC x 10⁻⁶)	Min. Bending Radius (installed) (mm)	
															Core	Cable
NMS Non-metallic Screened	**50**	6.35/11		8.1	19	51.9	14.3	AAAC	124	7/4.75	27.1	1.41	59	23	285	795
	35	12.7/22	10.30.50	6.9	23	58.3	14.3	AAAC	124	7/4.75	27.1	1.63	59	23	345	885
	150	6.35/11		14.2	26	67.4	17.5	AAAC	182	19/3.50	41.7	2.68	56	23	390	1035
	185	12.7/22	10.30.51	15.7	32	80.0	17.5	AAAC	182	19/3.50	41.7	3.64	56	23	480	1230
NMS Non-metallic Screened **with 1.2mm HDPE Outer Sheath**	**50**	6.35/11		8.1	19	54.6	14.3	AAAC	124	7/4.75	27.1	1.53	59	23	300	550
	35	12.7/22	14.91.11	6.9	23	61.0	14.3	AAAC	124	7/4.75	27.1	1.78	59	23	350	610
	150	6.35/11		14.2	26	70.1	17.5	AAAC	182	19/3.50	41.7	2.84	56	23	390	700
	185	12.7/22	14.91.12	15.7	32	81.7	17.5	AAAC	182	19/3.50	41.7	3.76	56	23	480	820
MS Metallic Screened **(Heavy Duty Screen)**	**35**	6.35/11		6.9	23.5	57.1 (52.1)	10.0	SC/GZ	59.7	19/2.00	70.5	2.31	166	11.5	350	570
	35	12.7/22		6.9	27.8	65.7 (60.7)	10.0	SC/GZ	59.7	19/2.00	70.5	2.76	166	11.5	420	660
	185	6.35/11		15.7	33.5	77.0 (72.0)	10.0	SC/GZ	59.7	19/2.00	70.5	4.96	166	11.5	500	770
	185	12.7/22		15.7	38.2	86.4 (81.4)	10.0	SC/GZ	59.7	19/2.00	70.5	5.64	166	11.5	570	860

Notes:

1. All cables are 3-core with catenary. Cables other than current preferred sizes are included for reference purposes.
2. Note that product from various manufacturers may differ slightly from the above data.
3. Overall cable diameter figures shown in parentheses are projected diameter for wind loading.
4. NMSHVABC catenary 7/4.75 sometimes shown as 7/5.00 and 19/3.50 as 19/3.65.

4.3.5 Service Cables

Type	No. of Cores	CSA of Cores (mm^2)	Strands (No./Dia.)		Stock Code	Nom. Conductor Diameter (mm)	Nom. Core Diameter Over Insulation (mm)	Nom. Overall Dimensions (mm)	Mass (kg/m)
			Metric (mm)	Imperial (in)					
Aluminium XLPE	**2**	**25**			10.30.05	5.9	8.6	17.2	0.190
	3	**25**			10.30.06	5.9	8.6	18.5	0.290
	4	**25**			10.30.07	5.9	8.6	20.8	0.390
HDC PVC V75 Insulated 0.6/1kV	**1**	**10**	7/.135			4.1	6.2	6.2	0.118
	2	**10**	7/.135			4.1	6.2	6.2 x 13.0	0.236
	3	**10**	7/.135			4.1	6.2	14	0.354
	4	**10**	7/.135			5.1	6.2	15.6	0.472
	1	**16**	7/1.70			5.1	7.2	7.2	0.180
	2	**16**	7/1.70			5.1	7.2	7.2 x 15.1	0.360
	3	**16**	7/1.70			5.1	7.2	18	0.540
	4	**16**	7/1.70			5.1	7.2	18	0.720
	1	**25**	19/1.35			6.8	9.3	9.3	0.300
	1	**50**	19/1.78			8.9	11.9	11.9	0.511
	1	**70**	19/2.14			10.7	13.7	13.7	0.722
	1	**6.8**	7/1.12	**7/.044**		3.4	6	6	0.084
	2	**6.8**	7/1.12	**7/.044**		3.4	6	6 x 12.5	0.168
	3	**6.8**	7/1.12	**7/.044**		3.4	6	12.5	0.252
	4	**6.8**	7/1.12	**7/.044**		3.4	6	14	0.336
	1	**14.5**	7/1.63	**7/.064**		4.9	7.5	7.5	0.168
	2	**14.5**	7/1.63	**7/.064**		4.9	7.5	7.5 x 15	0.336
	3	**14.5**	7/1.63	**7/.064**		4.9	7.5	16	0.505
	4	**14.5**	7/1.63	**7/.064**		4.9	7.5	18	0.670
	1	**22.7**	7/2.03	**7/.080**		6.1	9	9	0.247
	1	**38.4**	19/1.63	**19/.064**		8.2	11.5	11.5	0.427
	1	**66.3**	19/2.11	**19/.083**		10.6	14.5	14.5	0.668

Notes:

1. Cables other than current preferred sizes are included for reference purposes.

4.3.6 Communications and Other Cables

Type	Name/Code	Stock Code	Catenary/ Cable CSA (mm²)	Catenary Diameter (mm)	Core Diameter (mm)	Nom. Overall Diameter (mm)	Nom. Breaking Load (kN)	Mass (kg/m)	Modulus of Elasticity (GPa)	Linear Expansion Coefficient (/ºC x 10^{-6})
Pilot Cable	20 Pair + 7/1.75SC/GZ		21.99	5.29		42.0	26.0	1.31	193	11.5
	10 Pair + 3/2.75SC/GZ		17.82	5.93		~32	22.2	~0.839	193	11.5
	10 Pair + 7/2.75SC/GZ		41.58	8.25		~35	50.1	~0.977	193	11.5
ADSS (Fibre Optic Cable)	ADSS 72SM		124			12.5	28.0	0.12	13	7.2
	ADSS 312		247.6			22.0	22.0	0.365	7.8	19.2
NBN Cable	RPX 144F ribbon		114.9			15.2	8.6	0.095	3.8	6.2
	SST 12F		31.5			8.1	4.0	0.031	6.6	6.2
	ROC 1F drop		12.4			5.4	3.0	0.0148	10.3	6.2
Telephone (PSTN) Cable	10 Pair		5.94	2.75		14.89	7.39	0.134	193	11.5
	30 Pair		8.59	3.31		25.95	10.69	0.435	193	11.5

Notes:

1. Cables other than current preferred sizes are included for reference purposes.
2. Note that product from various manufacturers may differ slightly from the above data.

4.4 ENGINEERING NOTES

4.4.1 Conductor/Cable Designations

Conductors may be referred to in various ways:

- Code names which indicate conductor material, size, and stranding. For example, MERCURY represents an aluminium conductor with 7 x 4.50mm dia. strands, or APPLE, which refers to a conductor with 6 x 3.00mm dia. aluminium strands and 1 x 3.00mm dia. galvanized steel reinforcing strand. These codes provide a very concise way of designating conductors. Different families of codes indicate the general class of conductor, such as celestial names for metric AAC, fruit names for metric ACSR, animal names for imperial ACSR (e.g. DOG), chemical elements for AAAC alloy 1120 (e.g. FLUORINE).
- Stranding and material, e.g. 7/4.50 AAC for MERCURY indicates 7 strands, each of 4.50mm diameter. APPLE may be described as 6/1/3.00 ACSR/GZ. For imperial sizes, strand diameter may be expressed in inches (e.g. 7/.104 HDC, which is equivalent to 7/2.64), or even as a wire gauge (7/12 HDC).
- Nominal cross-sectional area, particularly for insulated cables, e.g. LVABC95, HVABC35. The numbers pertain to square millimetres for metric sizes.

4.4.2 Conductor Materials

<u>Copper Conductors</u>

In the early days of electrification, hard drawn copper (HDC) conductors were used widely. Although copper has excellent conductivity, it is expensive and very heavy. Thus, the forces exerted upon supporting structures are high.

Many older light-gauge copper lines now suffer from corrosion, low current-carrying capacity, and low fault current capacity.

<u>Aluminium Conductors</u>

On a weight-for-weight basis, aluminium is more than twice as conductive as copper. Aluminium conductors are also less expensive than copper conductors of equivalent capacity. All Aluminium Conductor (AAC) is used for most bare distribution mains within TasNetworks. The metal used is known as alloy 1350, which is 99.6% pure aluminium.

Some All Aluminium Alloy Conductor (AAAC) is used within TasNetworks, generally alloy 1120. This has greater strength than AAC and is suitable for tight stringing on long spans. However, the conductivity of AAAC is slightly inferior to AAC. AAAC can provide a useful alternative to ACSR for rural lines in coastal areas where corrosion due to salt pollution is a problem.

Aluminium has good resistance to corrosion in most environments, except in the vicinity of alkaline industrial pollution. Also, it is important that aluminium is kept clear of copper or copper salts/residue. When connecting copper to aluminium, bi-metal clamps are required. When replacing copper conductors with aluminium, it is usual practice to replace insulators.

Although aluminium oxidizes in a way that is self-passivating and prevents further corrosion, the oxide layer forms extremely rapidly and is not readily visible. When making an electrical connection, it is essential that the conductor be scratch-brushed first and immediately dipped in jointing compound; otherwise the connection will have high impedance and may burn out under fault current conditions.

Aluminium conductors can suffer from annealing when subjected to excessive heat, e.g. due to overloading or fires. Annealing weakens the conductor irreparably and causes excessive sag.

Since aluminium is a comparatively soft material, it can easily be abraded at the support points when subjected to aeolian (wind-induced) vibration. Therefore, armour rods are fitted to medium tension and full tension aluminium conductors at all intermediate structures.

Steel Conductors

Although a very strong material, steel has poor conductivity compared with copper and aluminium and is also quite heavy. Thus, nowadays steel conductor is only used within TasNetworks on rural HV lines with very low load currents.

Steel conductor is prone to corrosion in polluted or coastal environments as the zinc galvanizing layer is eventually consumed.

ACSR Conductors

These conductors have properties that lie between those of aluminium and those of steel, and therefore have moderate conductivity and moderate strength, with properties varying according to the steel/aluminium ratio. They are suited to rural areas where span lengths are long and electrical loading is light. Since the steel is susceptible to corrosion, particularly in coastal areas, TasNetworks now uses AAAC rather than ACSR.

4.4.3 Aerial Bundled Cable

ABC (Aerial Bundled Cable) is now widely used to improve network reliability due to its resistance to outages caused by vegetation or wildlife. It also offers improved safety in special situations, such as near boat ramps, loading docks, hang glider launch sites or in narrow easements. It can be used where reduced tree-trimming profiles are required.

Due to the additional weight and wind loading of the insulation, these conductors are heavier than bare conductors of equivalent capacity and consequently have reduced spanning capability. They are also more expensive than bare conductors. They also have reduced fault current capacity.

LVABC is the default LV conductor to be used on LV lines. It may be unsuitable for some long rural spans or in some applications where there are very heavy industrial loads. Two circuits can easily be run in parallel, one 300mm below the other.

For HV applications, bare conductors are still the default mains type. HVABC should only be used where circumstances warrant the additional cost. Unlike LVABC or covered conductor, HVABC has, not only insulation, but also earthed screening of the phase cores similar to underground HV cables. The use of Non-metallic screen (NMS) HVABC has been discontinued within TasNetworks due to problems that may arise with degradation of the semi-conductive outer screen layer of the cable. Metallic-screened (MS) HVABC is considerably heavier than NMSHVABC. HVABC has a catenary or support conductor, unlike LVABC.

4.4.4 Mechanical Properties

Nominal or Projected Diameter is important for determining 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.

Cross-Sectional Area (CSA) is equal to the area of each strand times the number of strands. Conductor strength, weight and conductivity are all proportional to the CSA.

Mass affects the tension in the line. Heavier conductors need to be strung tighter than light conductors for equivalent sags and therefore apply more force to supporting poles. Aluminium conductors have a very low mass relative to their cross-sectional area.

Nominal Breaking Load (NBL) is also known as minimum/calculated breaking load or ultimate tensile strength (UTS).

Modulus of Elasticity is a measure of stress or load applied to a material to cause a given strain (deformation or stretch).

Coefficient of Linear Expansion 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.

4.4.5 Current Ratings

The current rating of a line is dependent upon various factors, such as:

- the resistance of the line and how much heat is generated: I^2R losses
- the maximum temperature for which a line is designed to operate, a function of the material and available clearances
- how much heat the line absorbs from and dissipates to the surroundings through:
  - incident solar radiation on the line, including reflection from the ground
  - convection and radiation losses to the surroundings, which depend on ambient air temperature, wind speed and conductor surface emissivity.

Line ratings are calculated by solving a heat balance equation.

The maximum design temperature of 50ºC used by TasNetworks for bare conductor lines is low compared with that used elsewhere in Australia and significantly limits the current-carrying capacity of conductors. However, LVABC has a maximum design temperature of 75ºC, much like other Australian distribution authorities. HVABC has a maximum design temperature of 50ºC for the catenary and 90ºC operation of the phase cores.

One alternative to conductor replacement is line re-rating. Allowing conductors to operate at higher temperatures enables them to carry greater loads. This is acceptable provided that:

- clearances from ground and subcircuits are adequate with the increased sag
- no damage will be sustained by the line, e.g. annealing of conductors or plasticising of any insulation.

4.4.6 Fault Current Ratings

Fault current ratings may be calculated using the following material heating equation:

Temperature Rise = Energy dissipated / (Mass x Specific Heat)

The temperature rise must not be sufficient to cause annealing or permanent damage to the conductor or any insulation. Since energy dissipated depends upon the I^2R losses and the duration of the fault, an expression for the maximum fault current can be derived:

$$I_F(t) = \left((T_{max} - T_a)\, m\, C / R\, t \right)^{1/2}$$

where:

$I_F(t)$	maximum allowable fault current (kA) for duration t
t	duration of fault (s) – typically 1s
T_2	final maximum allowable conductor temperature (°C)—160°C for aluminium and ACSR, 200°C for copper, 400°C for steel, these temperatures corresponding to a 5% loss of strength through annealing over total fault clearing time over entire life of conductor, including recloses
T_1	initial/ambient temperature (°C), say 40°C or 50°C
m	conductor mass (kg/m)
C	specific heat of conductor material (J/g°C) – 0.9 for aluminium, 0.5 for steel, 0.4 for copper– strictly, not a constant
R	conductor resistance (Ω/km) – strictly, not a constant

However, since resistance and specific heat are not constant but vary with temperature, a more sophisticated equation for determining maximum fault currents is presented in AS/NZS7000 Appendix Z:

$$J^2 t = \frac{DC_{20}\left[1 + A_c\left(\frac{T_1 + T_2}{2} - 20\right)\right]}{A_r R} \ln\left[\frac{T_2 - 20 + \frac{1}{A_r}}{T_1 - 20 + \frac{1}{A_r}}\right]$$

where:

A_r	=	temperature coefficient of resistance in °C^{-1}
R	=	resistivity in ohm.mm at 20°C
D	=	density in g/mm^3 or kg/cm^3
J	=	current density in A/mm^2

A_c = temperature coefficient of specific heat

Typical values of these parameters for various conductor materials are shown in the following table. For ACSR conductors, values may be calculated according to the ratio of aluminium to steel cross-sectional area.

Parameter	Units	AAC	AAAC/ 1120	HD copper	SC/GZ
A_r (at 20°C)	$°C^{-1}$	0.00403	0.00390	0.00381	0.00440
R (at 20°C)	Ωmm	28.3×10^{-6}	29.3×10^{-6}	17.77×10^{-6}	190×10^{-6}
D	g/mm^3	2.70×10^{-3}	2.70×10^{-3}	8.89×10^{-3}	7.8×10^{-3}
C_{20}	$Jg^{-1}°C^{-1}$	0.9	0.9	0.4	0.5
A_c	$°C^{-1}$	4.5×10^{-4}	4.5×10^{-4}	2.9×10^{-4}	1.0×10^{-4}

Fault ratings for different durations may be related to the one second fault rating, $I_F(1)$, using the relationship:

$$I_F(t) = I_F(1) / \sqrt{t}$$

For example, a 2s fault rating is equal to the 1s fault rating divided by √2.

4.4.7 Conductor Ageing

Conductor properties change with age.

The conductor will lose strength over time as it anneals, depending upon its thermal operating history. If it has suffered overloading or a large number of fault currents, then the effect will be more pronounced.

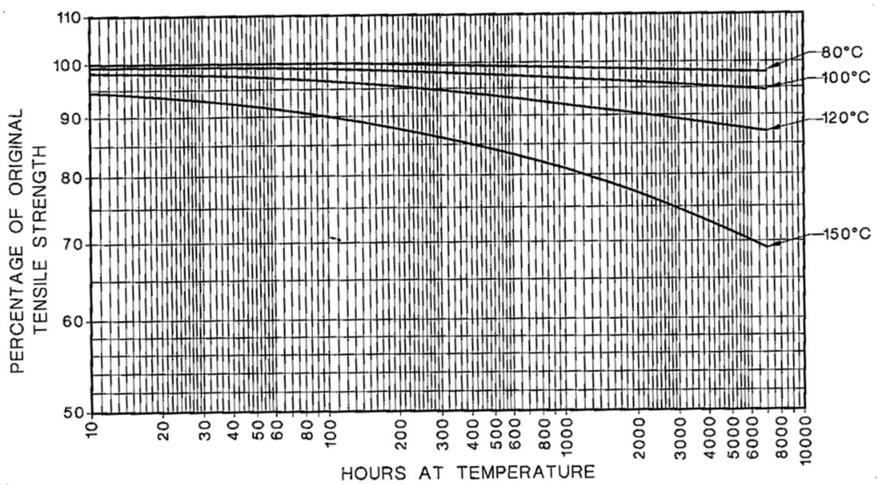


FIGURE D1 PERCENTAGE OF ORIGINAL TENSILE STRENGTH FOR ALLOY 1350 vs AGEING TIME

The conductor's absorptivity and emissivity change as it loses its initial shine and discolours due to pollution or external corrosion.

The conductor will also suffer from fatigue, corrosion and creep to varying degrees, depending upon the material and environmental conditions. Creep is discussed further in section 5.14.5.

4.4.8 Calculation of Voltage Drop

Voltage drop in a line can be calculated using Ohm's Law:

$$V = I\,Z$$

where:

- V Voltage drop (V)
- I Current (A)
- Z Cable/conductor impedance (Ω), a function of circuit length.

Note that impedance includes reactance, X, as well as the resistance, R.

$$Z = \sqrt{(R^2 + X^2)}$$

AC resistance is a little higher than DC resistance due to the 'skin effect' (where current density is greater in the surface layers of a conductor than in its interior due to the self-inductance of the conductor) and the magnetic effect for steel or ACSR conductor (which leads to hysteresis and eddy currents, increasing the losses and the effective resistance).

Reactance includes inductive and capacitive effects, the latter being particularly relevant for insulated cables. The inductive reactance depends upon the height and phase spacing/configuration of the line.

SECTION 5 – CONDUCTOR STRINGING

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SECTION 5 – CONDUCTOR STRINGING

5.1 STRINGING TABLE SELECTION

5.1.1 Standard Stringing Tables

Standard conductor stringing tensions have been developed to enable line designers to determine sags and mechanical forces by reference to the standard tables. Designers with access to computer software for line design are not constrained to use standard tensions but may find these useful to follow where practical to do so.

The tables in this section give sag for a range of span lengths, temperatures and ruling spans for each class of conductor. Blowout and conductor tensions are also detailed. Both initial sag (prior to creep or inelastic stretching of the conductor) and final sags (after creep) are presented, except for slacker stringing where creep is negligible. The final sag values will primarily be of interest to designers.

Users may need to interpolate between tabulated values where the precise span length or ruling span is not available. For situations not covered by the tables, designers will need to use sag-tension-temperature calculation software.

The following points should be noted regarding the stringing tables within this section:

1. Ensure that you are using the correct chart—correct conductor material type, correct stringing tension and suitable ruling span.
2. Some non-preferred and obsolete conductor types and sizes have been included for reference purposes only.
3. Initial sag is for construction—stringing new conductors. Final sag is after inelastic stretch (creep) and applies to conductors that have been in-service for some time.
4. Ensure tight-strung conductors have proper anti-vibration protection and damping.
5. Reference temperature for conductor stringing is 5ºC. Tension is for 'no wind' condition. Blowout is calculated at 500Pa and 15ºC and includes allowance for conductor stretch. (Blowout for service cables is shown at 350Pa, as there is frequently a lot of shielding of these lines by buildings and trees.)
6. There will be slight variations in sag from conductor to conductor within a class, e.g. Mercury (7/4.50 AAC) will differ slightly from Neptune (19/3.25 AAC), but these differences are relatively minor. If greater accuracy is needed, then software should be used to calculate values.
7. Designers should be wary of extrapolating far beyond the range of span lengths provided in the stringing tables due to the "2:1 rule" for spans (see next page).
8. It is recommended that a minimum stringing tension of 10%NBL be used for steel conductors and ACSR conductors with a high steel content so that helical termination (dead-end) fittings remain adequately tensioned to maintain proper grip.
9. It is recommended that designers do not nominate higher tensions than those used in this section, except where carried out strictly in accordance with *AS/NZS7000* Appendix Y.

5.1.2 Selection

Designers should select a stringing tension appropriate to the span length, as shown below. Note that the span lengths and ranges shown are typical for distribution lines and presented as a general *guideline* only. Span length limits will be influenced by the type of conductor/cable used, conductor fittings, structure strength, interphase spacing, line voltage and available ground clearance.

Stringing Tension		*Typical* Span (m)		Typical Application
% NBL[1]	Desc	Length	Range	
2	Slack	20	5 - 35	Short slack spans, service lines
6	Urban	40	30 - 75	Urban areas
10	Limited	90	50 - 120	Semi-rural areas, Max. for ABC
18	Medium	130	80 - 170	Rural areas, Max. for AAC
22	Full Tension	170	100 - 220	Rural areas, AAAC, ACSR Low Steel Content
		220	120 - 270	Rural areas, ACSR High Steel Content
22	Full Tension	280	150 - 400	Rural areas, SC/GZ

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

- Do not make lines unnecessarily tight—this increases the cost of structures and the number of stays required.
- Attempt to keep spans of similar length within a strain section where it is practical to do so, taking into account terrain, property boundaries etc. Strain constructions should be used to isolate any spans that are significantly shorter or longer than adjacent spans.
- Within any strain section, no span length should be more than double the MES (ruling span), or less than half the MES. In fact, on tight-strung lines, it is preferable that the longest span is not more than double the shortest span within any strain section (the “2:1 rule”). If this is not done, large forces can occur when the line is cold, damaging insulators and crossarms.
- Subcircuits should generally not be strung tighter than supercircuits (ADSS excepted).

Expressing stringing tension as a percentage of Nominal Breaking Load is useful for simple bare conductors but is not always suitable for other types of cable where there is a catenary or composite material involved. For ADSS, pilot and HVABC cables, stringing tables with known sag characteristics have been used – the table number gives the sag in centimetres that would occur in a 100m span at the nominated tension. NBN cables are strung with a fixed sag/span ratio; each span is effectively an individual span with the ends clamped.

[1] Tensions are given at a reference temperature of 5ºC. As temperature increases, actual conductor tensions reduce, and vice versa.

5.2 PAGE INDEX OF STRINGING TABLES

Conductor Class	Stringing Tension		MES (m)	Section
	%NBL	Description		
AAC Aluminium	2	Slack	20	5.3.1
			Forces	5.3.2
	6	Urban	40	5.3.3
			60	5.3.4
			Forces	5.3.5
	10	Limited	50	5.3.6
			75	5.3.7
			100	5.3.8
			Forces	5.3.9
	18	Medium	100	5.3.10
			150	5.3.11
			Forces	5.3.12
AAAC Aluminium Alloy	10	Limited	50	5.4.1
			75	5.4.2
			100	5.4.3
			Forces	5.4.4
	18	Medium	100	5.4.5
			150	5.4.6
			Forces	5.4.7
	22	Full	100	5.4.8
			150	5.4.9
			200	5.4.10
			250	5.4.11
			Forces	5.4.12
ACSR Aluminium/Steel Low Steel Content	10	Limited	50	5.5.1
			75	5.5.2
			100	5.5.3
			Forces	5.5.4
	18	Medium	100	5.5.5
			150	5.5.6
			Forces	5.5.7
	22	Full	100	5.5.8
			150	5.5.9
			200	5.5.10
			250	5.5.11
			Forces	5.5.12
ACSR Aluminium/Steel High Steel Content	10	Limited	50	5.6.1
			75	5.6.2
			100	5.6.3
			Forces	5.6.4
	22	Full	100	5.6.5
			150	5.6.6
			200	5.6.7
			250	5.6.8
			Forces	5.7.9

Conductor Class		Stringing Tension		MES (m)	Section
		%NBL	Description		
SC/GZ Steel		10	Limited	50	5.7.1
				75	5.7.2
				100	5.7.3
				Forces	5.7.4
		22	Full	150	5.7.5
				200	5.7.6
				250	5.7.7
				300	5.7.8
				350	5.7.9
				400	5.7.10
				Forces	5.7.11
HDC Copper		2	Slack	20	5.8.1
				Forces	5.8.2
		6	Urban	40	5.8.3
				60	5.8.4
				Forces	5.8.5
		10	Limited	50	5.8.6
				75	5.8.7
				100	5.8.8
				Forces	5.8.9
		18	Medium	100	5.8.10
				150	5.8.11
				Forces	5.8.12
LVABC		2	Slack	20	5.9.1
				Forces	5.9.2
		6	Urban	40	5.9.3
				60	5.9.4
				Forces	5.9.5
		10	Limited	50	5.9.6
				75	5.9.7
				100	5.9.8
				Forces	5.9.9
MSHVABC		T1000	Slack	Span	5.10.1
				Forces	5.10.2
		T700	Urban	Span	5.10.3
				Forces	5.10.4
		T400	Limited	Span	5.10.5
				Forces	5.10.6
ADSS		T600	Slack	20	5.11.1
				Forces	5.11.2
		T300	Urban	50	5.11.3
				Forces	5.11.4
		T100	Tight	100	5.11.5
				Forces	5.11.6
Services Al/XLPE 25mm^2	2C	4.4	Slack	Span	5.12.1
	3/4C	3.3	Slack	Span	5.12.2
	All	5.6	Urban	Span	5.12.3
NBN	RPX 144F	2%	Moderate	Span	5.13.1
		1%	Tight	Span	5.13.2

5.3 AAC

5.3.1 AAC Slack 2% NBL 20m MES

SPAN LENGTH (m)	SAG (m) Temperature -5ºC	0ºC	5ºC	10ºC	15ºC	20ºC	25ºC	30ºC	50ºC	60ºC	BLOW OUT (m)
10	0.10	0.11	0.11	0.12	0.12	0.12	0.13	0.13	0.15	0.15	0.11
15	0.23	0.24	0.25	0.26	0.27	0.28	0.29	0.30	0.33	0.35	0.25
20	0.40	0.42	0.44	0.46	0.48	0.50	0.51	0.53	0.59	0.62	0.45
25	0.63	0.66	0.69	0.72	0.75	0.78	0.80	0.83	0.92	0.97	0.70
30	0.91	0.95	1.00	1.04	1.08	1.12	1.16	1.19	1.33	1.40	1.01
35	1.23	1.30	1.36	1.41	1.47	1.52	1.58	1.63	1.82	1.90	1.37
CONDUCTOR	**NO WIND TENSION (kN)**										
LEO (7/2.50)	0.13	0.12	0.12	0.11	0.10	0.10	0.10	0.09	0.08	0.08	
LIBRA (7/3.00)	0.18	0.17	0.16	0.15	0.14	0.14	0.13	0.13	0.12	0.11	
MARS (7/3.75)	0.26	0.25	0.24	0.23	0.22	0.21	0.20	0.20	0.18	0.17	
MERCURY (7/4.50)	0.37	0.35	0.34	0.32	0.31	0.30	0.29	0.28	0.25	0.24	
NEPTUNE (19/3.25)	0.55	0.52	0.49	0.47	0.45	0.44	0.42	0.41	0.37	0.35	

Sag and Blowout Calculations for MERCURY. **Refer NOTES Section 5.1.1** Creep Allowance: **Nil**

5.3.2 AAC Slack 2% NBL Mechanical Forces per Conductor

SPAN LENGTH (m)	CONDUCTOR TENSION (kN) LEO (7/2.50) No Wind	LEO (7/2.50) Max Wind	LIBRA (7/3.00) No Wind	LIBRA (7/3.00) Max Wind	MARS (7/3.75) No Wind	MARS (7/3.75) Max Wind	MERCURY (7/4.50) No Wind	MERCURY (7/4.50) Max Wind	NEPTUNE (19/3.25) No Wind	NEPTUNE (19/3.25) Max Wind
10	0.13	0.65	0.18	0.80	0.26	1.03	0.37	1.25	0.54	1.56
20		0.86		1.04		1.29		1.56		1.96
30		0.95		1.13		1.39		1.66		2.09
40		0.99		1.16		1.43		1.71		2.14

MES = Span Length. No Wind tension is at 5°C and includes 1.1 Load Factor. Max Wind (900Pa) tension is at 15°C and includes 1.25 Load Factor.

5.3.3 AAC Urban 6% NBL 40m MES

SPAN LENGTH (m)	SAG (m) Temperature -5ºC	0ºC	5ºC	10ºC	15ºC	20ºC	25ºC	30ºC	50ºC	60ºC	BLOW OUT (m)
20	0.12	0.13	0.15	0.16	0.17	0.18	0.19	0.20	0.24	0.26	0.17
25	0.19	0.21	0.23	0.25	0.27	0.29	0.30	0.32	0.38	0.40	0.27
30	0.27	0.30	0.33	0.36	0.39	0.41	0.44	0.46	0.54	0.58	0.39
35	0.37	0.41	0.45	0.49	0.53	0.56	0.59	0.63	0.74	0.79	0.53
40	0.48	0.54	0.59	0.64	0.69	0.73	0.78	0.82	0.97	1.03	0.69
45	0.61	0.68	0.75	0.81	0.87	0.93	0.98	1.03	1.22	1.31	0.88
50	0.75	0.84	0.92	1.00	1.07	1.15	1.21	1.28	1.51	1.62	1.08
55	0.91	1.01	1.12	1.21	1.30	1.39	1.47	1.55	1.83	1.96	1.31
60	1.08	1.21	1.33	1.44	1.55	1.65	1.75	1.84	2.18	2.33	1.56
65	1.27	1.42	1.56	1.69	1.82	1.94	2.05	2.16	2.56	2.73	1.83
CONDUCTOR	**NO WIND TENSION (kN)**										
LEO (7/2.50)	0.44	0.38	0.35	0.31	0.29	0.27	0.25	0.24	0.20	0.19	
LIBRA (7/3.00)	0.60	0.53	0.47	0.43	0.40	0.37	0.35	0.33	0.28	0.26	
MARS (7/3.75)	0.88	0.79	0.71	0.66	0.61	0.57	0.54	0.51	0.43	0.40	
MERCURY (7/4.50)	1.24	1.11	1.01	0.93	0.87	0.82	0.77	0.73	0.62	0.58	
NEPTUNE (19/3.25)	1.83	1.63	1.48	1.36	1.26	1.18	1.12	1.06	0.89	0.83	

Sag and Blowout Calculations for MERCURY. **Refer NOTES Section 5.1.1** Creep Allowance: **Nil**

5.3.4 AAC Urban 6% NBL 60m MES

SPAN LENGTH (m)	SAG (m) Temperature -5ºC	0ºC	5ºC	10ºC	15ºC	20ºC	25ºC	30ºC	50ºC	60ºC	BLOW OUT (m)
30	0.30	0.32	0.33	0.35	0.36	0.37	0.38	0.40	0.44	0.46	0.35
35	0.41	0.43	0.45	0.47	0.49	0.51	0.52	0.54	0.60	0.63	0.47
40	0.54	0.56	0.59	0.61	0.64	0.66	0.68	0.70	0.78	0.82	0.61
45	0.68	0.71	0.75	0.78	0.81	0.84	0.86	0.89	0.99	1.04	0.78
50	0.84	0.88	0.92	0.96	1.00	1.03	1.07	1.10	1.22	1.28	0.97
55	1.02	1.07	1.12	1.16	1.21	1.25	1.29	1.33	1.48	1.55	1.17
60	1.21	1.27	1.33	1.38	1.43	1.49	1.54	1.58	1.76	1.85	1.39
65	1.42	1.49	1.56	1.62	1.68	1.74	1.80	1.86	2.07	2.17	1.63
70	1.65	1.73	1.81	1.88	1.95	2.02	2.09	2.16	2.40	2.52	1.89
75	1.90	1.99	2.07	2.16	2.24	2.32	2.40	2.48	2.76	2.89	2.17
80	2.16	2.26	2.36	2.46	2.55	2.64	2.73	2.82	3.14	3.29	2.47
85	2.43	2.55	2.67	2.78	2.88	2.98	3.08	3.18	3.54	3.71	2.79
90	2.73	2.86	2.99	3.11	3.23	3.35	3.46	3.57	3.98	4.17	3.13
CONDUCTOR	**NO WIND TENSION (kN)**										
LEO (7/2.50)	0.38	0.36	0.35	0.33	0.32	0.30	0.29	0.28	0.25	0.24	
LIBRA (7/3.00)	0.53	0.50	0.47	0.45	0.44	0.42	0.40	0.39	0.35	0.33	
MARS (7/3.75)	0.78	0.75	0.71	0.69	0.66	0.64	0.62	0.60	0.53	0.51	
MERCURY (7/4.50)	1.11	1.06	1.01	0.97	0.94	0.91	0.88	0.85	0.76	0.73	
NEPTUNE (19/3.25)	1.63	1.55	1.48	1.42	1.37	1.32	1.27	1.23	1.10	1.05	

Sag and Blowout Calculations for MERCURY. **Refer NOTES Section 5.1.1** Creep Allowance: **Nil**

5.3.5 AAC Urban 6% NBL Mechanical Forces per Conductor

SPAN LENGTH (m)	CONDUCTOR TENSION (kN)									
	LEO (7/2.50)		LIBRA (7/3.00)		MARS (7/3.75)		MERCURY (7/4.50)		NEPTUNE (19/3.25)	
	No Wind	Max Wind	No Wind	Max Wind	No Wind	Max Wind	No Wind	Max Wind	No Wind	Max Wind
20	0.39	1.31	0.52	1.65	0.78	2.18	1.11	2.71	1.63	3.45
30		1.66		2.06		2.70		3.36		4.25
40		1.93		2.39		3.09		3.81		4.81
50		2.14		2.63		3.36		4.14		5.23
60		2.30		2.81		3.58		4.38		5.51
70		2.44		2.96		3.74		4.55		5.74
80		2.54		3.08		3.86		4.69		5.90
90		2.63		3.16		3.95		4.79		6.03

MES = Span Length. No Wind tension is at 5°C and includes 1.1 Load Factor. Max Wind (900Pa) tension is at 15°C and includes 1.25 Load Factor.

5.3.6 AAC Limited 10% NBL 50m MES

SPAN LENGTH (m)	SAG (m) Temperature -5ºC	0ºC		5ºC		10ºC		15ºC		20ºC		25ºC		30ºC		50ºC	60ºC	BLOW OUT (m)
	FINAL	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	**FINAL**	**FINAL**	
30	0.15	0.15	0.17	0.17	0.20	0.20	0.22	0.22	0.25	0.25	0.27	0.27	0.29	0.29	0.31	0.39	0.42	0.27
35	0.20	0.20	0.24	0.24	0.27	0.27	0.30	0.30	0.34	0.34	0.37	0.37	0.40	0.40	0.43	0.53	0.57	0.37
40	0.26	0.26	0.31	0.31	0.35	0.35	0.40	0.40	0.44	0.44	0.48	0.48	0.52	0.52	0.56	0.69	0.75	0.48
45	0.33	0.33	0.39	0.39	0.45	0.45	0.50	0.50	0.56	0.56	0.61	0.61	0.66	0.66	0.70	0.87	0.95	0.61
50	0.41	0.41	0.48	0.48	0.55	0.55	0.62	0.62	0.69	0.69	0.75	0.75	0.81	0.81	0.87	1.08	1.17	0.75
55	0.50	0.50	0.58	0.58	0.67	0.67	0.75	0.75	0.83	0.83	0.91	0.91	0.98	0.98	1.05	1.30	1.41	0.91
60	0.60	0.60	0.69	0.69	0.80	0.80	0.90	0.90	0.99	0.99	1.08	1.08	1.17	1.17	1.25	1.55	1.68	1.09
65	0.70	0.70	0.82	0.82	0.93	0.93	1.05	1.05	1.16	1.16	1.27	1.27	1.37	1.37	1.47	1.82	1.98	1.28
70	0.81	0.81	0.95	0.95	1.08	1.08	1.22	1.22	1.35	1.35	1.47	1.47	1.59	1.59	1.71	2.11	2.29	1.48
75	0.93	0.93	1.09	1.09	1.24	1.24	1.40	1.40	1.55	1.55	1.69	1.69	1.83	1.83	1.96	2.42	2.63	1.70
80	1.06	1.06	1.24	1.24	1.42	1.42	1.59	1.59	1.76	1.76	1.93	1.93	2.08	2.08	2.23	2.76	3.00	1.93
CONDUCTOR	**NO WIND TENSION (kN)**																	
LEO (7/2.50)	0.79	0.79	0.67	0.67	0.58	0.58	0.51	0.51	0.45	0.45	0.41	0.41	0.38	0.38	0.35	0.28	0.26	
LIBRA (7/3.00)	1.07	1.07	0.91	0.91	0.79	0.79	0.70	0.70	0.63	0.63	0.57	0.57	0.52	0.52	0.49	0.39	0.36	
MARS (7/3.75)	1.60	1.60	1.37	1.37	1.19	1.19	1.06	1.06	0.95	0.95	0.87	0.87	0.81	0.81	0.75	0.61	0.56	
MERCURY (7/4.50)	2.26	2.26	1.94	1.94	1.69	1.69	1.50	1.50	1.36	1.36	1.24	1.24	1.15	1.15	1.07	0.87	0.80	
NEPTUNE (19/3.25)	3.30	3.30	2.83	2.83	2.47	2.47	2.19	2.19	1.97	1.97	1.80	1.80	1.67	1.67	1.55	1.25	1.15	

Sag and Blowout Calculations for MERCURY. **Refer NOTES Section 5.1.1** Creep Allowance: **5ºC**

5.3.7 AAC Limited 10% NBL 75m MES

SPAN LENGTH (m)	SAG (m) Temperature -5ºC	0ºC		5ºC		10ºC		15ºC		20ºC		25ºC		30ºC		50ºC	60ºC	BLOW OUT (m)
	FINAL	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	**FINAL**	**FINAL**	
40	0.30	0.30	0.33	0.33	0.35	0.35	0.38	0.38	0.40	0.40	0.42	0.42	0.44	0.44	0.46	0.54	0.57	0.41
45	0.38	0.38	0.42	0.42	0.45	0.45	0.48	0.48	0.50	0.50	0.53	0.53	0.56	0.56	0.58	0.68	0.72	0.52
50	0.47	0.47	0.51	0.51	0.55	0.55	0.59	0.59	0.62	0.62	0.66	0.66	0.69	0.69	0.72	0.84	0.89	0.64
55	0.57	0.57	0.62	0.62	0.67	0.67	0.71	0.71	0.75	0.75	0.80	0.80	0.84	0.84	0.87	1.01	1.08	0.78
60	0.68	0.68	0.74	0.74	0.79	0.79	0.85	0.85	0.90	0.90	0.95	0.95	0.99	0.99	1.04	1.21	1.28	0.92
65	0.80	0.80	0.87	0.87	0.93	0.93	0.99	0.99	1.05	1.05	1.11	1.11	1.17	1.17	1.22	1.42	1.51	1.08
70	0.93	0.93	1.01	1.01	1.08	1.08	1.15	1.15	1.22	1.22	1.29	1.29	1.35	1.35	1.41	1.64	1.75	1.26
75	1.07	1.07	1.15	1.15	1.24	1.24	1.32	1.32	1.40	1.40	1.48	1.48	1.55	1.55	1.62	1.89	2.01	1.44
80	1.21	1.21	1.31	1.31	1.41	1.41	1.51	1.51	1.60	1.60	1.68	1.68	1.77	1.77	1.85	2.15	2.28	1.64
85	1.37	1.37	1.48	1.48	1.59	1.59	1.70	1.70	1.80	1.80	1.90	1.90	2.00	2.00	2.09	2.42	2.58	1.86
90	1.53	1.53	1.66	1.66	1.79	1.79	1.91	1.91	2.02	2.02	2.13	2.13	2.24	2.24	2.34	2.72	2.89	2.08
95	1.71	1.71	1.85	1.85	1.99	1.99	2.12	2.12	2.25	2.25	2.37	2.37	2.49	2.49	2.61	3.03	3.22	2.32
100	1.89	1.89	2.05	2.05	2.21	2.21	2.35	2.35	2.50	2.50	2.63	2.63	2.76	2.76	2.89	3.36	3.57	2.57
105	2.09	2.09	2.26	2.26	2.43	2.43	2.60	2.60	2.75	2.75	2.90	2.90	3.05	3.05	3.19	3.70	3.94	2.83
110	2.29	2.29	2.48	2.48	2.67	2.67	2.85	2.85	3.02	3.02	3.18	3.18	3.34	3.34	3.50	4.06	4.32	3.11
115	2.51	2.51	2.72	2.72	2.92	2.92	3.11	3.11	3.30	3.30	3.48	3.48	3.65	3.65	3.82	4.44	4.72	3.40
CONDUCTOR	**NO WIND TENSION (kN)**																	
LEO (7/2.50)	0.68	0.68	0.62	0.62	0.57	0.57	0.53	0.53	0.50	0.50	0.47	0.47	0.44	0.44	0.42	0.36	0.34	
LIBRA (7/3.00)	0.94	0.48	0.86	0.86	0.80	0.80	0.74	0.74	0.70	0.70	0.66	0.66	0.63	0.63	0.60	0.51	0.48	
MARS (7/3.75)	1.38	1.38	1.27	1.27	1.18	1.18	1.11	1.11	1.04	1.04	0.99	0.99	0.94	0.94	0.90	0.77	0.73	
MERCURY (7/4.50)	1.97	1.97	1.82	1.82	1.69	1.69	1.58	1.58	1.49	1.49	1.42	1.42	1.35	1.35	1.29	1.11	1.05	
NEPTUNE (19/3.25)	2.90	2.90	2.66	2.66	2.47	2.47	2.31	2.31	2.17	2.17	2.06	2.06	1.96	1.96	1.87	1.60	1.51	

Sag and Blowout Calculations for MERCURY. **Refer NOTES Section 5.1.1** Creep Allowance: **5ºC**

5.3.8 AAC Limited 10% NBL 100m MES

SPAN LENGTH (m)	SAG (m) – Temperature																	BLOW OUT (m)
	-5ºC	0ºC		5ºC		10ºC		15ºC		20ºC		25ºC		30ºC		50ºC	60ºC	
	FINAL	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	**FINAL**	**FINAL**	
50	0.51	0.51	0.53	0.53	0.55	0.55	0.57	0.57	0.59	0.59	0.62	0.62	0.64	0.64	0.66	0.73	0.77	0.59
55	0.61	0.61	0.64	0.64	0.67	0.67	0.69	0.69	0.72	0.72	0.75	0.75	0.77	0.77	0.79	0.88	0.93	0.72
60	0.73	0.73	0.76	0.76	0.79	0.79	0.83	0.83	0.86	0.86	0.89	0.89	0.92	0.92	0.94	1.05	1.10	0.85
65	0.85	0.85	0.89	0.89	0.93	0.93	0.97	0.97	1.01	1.01	1.04	1.04	1.08	1.08	1.11	1.23	1.29	1.00
70	0.99	0.99	1.04	1.04	1.08	1.08	1.12	1.12	1.17	1.17	1.21	1.21	1.25	1.25	1.29	1.43	1.50	1.16
75	1.14	1.14	1.19	1.19	1.24	1.24	1.29	1.29	1.34	1.34	1.39	1.39	1.43	1.43	1.48	1.64	1.72	1.33
80	1.29	1.29	1.35	1.35	1.41	1.41	1.47	1.47	1.52	1.52	1.58	1.58	1.63	1.63	1.68	1.87	1.96	1.52
85	1.46	1.46	1.53	1.53	1.59	1.59	1.66	1.66	1.72	1.72	1.78	1.78	1.84	1.84	1.90	2.11	2.21	1.71
90	1.64	1.64	1.71	1.71	1.79	1.79	1.86	1.86	1.93	1.93	2.00	2.00	2.06	2.06	2.13	2.37	2.48	1.92
95	1.82	1.82	1.91	1.91	1.99	1.99	2.07	2.07	2.15	2.15	2.22	2.22	2.30	2.30	2.37	2.64	2.76	2.14
100	2.02	2.02	2.12	2.12	2.21	2.21	2.30	2.30	2.38	2.38	2.46	2.46	2.55	2.55	2.63	2.92	3.06	2.37
105	2.23	2.23	2.33	2.33	2.43	2.43	2.53	2.53	2.63	2.63	2.72	2.72	2.81	2.81	2.89	3.22	3.38	2.61
110	2.45	2.45	2.56	2.56	2.67	2.67	2.78	2.78	2.88	2.88	2.98	2.98	3.08	3.08	3.18	3.54	3.71	2.87
115	2.67	2.67	2.80	2.80	2.92	2.92	3.04	3.04	3.15	3.15	3.26	3.26	3.37	3.37	3.47	3.87	4.05	3.13
120	2.91	2.91	3.05	3.05	3.18	3.18	3.31	3.31	3.43	3.43	3.55	3.55	3.67	3.67	3.78	4.21	4.41	3.41
125	3.16	3.16	3.31	3.31	3.45	3.45	3.59	3.59	3.72	3.72	3.85	3.85	3.98	3.98	4.10	4.57	4.79	3.70
130	3.42	3.42	3.58	3.58	3.73	3.73	3.88	3.88	4.03	4.03	4.17	4.17	4.31	4.31	4.44	4.95	5.18	4.01
135	3.68	3.68	3.86	3.86	4.02	4.02	4.19	4.19	4.34	4.34	4.49	4.49	4.64	4.64	4.79	5.33	5.59	4.32
140	3.96	3.96	4.15	4.15	4.33	4.33	4.50	4.50	4.67	4.67	4.83	4.83	4.99	4.99	5.15	5.74	6.01	4.65
CONDUCTOR	**NO WIND TENSION (kN)**																	
LEO (7/2.50)	0.63	0.63	0.60	0.60	0.57	0.57	0.55	0.55	0.52	0.52	0.50	0.50	0.49	0.49	0.47	0.42	0.40	
LIBRA (7/3.00)	0.88	0.88	0.84	0.84	0.80	0.80	0.76	0.76	0.73	0.73	0.71	0.71	0.68	0.68	0.66	0.59	0.56	
MARS (7/3.75)	1.29	1.29	1.23	1.23	1.18	1.18	1.13	1.13	1.09	1.09	1.06	1.06	1.02	1.02	0.99	0.89	0.85	
MERCURY (7/4.50)	1.85	1.85	1.76	1.76	1.69	1.69	1.62	1.62	1.57	1.57	1.51	1.51	1.46	1.46	1.42	1.28	1.22	
NEPTUNE (19/3.25)	2.71	2.71	2.58	2.58	2.47	2.47	2.37	2.37	2.28	2.28	2.20	2.20	2.13	2.13	2.06	1.85	1.76	

Sag and Blowout Calculations for MERCURY. **Refer NOTES Section 5.1.1** Creep Allowance: **5ºC**

5.3.9 AAC Limited 10% NBL Mechanical Forces per Conductor

SPAN LENGTH (m)	CONDUCTOR TENSION (kN)									
	LEO (7/2.50)		LIBRA (7/3.00)		MARS (7/3.75)		MERCURY (7/4.50)		NEPTUNE (19/3.25)	
	No Wind	Max Wind	No Wind	Max Wind	No Wind	Max Wind	No Wind	Max Wind	No Wind	Max Wind
30	0.64	1.86	0.87	2.36	1.31	3.15	1.86	3.99	2.72	5.11
40		2.21		2.78		3.70		4.66		5.95
50		2.50		3.14		4.15		5.23		6.64
60		2.76		3.45		4.54		5.69		7.23
70		2.99		3.73		4.88		6.08		7.70
80		3.19		3.96		5.15		6.41		8.11
90		3.36		4.18		5.40		6.69		8.46
100		3.53		4.35		5.61		6.93		8.76
110		3.68		4.51		5.80		7.14		9.01
120		3.80		4.66		5.95		7.31		9.24
130		3.91		4.79		6.10		7.46		9.43
140		4.01		4.90		6.21		7.60		9.59

MES = Span Length. No Wind tension is at 5°C and includes 1.1 Load Factor. Max Wind (900Pa) tension is at 15°C and includes 1.25 Load Factor.

5.3.10 AAC Medium 18% NBL 100m MES

SPAN LENGTH (m)	SAG (m) Temperature -5ºC	0ºC		5ºC		10ºC		15ºC		20ºC		25ºC		30ºC		50ºC	60ºC	BLOW OUT (m)
	FINAL	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL	FINAL	FINAL	
50	0.25	0.22	0.28	0.25	0.31	0.28	0.34	0.31	0.36	0.34	0.39	0.36	0.42	0.39	0.44	0.54	0.59	0.42
55	0.30	0.27	0.34	0.30	0.37	0.34	0.41	0.37	0.44	0.41	0.47	0.44	0.51	0.47	0.54	0.66	0.71	0.51
60	0.36	0.32	0.40	0.36	0.44	0.40	0.48	0.44	0.52	0.48	0.56	0.52	0.60	0.56	0.64	0.78	0.84	0.61
65	0.42	0.38	0.47	0.42	0.52	0.47	0.57	0.52	0.61	0.57	0.66	0.61	0.71	0.66	0.75	0.92	0.99	0.71
70	0.49	0.44	0.54	0.49	0.60	0.54	0.66	0.60	0.71	0.66	0.77	0.71	0.82	0.77	0.87	1.06	1.15	0.82
75	0.56	0.50	0.62	0.56	0.69	0.62	0.75	0.69	0.82	0.75	0.88	0.82	0.94	0.88	1.00	1.22	1.32	0.95
80	0.64	0.57	0.71	0.64	0.78	0.71	0.86	0.78	0.93	0.86	1.00	0.93	1.07	1.00	1.14	1.39	1.50	1.08
85	0.72	0.64	0.80	0.72	0.89	0.80	0.97	0.89	1.05	0.97	1.13	1.05	1.21	1.13	1.29	1.57	1.69	1.22
90	0.81	0.72	0.90	0.81	0.99	0.90	1.09	0.99	1.18	1.09	1.27	1.18	1.36	1.27	1.44	1.76	1.90	1.36
95	0.90	0.80	1.00	0.90	1.11	1.00	1.21	1.11	1.31	1.21	1.41	1.31	1.51	1.41	1.61	1.96	2.12	1.52
100	1.00	0.89	1.11	1.00	1.23	1.11	1.34	1.23	1.45	1.34	1.57	1.45	1.67	1.57	1.78	2.17	2.35	1.68
105	1.10	0.98	1.22	1.10	1.35	1.22	1.48	1.35	1.60	1.48	1.73	1.60	1.85	1.73	1.96	2.39	2.59	1.86
110	1.21	1.08	1.34	1.21	1.48	1.34	1.62	1.48	1.76	1.62	1.90	1.76	2.03	1.90	2.15	2.62	2.84	2.04
115	1.32	1.18	1.47	1.32	1.62	1.47	1.77	1.62	1.92	1.77	2.07	1.92	2.22	2.07	2.35	2.87	3.10	2.23
120	1.44	1.28	1.60	1.44	1.76	1.60	1.93	1.76	2.09	1.93	2.26	2.09	2.41	2.26	2.56	3.12	3.38	2.43
125	1.56	1.39	1.74	1.56	1.91	1.74	2.10	1.91	2.27	2.10	2.45	2.27	2.62	2.45	2.78	3.39	3.67	2.63
130	1.69	1.51	1.88	1.69	2.07	1.88	2.27	2.07	2.46	2.27	2.65	2.46	2.83	2.65	3.01	3.67	3.97	2.85
135	1.82	1.63	2.02	1.82	2.23	2.02	2.44	2.23	2.65	2.44	2.86	2.65	3.05	2.86	3.25	3.95	4.28	3.07
140	1.96	1.75	2.18	1.96	2.40	2.18	2.63	2.40	2.85	2.63	3.07	2.85	3.28	3.07	3.49	4.25	4.60	3.30
145	2.10	1.88	2.33	2.10	2.58	2.33	2.82	2.58	3.06	2.82	3.29	3.06	3.52	3.29	3.74	4.56	4.93	3.54
150	2.25	2.01	2.50	2.25	2.76	2.50	3.02	2.76	3.27	3.02	3.53	3.27	3.77	3.53	4.01	4.88	5.28	3.79
155	2.40	2.14	2.67	2.40	2.94	2.67	3.22	2.94	3.50	3.22	3.76	3.50	4.03	3.76	4.28	5.21	5.64	4.05
160	2.56	2.28	2.84	2.56	3.14	2.84	3.43	3.14	3.73	3.43	4.01	3.73	4.29	4.01	4.56	5.56	6.01	4.31
CONDUCTOR	**NO WIND TENSION (kN)**																	
LEO (7/2.50)	1.28	1.43	1.14	1.28	1.03	1.14	0.93	1.03	0.85	0.93	0.79	0.85	0.73	0.79	0.69	0.55	0.51	
LIBRA (7/3.00)	1.78	2.00	1.59	1.78	1.44	1.59	1.31	1.44	1.20	1.31	1.11	1.20	1.03	1.11	0.97	0.78	0.72	
MARS (7/3.75)	2.61	2.92	2.35	2.61	2.12	2.35	1.94	2.12	1.79	1.94	1.66	1.79	1.55	1.66	1.46	1.20	1.11	
MERCURY (7/4.50)	3.73	4.18	3.36	3.73	3.04	3.36	2.78	3.04	2.56	2.78	2.38	2.56	2.23	2.38	2.09	1.72	1.59	
NEPTUNE (19/3.25)	5.48	6.13	4.92	5.48	4.45	4.92	4.05	4.45	3.73	4.05	3.46	3.73	3.23	3.46	3.03	2.48	2.29	

Sag and Blowout Calculations for MERCURY. **Refer NOTES Section 5.1.1** Creep Allowance: **10ºC**

5.3.11 AAC Medium 18% NBL 150m MES

SPAN LENGTH (m)	SAG (m) Temperature																	BLOW OUT (m)
	-5ºC	0ºC		5ºC		10ºC		15ºC		20ºC		25ºC		30ºC		50ºC	60ºC	
	FINAL	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL	FINAL	FINAL	
80	0.70	0.66	0.74	0.70	0.78	0.74	0.82	0.78	0.86	0.82	0.90	0.86	0.94	0.90	0.98	1.11	1.18	0.93
90	0.89	0.83	0.94	0.89	0.99	0.94	1.04	0.99	1.09	1.04	1.14	1.09	1.19	1.14	1.23	1.41	1.49	1.18
100	1.10	1.03	1.16	1.10	1.23	1.16	1.29	1.23	1.35	1.29	1.41	1.35	1.47	1.41	1.52	1.74	1.84	1.45
110	1.33	1.25	1.40	1.33	1.48	1.40	1.56	1.48	1.63	1.56	1.71	1.63	1.78	1.71	1.84	2.10	2.22	1.76
120	1.58	1.48	1.67	1.58	1.76	1.67	1.85	1.76	1.94	1.85	2.03	1.94	2.11	2.03	2.20	2.50	2.65	2.09
130	1.85	1.74	1.96	1.85	2.07	1.96	2.18	2.07	2.28	2.18	2.38	2.28	2.48	2.38	2.58	2.94	3.11	2.46
140	2.15	2.02	2.28	2.15	2.40	2.28	2.53	2.40	2.65	2.53	2.76	2.65	2.88	2.76	2.99	3.41	3.60	2.85
150	2.47	2.32	2.61	2.47	2.76	2.61	2.90	2.76	3.04	2.90	3.17	3.04	3.30	3.17	3.43	3.91	4.14	3.27
160	2.81	2.64	2.97	2.81	3.14	2.97	3.30	3.14	3.46	3.30	3.61	3.46	3.76	3.61	3.90	4.45	4.71	3.72
170	3.17	2.97	3.36	3.17	3.54	3.36	3.72	3.54	3.90	3.72	4.07	3.90	4.24	4.07	4.41	5.03	5.32	4.20
180	3.55	3.34	3.76	3.55	3.97	3.76	4.18	3.97	4.37	4.18	4.57	4.37	4.76	4.57	4.94	5.64	5.96	4.71
190	3.96	3.72	4.19	3.96	4.43	4.19	4.65	4.43	4.87	4.65	5.09	4.87	5.30	5.09	5.51	6.28	6.64	5.25
200	4.38	4.12	4.65	4.38	4.90	4.65	5.16	4.90	5.40	5.16	5.64	5.40	5.87	5.64	6.10	6.96	7.36	5.82
CONDUCTOR	**NO WIND TENSION (kN)**																	
LEO (7/2.50)	1.17	1.25	1.09	1.17	1.03	1.09	0.97	1.03	0.92	0.97	0.88	0.92	0.84	0.88	0.81	0.70	0.66	
LIBRA (7/3.00)	1.62	1.74	1.52	1.62	1.44	1.52	1.36	1.44	1.29	1.36	1.23	1.29	1.18	1.23	1.13	0.99	0.93	
MARS (7/3.75)	2.38	2.53	2.24	2.38	2.12	2.24	2.02	2.12	1.93	2.02	1.84	1.93	1.77	1.84	1.70	1.49	1.41	
MERCURY (7/4.50)	3.40	3.62	3.21	3.40	3.04	3.21	2.89	3.04	2.76	2.89	2.65	2.76	2.54	2.65	2.45	2.14	2.03	
NEPTUNE (19/3.25)	4.99	5.33	4.70	4.99	4.45	4.70	4.22	4.45	4.02	4.22	3.85	4.02	3.69	3.85	3.55	3.10	2.93	

Sag and Blowout Calculations for MERCURY. **Refer NOTES Section 5.1.1** Creep Allowance: **10ºC**

5.3.12 AAC Medium 18% NBL Mechanical Forces per Conductor

SPAN LENGTH (m)	CONDUCTOR TENSION (kN)									
	LEO (7/2.50)		LIBRA (7/3.00)		MARS (7/3.75)		MERCURY (7/4.50)		NEPTUNE (19/3.25)	
	No Wind	Max Wind	No Wind	Max Wind	No Wind	Max Wind	No Wind	Max Wind	No Wind	Max Wind
50	1.14	2.85	1.56	3.64	2.35	4.93	3.34	6.33	4.90	8.20
60		3.16		4.03		5.44		6.95		8.99
70		3.45		4.39		5.90		7.53		9.70
80		3.71		4.71		6.33		8.05		10.35
90		3.96		5.03		6.73		8.54		10.94
100		4.20		5.31		7.09		8.98		11.50
110		4.43		5.58		7.43		9.39		12.00
120		4.63		5.83		7.74		9.78		12.48
130		4.83		6.06		8.04		10.13		12.91
140		5.01		6.29		8.31		10.45		13.31
150		5.19		6.50		8.58		10.75		13.69
160		5.35		6.70		8.81		11.04		14.04
170		5.51		6.89		9.04		11.30		14.36
180		5.66		7.06		9.25		11.54		14.66
190		5.81		7.24		9.45		11.78		14.94
200		5.95		7.40		9.64		11.99		15.20

MES = Span Length. No Wind tension is at 5°C and includes 1.1 Load Factor. Max Wind (900Pa) tension is at 15°C and includes 1.25 Load Factor.

5.4 AAAC

5.4.1 AAAC 1120 Limited 10% NBL 50m MES

SPAN LENGTH (m)	SAG (m) Temperature -5ºC	0ºC		5ºC		10ºC		15ºC		20ºC		25ºC		30ºC		50ºC	60ºC	BLOW OUT (m)
	FINAL	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	**FINAL**	**FINAL**	
30	0.09	0.09	0.11	0.11	0.13	0.13	0.15	0.15	0.17	0.17	0.20	0.20	0.22	0.22	0.25	0.33	0.37	0.26
35	0.12	0.12	0.14	0.14	0.17	0.17	0.20	0.20	0.23	0.23	0.27	0.27	0.30	0.30	0.33	0.45	0.50	0.36
40	0.16	0.16	0.19	0.19	0.22	0.22	0.26	0.26	0.31	0.31	0.35	0.35	0.39	0.39	0.44	0.59	0.65	0.47
45	0.20	0.20	0.24	0.24	0.28	0.28	0.33	0.33	0.39	0.39	0.44	0.44	0.50	0.50	0.55	0.74	0.83	0.60
50	0.25	0.25	0.30	0.30	0.35	0.35	0.41	0.41	0.48	0.48	0.55	0.55	0.62	0.62	0.68	0.92	1.02	0.73
55	0.30	0.30	0.36	0.36	0.42	0.42	0.50	0.50	0.58	0.58	0.66	0.66	0.75	0.75	0.83	1.11	1.24	0.89
60	0.36	0.36	0.43	0.43	0.50	0.50	0.59	0.59	0.69	0.69	0.79	0.79	0.89	0.89	0.98	1.32	1.47	1.06
65	0.42	0.42	0.50	0.50	0.59	0.59	0.70	0.70	0.81	0.81	0.93	0.93	1.04	1.04	1.15	1.55	1.73	1.24
70	0.49	0.49	0.58	0.58	0.69	0.69	0.81	0.81	0.94	0.94	1.08	1.08	1.21	1.21	1.34	1.80	2.01	1.44
75	0.56	0.56	0.66	0.66	0.79	0.79	0.93	0.93	1.08	1.08	1.23	1.23	1.39	1.39	1.54	2.07	2.30	1.65
80	0.64	0.64	0.76	0.76	0.89	0.89	1.05	1.05	1.23	1.23	1.40	1.40	1.58	1.58	1.75	2.36	2.62	1.88
CONDUCTOR	**NO WIND TENSION (kN)**																	
FLUORINE (7/3.00)	1.64	1.64	1.40	1.40	1.18	1.18	1.00	1.00	0.86	0.86	0.75	0.75	0.67	0.67	0.60	0.45	0.40	

Sag and Blowout Calculations for FLUORINE. **Refer NOTES Section 5.1.1** Creep Allowance: **5ºC**

5.4.2 AAAC 1120 Limited 10% NBL 75m MES

SPAN LENGTH (m)	SAG (m)																BLOW OUT (m)
	Temperature																
	-5ºC	0ºC		5ºC		10ºC		15ºC		20ºC		25ºC		30ºC		50ºC	60ºC
	FINAL	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	**FINAL**	**FINAL**	
40	0.18	0.18	0.20	0.20	0.22	0.22	0.25	0.25	0.28	0.28	0.30	0.30	0.33	0.33	0.35	0.44	0.48	0.39
45	0.22	0.22	0.25	0.25	0.28	0.28	0.32	0.32	0.35	0.35	0.38	0.38	0.41	0.41	0.44	0.55	0.60	0.49
50	0.28	0.28	0.31	0.31	0.35	0.35	0.39	0.39	0.43	0.43	0.47	0.47	0.51	0.51	0.55	0.68	0.75	0.60
55	0.33	0.33	0.38	0.38	0.42	0.42	0.47	0.47	0.52	0.52	0.57	0.57	0.62	0.62	0.66	0.83	0.90	0.73
60	0.40	0.40	0.45	0.45	0.50	0.50	0.56	0.56	0.62	0.62	0.68	0.68	0.73	0.73	0.79	0.99	1.07	0.87
65	0.47	0.47	0.53	0.53	0.59	0.59	0.66	0.66	0.73	0.73	0.80	0.80	0.86	0.86	0.92	1.16	1.26	1.02
70	0.54	0.54	0.61	0.61	0.69	0.69	0.77	0.77	0.84	0.84	0.92	0.92	1.00	1.00	1.07	1.34	1.46	1.18
75	0.62	0.62	0.70	0.70	0.79	0.79	0.88	0.88	0.97	0.97	1.06	1.06	1.15	1.15	1.23	1.54	1.68	1.35
80	0.70	0.70	0.80	0.80	0.90	0.90	1.00	1.00	1.10	1.10	1.21	1.21	1.30	1.30	1.40	1.75	1.91	1.54
85	0.80	0.80	0.90	0.90	1.01	1.01	1.13	1.13	1.25	1.25	1.36	1.36	1.47	1.47	1.58	1.98	2.16	1.74
90	0.89	0.89	1.01	1.01	1.14	1.14	1.27	1.27	1.40	1.40	1.53	1.53	1.65	1.65	1.77	2.22	2.42	1.95
95	0.99	0.99	1.13	1.13	1.27	1.27	1.41	1.41	1.56	1.56	1.70	1.70	1.84	1.84	1.97	2.47	2.69	2.17
100	1.10	1.10	1.25	1.25	1.40	1.40	1.56	1.56	1.72	1.72	1.88	1.88	2.04	2.04	2.19	2.74	2.99	2.41
105	1.21	1.21	1.37	1.37	1.55	1.55	1.72	1.72	1.90	1.90	2.08	2.08	2.25	2.25	2.41	3.02	3.29	2.66
110	1.33	1.33	1.51	1.51	1.70	1.70	1.89	1.89	2.09	2.09	2.28	2.28	2.47	2.47	2.65	3.31	3.61	2.91
115	1.46	1.46	1.65	1.65	1.86	1.86	2.07	2.07	2.28	2.28	2.49	2.49	2.70	2.70	2.89	3.62	3.95	3.19
CONDUCTOR	**NO WIND TENSION (kN)**																
FLUORINE (7/3.00)	1.50	1.50	1.33	1.33	1.18	1.18	1.06	1.06	0.96	0.96	0.88	0.88	0.81	0.81	0.76	0.60	0.55	

Sag and Blowout Calculations for FLUORINE. **Refer NOTES Section 5.1.1** Creep Allowance: **5ºC**

5.4.3 AAAC 1120 Limited 10% NBL 100m MES

SPAN LENGTH (m)	SAG (m)																	BLOW OUT (m)
	Temperature																	
	-5ºC	0ºC		5ºC		10ºC		15ºC		20ºC		25ºC		30ºC		50ºC	60ºC	
	FINAL	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL	FINAL	FINAL	
50	0.30	0.30	0.32	0.32	0.35	0.35	0.38	0.38	0.40	0.40	0.43	0.43	0.46	0.46	0.48	0.57	0.61	0.53
55	0.36	0.36	0.39	0.39	0.42	0.42	0.46	0.46	0.49	0.49	0.52	0.52	0.55	0.55	0.58	0.69	0.74	0.64
60	0.43	0.43	0.47	0.47	0.50	0.50	0.54	0.54	0.58	0.58	0.62	0.62	0.66	0.66	0.69	0.82	0.88	0.76
65	0.50	0.50	0.55	0.55	0.59	0.59	0.64	0.64	0.68	0.68	0.73	0.73	0.77	0.77	0.81	0.97	1.04	0.89
70	0.58	0.58	0.63	0.63	0.69	0.69	0.74	0.74	0.79	0.79	0.84	0.84	0.89	0.89	0.94	1.12	1.20	1.03
75	0.67	0.67	0.73	0.73	0.79	0.79	0.85	0.85	0.91	0.91	0.97	0.97	1.03	1.03	1.08	1.29	1.38	1.19
80	0.76	0.76	0.83	0.83	0.90	0.90	0.97	0.97	1.04	1.04	1.10	1.10	1.17	1.17	1.23	1.46	1.57	1.35
85	0.85	0.85	0.93	0.93	1.01	1.01	1.09	1.09	1.17	1.17	1.24	1.24	1.32	1.32	1.39	1.65	1.77	1.53
90	0.96	0.96	1.05	1.05	1.14	1.14	1.22	1.22	1.31	1.31	1.40	1.40	1.48	1.48	1.56	1.85	1.99	1.71
95	1.07	1.07	1.17	1.17	1.27	1.27	1.36	1.36	1.46	1.46	1.55	1.55	1.65	1.65	1.73	2.07	2.22	1.91
100	1.18	1.18	1.29	1.29	1.40	1.40	1.51	1.51	1.62	1.62	1.72	1.72	1.82	1.82	1.92	2.29	2.46	2.11
105	1.30	1.30	1.43	1.43	1.55	1.55	1.67	1.67	1.78	1.78	1.90	1.90	2.01	2.01	2.12	2.52	2.71	2.33
110	1.43	1.43	1.56	1.56	1.70	1.70	1.83	1.83	1.96	1.96	2.08	2.08	2.21	2.21	2.33	2.77	2.97	2.56
115	1.57	1.57	1.71	1.71	1.86	1.86	2.00	2.00	2.14	2.14	2.28	2.28	2.41	2.41	2.54	3.03	3.25	2.79
120	1.70	1.70	1.86	1.86	2.02	2.02	2.18	2.18	2.33	2.33	2.48	2.48	2.63	2.63	2.77	3.30	3.54	3.04
125	1.85	1.85	2.02	2.02	2.19	2.19	2.36	2.36	2.53	2.53	2.69	2.69	2.85	2.85	3.00	3.58	3.84	3.30
130	2.00	2.00	2.19	2.19	2.37	2.37	2.56	2.56	2.74	2.74	2.91	2.91	3.08	3.08	3.25	3.87	4.15	3.57
135	2.16	2.16	2.36	2.36	2.56	2.56	2.76	2.76	2.95	2.95	3.14	3.14	3.33	3.33	3.51	4.17	4.48	3.85
140	2.32	2.32	2.53	2.53	2.75	2.75	2.96	2.96	3.17	3.17	3.38	3.38	3.58	3.58	3.77	4.49	4.82	4.14
145	2.49	2.49	2.72	2.72	2.95	2.95	3.18	3.18	3.40	3.40	3.62	3.62	3.84	3.84	4.04	4.82	5.17	4.44
150	2.66	2.66	2.91	2.91	3.16	3.16	3.40	3.40	3.64	3.64	3.88	3.88	4.11	4.11	4.33	5.15	5.53	4.76
155	2.84	2.84	3.11	3.11	3.37	3.37	3.63	3.63	3.89	3.89	4.14	4.14	4.38	4.38	4.62	5.50	5.91	5.08
160	3.03	3.03	3.31	3.31	3.59	3.59	3.87	3.87	4.15	4.15	4.41	4.41	4.67	4.67	4.93	5.87	6.30	5.41
CONDUCTOR	**NO WIND TENSION (kN)**																	
FLUORINE (7/3.00)	1.40	1.40	1.28	1.28	1.18	1.18	1.10	1.10	1.02	1.02	0.96	0.96	0.91	0.91	0.86	0.72	0.67	

Sag and Blowout Calculations for FLUORINE. **Refer NOTES Section 5.1.1** Creep Allowance: **5ºC**

5.4.4 AAAC 1120 Limited 10% NBL Mechanical Forces per Conductor

SPAN LENGTH (m)	CONDUCTOR TENSION (kN)	
	FLUORINE (7/3.00)	
	No Wind	Max Wind
30	1.30	2.58
40		3.04
50		3.44
60		3.80
70		4.14
80		4.44
90		4.73
100		4.99
110		5.23
120		5.45
130		5.65
140		5.85
150		6.03
160		6.19

MES = Span Length. No Wind tension is at 5°C and includes 1.1 Load Factor. Max Wind (900Pa) tension is at 15°C and includes 1.25 Load Factor.

5.4.5 AAAC 1120 Medium 18% NBL 100m MES

SPAN LENGTH (m)	SAG (m) Temperature																BLOW OUT (m)
	-5ºC	0ºC		5ºC		10ºC		15ºC		20ºC		25ºC		30ºC		50ºC	60ºC	
	FINAL	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	**FINAL**	**FINAL**	
50	0.16	0.14	0.18	0.16	0.19	0.18	0.22	0.19	0.24	0.22	0.27	0.24	0.29	0.27	0.32	0.43	0.48	0.42
55	0.19	0.17	0.21	0.19	0.24	0.21	0.26	0.24	0.29	0.26	0.32	0.29	0.35	0.32	0.39	0.52	0.58	0.51
60	0.23	0.21	0.25	0.23	0.28	0.25	0.31	0.28	0.35	0.31	0.38	0.35	0.42	0.38	0.46	0.62	0.69	0.61
65	0.27	0.24	0.30	0.27	0.33	0.30	0.37	0.33	0.41	0.37	0.45	0.41	0.49	0.45	0.54	0.72	0.81	0.71
70	0.31	0.28	0.34	0.31	0.38	0.34	0.42	0.38	0.47	0.42	0.52	0.47	0.57	0.52	0.63	0.84	0.94	0.83
75	0.36	0.32	0.39	0.36	0.44	0.39	0.49	0.44	0.54	0.49	0.60	0.54	0.66	0.60	0.72	0.96	1.07	0.95
80	0.41	0.37	0.45	0.41	0.50	0.45	0.55	0.50	0.62	0.55	0.68	0.62	0.75	0.68	0.82	1.09	1.22	1.08
85	0.46	0.42	0.51	0.46	0.56	0.51	0.63	0.56	0.69	0.63	0.77	0.69	0.85	0.77	0.93	1.24	1.38	1.22
90	0.51	0.47	0.57	0.51	0.63	0.57	0.70	0.63	0.78	0.70	0.86	0.78	0.95	0.86	1.04	1.39	1.55	1.37
95	0.57	0.52	0.63	0.57	0.70	0.63	0.78	0.70	0.87	0.78	0.96	0.87	1.06	0.96	1.16	1.54	1.72	1.53
100	0.63	0.58	0.70	0.63	0.78	0.70	0.87	0.78	0.96	0.87	1.06	0.96	1.17	1.06	1.28	1.71	1.91	1.69
105	0.70	0.63	0.77	0.70	0.86	0.77	0.95	0.86	1.06	0.95	1.17	1.06	1.29	1.17	1.41	1.89	2.11	1.86
110	0.77	0.70	0.85	0.77	0.94	0.85	1.05	0.94	1.16	1.05	1.29	1.16	1.42	1.29	1.55	2.07	2.31	2.05
115	0.84	0.76	0.93	0.84	1.03	0.93	1.15	1.03	1.27	1.15	1.41	1.27	1.55	1.41	1.69	2.26	2.53	2.24
120	0.91	0.83	1.01	0.91	1.12	1.01	1.25	1.12	1.38	1.25	1.53	1.38	1.69	1.53	1.84	2.46	2.75	2.43
125	0.99	0.90	1.10	0.99	1.22	1.10	1.35	1.22	1.50	1.35	1.66	1.50	1.83	1.66	2.00	2.67	2.99	2.64
130	1.07	0.97	1.19	1.07	1.32	1.19	1.46	1.32	1.63	1.46	1.80	1.63	1.98	1.80	2.16	2.89	3.23	2.86
135	1.16	1.05	1.28	1.16	1.42	1.28	1.58	1.42	1.75	1.58	1.94	1.75	2.13	1.94	2.33	3.12	3.48	3.08
140	1.24	1.13	1.38	1.24	1.53	1.38	1.70	1.53	1.89	1.70	2.09	1.89	2.30	2.09	2.51	3.35	3.75	3.31
145	1.33	1.21	1.48	1.33	1.64	1.48	1.82	1.64	2.02	1.82	2.24	2.02	2.46	2.24	2.69	3.60	4.02	3.56
150	1.43	1.29	1.58	1.43	1.75	1.58	1.95	1.75	2.16	1.95	2.39	2.16	2.64	2.39	2.88	3.85	4.30	3.81
155	1.52	1.38	1.69	1.52	1.87	1.69	2.08	1.87	2.31	2.08	2.56	2.31	2.81	2.56	3.08	4.11	4.59	4.06
160	1.62	1.47	1.80	1.62	1.99	1.80	2.22	1.99	2.46	2.22	2.72	2.46	3.00	2.72	3.28	4.38	4.90	4.33
CONDUCTOR	**NO WIND TENSION (kN)**																
FLUORINE (7/3.00)	2.61	2.88	2.36	2.61	2.12	2.36	1.91	2.12	1.72	1.91	1.56	1.72	1.41	1.56	1.29	0.97	0.87	

Sag and Blowout Calculations for FLUORINE. **Refer NOTES Section 5.1.1** Creep Allowance: **10ºC**

5.4.6 AAAC 1120 Medium 18% NBL 150m MES

SPAN LENGTH (m)	SAG (m) Temperature																BLOW OUT (m)
	-5ºC	0ºC		5ºC		10ºC		15ºC		20ºC		25ºC		30ºC		50ºC	60ºC	
	FINAL	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	**FINAL**	**FINAL**	
80	0.43	0.39	0.46	0.43	0.50	0.46	0.54	0.50	0.58	0.54	0.62	0.58	0.66	0.62	0.70	0.86	0.93	0.90
90	0.54	0.50	0.58	0.54	0.63	0.58	0.68	0.63	0.73	0.68	0.78	0.73	0.83	0.78	0.89	1.09	1.18	1.13
100	0.67	0.61	0.72	0.67	0.78	0.72	0.84	0.78	0.90	0.84	0.97	0.90	1.03	0.97	1.09	1.34	1.46	1.40
110	0.80	0.74	0.87	0.80	0.94	0.87	1.02	0.94	1.09	1.02	1.17	1.09	1.25	1.17	1.32	1.62	1.76	1.70
120	0.96	0.88	1.04	0.96	1.12	1.04	1.21	1.12	1.30	1.21	1.39	1.30	1.48	1.39	1.58	1.93	2.10	2.02
130	1.12	1.04	1.22	1.12	1.32	1.22	1.42	1.32	1.53	1.42	1.63	1.53	1.74	1.63	1.85	2.27	2.46	2.37
140	1.30	1.20	1.41	1.30	1.53	1.41	1.65	1.53	1.77	1.65	1.90	1.77	2.02	1.90	2.15	2.63	2.86	2.75
150	1.50	1.38	1.62	1.50	1.75	1.62	1.89	1.75	2.03	1.89	2.18	2.03	2.32	2.18	2.46	3.02	3.28	3.15
160	1.70	1.57	1.84	1.70	1.99	1.84	2.15	1.99	2.31	2.15	2.48	2.31	2.64	2.48	2.80	3.43	3.73	3.59
170	1.92	1.77	2.08	1.92	2.25	2.08	2.43	2.25	2.61	2.43	2.79	2.61	2.98	2.79	3.16	3.88	4.21	4.05
180	2.16	1.99	2.34	2.16	2.53	2.34	2.72	2.53	2.93	2.72	3.13	2.93	3.34	3.13	3.55	4.35	4.72	4.54
190	2.40	2.22	2.60	2.40	2.81	2.60	3.03	2.81	3.26	3.03	3.49	3.26	3.72	3.49	3.95	4.84	5.26	5.06
200	2.66	2.45	2.88	2.66	3.12	2.88	3.36	3.12	3.61	3.36	3.87	3.61	4.12	3.87	4.38	5.37	5.83	5.61
210	2.93	2.71	3.18	2.93	3.44	3.18	3.71	3.44	3.98	3.71	4.27	3.98	4.55	4.27	4.83	5.92	6.43	6.18
220	3.22	2.97	3.49	3.22	3.77	3.49	4.07	3.77	4.37	4.07	4.68	4.37	4.99	4.68	5.30	6.50	7.06	6.79
230	3.52	3.25	3.81	3.52	4.12	3.81	4.45	4.12	4.78	4.45	5.12	4.78	5.46	5.12	5.79	7.10	7.72	7.42
CONDUCTOR	**NO WIND TENSION (kN)**																
FLUORINE (7/3.00)	2.49	2.70	2.30	2.49	2.12	2.30	1.97	2.12	1.83	1.97	1.71	1.83	1.61	1.71	1.51	1.23	1.14	

Sag and Blowout Calculations for FLUORINE. **Refer NOTES Section 5.1.1** Creep Allowance: **10ºC**

5.4.7 AAAC 1120 Medium 18% NBL Mechanical Forces per Conductor

SPAN LENGTH (m)	CONDUCTOR TENSION (kN)	
	FLUORINE (7/3.00)	
	No Wind	Max Wind
50	2.33	4.04
60		4.44
70		4.80
80		5.15
90		5.49
100		5.80
110		6.11
120		6.40
130		6.68
140		6.94
150		7.20
160		7.44
170		7.68
180		7.91
190		8.13
200		8.34
210		8.55
220		8.75
230		8.94

MES = Span Length. No Wind tension is at 5°C and includes 1.1 Load Factor. Max Wind (900Pa) tension is at 15°C and includes 1.25 Load Factor.

5.4.8 AAAC 1120 Full 22% NBL 100m MES

SPAN LENGTH (m)	SAG (m)																BLOW OUT (m)
	Temperature																
	-5ºC	0ºC		5ºC		10ºC		15ºC		20ºC		25ºC		30ºC		50ºC	60ºC	
	FINAL	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL	FINAL	FINAL	
50	0.13	0.12	0.14	0.13	0.16	0.14	0.18	0.16	0.20	0.18	0.22	0.20	0.24	0.22	0.27	0.38	0.43	0.39
55	0.16	0.15	0.17	0.16	0.19	0.17	0.21	0.19	0.24	0.21	0.26	0.24	0.29	0.26	0.32	0.46	0.52	0.47
60	0.19	0.17	0.21	0.19	0.23	0.21	0.25	0.23	0.28	0.25	0.31	0.28	0.35	0.31	0.39	0.54	0.62	0.56
65	0.22	0.20	0.24	0.22	0.27	0.24	0.30	0.27	0.33	0.30	0.37	0.33	0.41	0.37	0.45	0.64	0.72	0.66
70	0.26	0.24	0.28	0.26	0.31	0.28	0.35	0.31	0.38	0.35	0.43	0.38	0.47	0.43	0.52	0.74	0.84	0.76
75	0.30	0.27	0.33	0.30	0.36	0.33	0.40	0.36	0.44	0.40	0.49	0.44	0.54	0.49	0.60	0.85	0.97	0.88
80	0.34	0.31	0.37	0.34	0.41	0.37	0.45	0.41	0.50	0.45	0.56	0.50	0.62	0.56	0.68	0.96	1.10	1.00
85	0.38	0.35	0.42	0.38	0.46	0.42	0.51	0.46	0.57	0.51	0.63	0.57	0.70	0.63	0.77	1.09	1.24	1.13
90	0.43	0.39	0.47	0.43	0.52	0.47	0.57	0.52	0.63	0.57	0.71	0.63	0.78	0.71	0.87	1.22	1.39	1.26
95	0.48	0.44	0.52	0.48	0.58	0.52	0.64	0.58	0.71	0.64	0.79	0.71	0.87	0.79	0.97	1.36	1.55	1.41
100	0.53	0.48	0.58	0.53	0.64	0.58	0.71	0.64	0.78	0.71	0.87	0.78	0.97	0.87	1.07	1.50	1.72	1.56
105	0.58	0.53	0.64	0.58	0.70	0.64	0.78	0.70	0.86	0.78	0.96	0.86	1.07	0.96	1.18	1.66	1.89	1.72
110	0.64	0.58	0.70	0.64	0.77	0.70	0.85	0.77	0.95	0.85	1.05	0.95	1.17	1.05	1.29	1.82	2.08	1.89
115	0.70	0.64	0.76	0.70	0.84	0.76	0.93	0.84	1.04	0.93	1.15	1.04	1.28	1.15	1.41	1.99	2.27	2.06
120	0.76	0.70	0.83	0.76	0.92	0.83	1.02	0.92	1.13	1.02	1.25	1.13	1.39	1.25	1.54	2.17	2.47	2.25
125	0.82	0.75	0.90	0.82	1.00	0.90	1.10	1.00	1.22	1.10	1.36	1.22	1.51	1.36	1.67	2.35	2.68	2.44
130	0.89	0.82	0.98	0.89	1.08	0.98	1.19	1.08	1.32	1.19	1.47	1.32	1.63	1.47	1.81	2.54	2.90	2.64
135	0.96	0.88	1.05	0.96	1.16	1.05	1.29	1.16	1.43	1.29	1.59	1.43	1.76	1.59	1.95	2.74	3.13	2.84
140	1.03	0.95	1.13	1.03	1.25	1.13	1.38	1.25	1.54	1.38	1.71	1.54	1.90	1.71	2.10	2.95	3.36	3.06
145	1.11	1.02	1.22	1.11	1.34	1.22	1.48	1.34	1.65	1.48	1.83	1.65	2.03	1.83	2.25	3.16	3.61	3.28
150	1.19	1.09	1.30	1.19	1.43	1.30	1.59	1.43	1.76	1.59	1.96	1.76	2.18	1.96	2.41	3.39	3.86	3.51
155	1.27	1.16	1.39	1.27	1.53	1.39	1.70	1.53	1.88	1.70	2.09	1.88	2.32	2.09	2.57	3.62	4.12	3.75
160	1.35	1.24	1.48	1.35	1.63	1.48	1.81	1.63	2.01	1.81	2.23	2.01	2.48	2.23	2.74	3.85	4.40	3.99
CONDUCTOR	**NO WIND TENSION (kN)**																
FLUORINE (7/3.00)	3.14	3.43	2.86	3.14	2.60	2.86	2.34	2.60	2.11	2.34	1.90	2.11	1.71	1.90	1.55	1.10	0.96	

Sag and Blowout Calculations for FLUORINE. **Refer NOTES Section 5.1.1** Creep Allowance: **10ºC**

5.4.9 AAAC 1120 Full 22% NBL 150m MES

SPAN LENGTH (m)	SAG (m) Temperature -5ºC	0ºC		5ºC		10ºC		15ºC		20ºC		25ºC		30ºC		50ºC	60ºC	BLOW OUT (m)
	FINAL	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	**FINAL**	**FINAL**	
80	0.35	0.32	0.38	0.35	0.41	0.38	0.44	0.41	0.48	0.44	0.52	0.48	0.56	0.52	0.60	0.76	0.84	0.83
90	0.44	0.41	0.48	0.44	0.52	0.48	0.56	0.52	0.61	0.56	0.65	0.61	0.70	0.65	0.76	0.96	1.06	1.05
100	0.54	0.50	0.59	0.54	0.64	0.59	0.69	0.64	0.75	0.69	0.81	0.75	0.87	0.81	0.93	1.19	1.31	1.30
110	0.66	0.61	0.71	0.66	0.77	0.71	0.84	0.77	0.91	0.84	0.98	0.91	1.05	0.98	1.13	1.44	1.58	1.57
120	0.78	0.72	0.85	0.78	0.92	0.85	1.00	0.92	1.08	1.00	1.16	1.08	1.25	1.16	1.34	1.71	1.89	1.87
130	0.92	0.85	0.99	0.92	1.08	0.99	1.17	1.08	1.26	1.17	1.37	1.26	1.47	1.37	1.58	2.01	2.21	2.20
140	1.06	0.98	1.15	1.06	1.25	1.15	1.35	1.25	1.47	1.35	1.58	1.47	1.70	1.58	1.83	2.33	2.57	2.55
150	1.22	1.13	1.32	1.22	1.43	1.32	1.55	1.43	1.68	1.55	1.82	1.68	1.96	1.82	2.10	2.67	2.95	2.92
160	1.39	1.29	1.51	1.39	1.63	1.51	1.77	1.63	1.92	1.77	2.07	1.92	2.23	2.07	2.39	3.04	3.35	3.33
170	1.57	1.45	1.70	1.57	1.84	1.70	2.00	1.84	2.16	2.00	2.34	2.16	2.51	2.34	2.70	3.43	3.79	3.76
180	1.76	1.63	1.91	1.76	2.07	1.91	2.24	2.07	2.42	2.24	2.62	2.42	2.82	2.62	3.02	3.85	4.24	4.21
190	1.96	1.81	2.12	1.96	2.30	2.12	2.49	2.30	2.70	2.49	2.92	2.70	3.14	2.92	3.37	4.29	4.73	4.69
200	2.17	2.01	2.35	2.17	2.55	2.35	2.76	2.55	2.99	2.76	3.23	2.99	3.48	3.23	3.73	4.75	5.24	5.20
210	2.39	2.21	2.59	2.39	2.81	2.59	3.05	2.81	3.30	3.05	3.56	3.30	3.84	3.56	4.12	5.24	5.78	5.74
220	2.63	2.43	2.85	2.63	3.09	2.85	3.35	3.09	3.62	3.35	3.91	3.62	4.21	3.91	4.52	5.75	6.34	6.30
230	2.87	2.66	3.11	2.87	3.37	3.11	3.66	3.37	3.96	3.66	4.28	3.96	4.60	4.28	4.94	6.28	6.93	6.88
240	3.13	2.89	3.39	3.13	3.67	3.39	3.98	3.67	4.31	3.98	4.66	4.31	5.01	4.66	5.38	6.84	7.55	7.49
CONDUCTOR	**NO WIND TENSION (kN)**																	
FLUORINE (7/3.00)	3.05	3.30	2.81	3.05	2.60	2.81	2.40	2.60	2.21	2.40	2.05	2.21	1.90	2.05	1.77	1.39	1.26	

Sag and Blowout Calculations for FLUORINE. **Refer NOTES Section 5.1.1** Creep Allowance: **10ºC**

5.4.10 AAAC 1120 Full 22% NBL 200m MES

	SAG (m)																BLOW OUT (m)
SPAN LENGTH (m)	Temperature																
	-5ºC	0ºC		5ºC		10ºC		15ºC		20ºC		25ºC		30ºC		50ºC	60ºC	
	FINAL	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL	FINAL	FINAL	
100	0.56	0.52	0.60	0.56	0.64	0.60	0.68	0.64	0.72	0.68	0.76	0.72	0.81	0.76	0.85	1.02	1.11	1.14
110	0.68	0.63	0.72	0.68	0.77	0.72	0.82	0.77	0.87	0.82	0.92	0.87	0.98	0.92	1.03	1.24	1.34	1.38
120	0.81	0.75	0.86	0.81	0.92	0.86	0.98	0.92	1.04	0.98	1.10	1.04	1.16	1.10	1.23	1.47	1.59	1.64
130	0.95	0.88	1.01	0.95	1.08	1.01	1.15	1.08	1.22	1.15	1.29	1.22	1.37	1.29	1.44	1.73	1.87	1.93
140	1.10	1.03	1.17	1.10	1.25	1.17	1.33	1.25	1.41	1.33	1.50	1.41	1.58	1.50	1.67	2.01	2.17	2.24
150	1.26	1.18	1.34	1.26	1.43	1.34	1.53	1.43	1.62	1.53	1.72	1.62	1.82	1.72	1.92	2.30	2.49	2.57
160	1.43	1.34	1.53	1.43	1.63	1.53	1.74	1.63	1.85	1.74	1.96	1.85	2.07	1.96	2.18	2.62	2.83	2.92
170	1.62	1.51	1.73	1.62	1.84	1.73	1.96	1.84	2.08	1.96	2.21	2.08	2.34	2.21	2.46	2.96	3.19	3.30
180	1.81	1.70	1.94	1.81	2.07	1.94	2.20	2.07	2.34	2.20	2.48	2.34	2.62	2.48	2.76	3.32	3.58	3.70
190	2.02	1.89	2.16	2.02	2.30	2.16	2.45	2.30	2.60	2.45	2.76	2.60	2.92	2.76	3.07	3.69	3.99	4.12
200	2.24	2.09	2.39	2.24	2.55	2.39	2.72	2.55	2.89	2.72	3.06	2.89	3.23	3.06	3.41	4.09	4.42	4.57
210	2.47	2.31	2.64	2.47	2.81	2.64	2.99	2.81	3.18	2.99	3.37	3.18	3.56	3.37	3.76	4.51	4.88	5.03
220	2.71	2.53	2.89	2.71	3.09	2.89	3.29	3.09	3.49	3.29	3.70	3.49	3.91	3.70	4.12	4.95	5.35	5.53
230	2.96	2.77	3.16	2.96	3.37	3.16	3.59	3.37	3.82	3.59	4.04	3.82	4.28	4.04	4.51	5.41	5.85	6.04
240	3.22	3.02	3.44	3.22	3.67	3.44	3.91	3.67	4.16	3.91	4.40	4.16	4.66	4.40	4.91	5.90	6.37	6.58
250	3.50	3.27	3.74	3.50	3.99	3.74	4.24	3.99	4.51	4.24	4.78	4.51	5.05	4.78	5.32	6.40	6.91	7.14
260	3.78	3.54	4.04	3.78	4.31	4.04	4.59	4.31	4.88	4.59	5.17	4.88	5.46	5.17	5.76	6.92	7.48	7.72
270	4.08	3.82	4.36	4.08	4.65	4.36	4.95	4.65	5.26	4.95	5.58	5.26	5.89	5.58	6.21	7.46	8.06	8.33
280	4.39	4.10	4.69	4.39	5.00	4.69	5.32	5.00	5.66	5.32	6.00	5.66	6.34	6.00	6.68	8.03	8.67	8.96
290	4.71	4.40	5.03	4.71	5.36	5.03	5.71	5.36	6.07	5.71	6.43	6.07	6.80	6.43	7.17	8.61	9.30	9.61
300	5.04	4.71	5.38	5.04	5.74	5.38	6.11	5.74	6.49	6.11	6.88	6.49	7.28	6.88	7.67	9.22	9.96	10.28
CONDUCTOR	**NO WIND TENSION (kN)**																
FLUORINE (7/3.00)	2.96	3.16	2.77	2.96	2.60	2.77	2.44	2.60	2.29	2.44	2.17	2.29	2.05	2.17	1.94	1.62	1.50	

Sag and Blowout Calculations for FLUORINE. **Refer NOTES Section 5.1.1** Creep Allowance: **10ºC**

5.4.11 AAAC 1120 Full 22% NBL 250m MES

SPAN LENGTH (m)	SAG (m)																BLOW OUT (m)
	Temperature																
	-5ºC	0ºC		5ºC		10ºC		15ºC		20ºC		25ºC		30ºC		50ºC	60ºC	
	FINAL	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	**FINAL**	**FINAL**	
130	0.97	0.92	1.02	0.97	1.08	1.02	1.13	1.08	1.19	1.13	1.24	1.19	1.30	1.24	1.35	1.56	1.66	1.75
140	1.13	1.07	1.19	1.13	1.25	1.19	1.31	1.25	1.38	1.31	1.44	1.38	1.50	1.44	1.57	1.81	1.93	2.03
150	1.29	1.22	1.36	1.29	1.43	1.36	1.51	1.43	1.58	1.51	1.65	1.58	1.73	1.65	1.80	2.08	2.21	2.33
160	1.47	1.39	1.55	1.47	1.63	1.55	1.71	1.63	1.80	1.71	1.88	1.80	1.96	1.88	2.05	2.37	2.52	2.65
170	1.66	1.57	1.75	1.66	1.84	1.75	1.94	1.84	2.03	1.94	2.12	2.03	2.22	2.12	2.31	2.67	2.84	2.99
180	1.86	1.76	1.96	1.86	2.07	1.96	2.17	2.07	2.27	2.17	2.38	2.27	2.48	2.38	2.59	2.99	3.19	3.35
190	2.07	1.96	2.19	2.07	2.30	2.19	2.42	2.30	2.53	2.42	2.65	2.53	2.77	2.65	2.88	3.34	3.55	3.73
200	2.30	2.18	2.42	2.30	2.55	2.42	2.68	2.55	2.81	2.68	2.94	2.81	3.07	2.94	3.20	3.70	3.94	4.14
210	2.53	2.40	2.67	2.53	2.81	2.67	2.95	2.81	3.10	2.95	3.24	3.10	3.38	3.24	3.52	4.08	4.34	4.56
220	2.78	2.63	2.93	2.78	3.09	2.93	3.24	3.09	3.40	3.24	3.56	3.40	3.71	3.56	3.87	4.47	4.76	5.01
230	3.04	2.88	3.20	3.04	3.37	3.20	3.54	3.37	3.71	3.54	3.89	3.71	4.06	3.89	4.23	4.89	5.21	5.47
240	3.31	3.13	3.49	3.31	3.67	3.49	3.86	3.67	4.05	3.86	4.23	4.05	4.42	4.23	4.60	5.32	5.67	5.96
250	3.59	3.40	3.79	3.59	3.99	3.79	4.19	3.99	4.39	4.19	4.59	4.39	4.79	4.59	4.99	5.78	6.15	6.47
260	3.88	3.68	4.10	3.88	4.31	4.10	4.53	4.31	4.75	4.53	4.97	4.75	5.19	4.97	5.40	6.25	6.66	7.00
270	4.19	3.97	4.42	4.19	4.65	4.42	4.88	4.65	5.12	4.88	5.36	5.12	5.59	5.36	5.83	6.74	7.18	7.55
280	4.50	4.27	4.75	4.50	5.00	4.75	5.25	5.00	5.51	5.25	5.76	5.51	6.01	5.76	6.27	7.25	7.72	8.12
290	4.83	4.58	5.10	4.83	5.36	5.10	5.63	5.36	5.91	5.63	6.18	5.91	6.45	6.18	6.72	7.78	8.28	8.71
300	5.17	4.90	5.45	5.17	5.74	5.45	6.03	5.74	6.32	6.03	6.61	6.32	6.90	6.61	7.19	8.32	8.86	9.32
310	5.52	5.23	5.82	5.52	6.13	5.82	6.44	6.13	6.75	6.44	7.06	6.75	7.37	7.06	7.68	8.89	9.47	9.95
320	5.88	5.57	6.21	5.88	6.53	6.21	6.86	6.53	7.19	6.86	7.53	7.19	7.86	7.53	8.19	9.47	10.09	10.60
330	6.26	5.93	6.60	6.26	6.95	6.60	7.30	6.95	7.65	7.30	8.00	7.65	8.36	8.00	8.71	10.07	10.73	11.28
CONDUCTOR	**NO WIND TENSION (kN)**																
FLUORINE (7/3.00)	2.88	3.04	2.73	2.88	2.60	2.73	2.47	2.60	2.36	2.47	2.25	2.36	2.16	2.25	2.07	1.79	1.68	

Sag and Blowout Calculations for FLUORINE. **Refer NOTES Section 5.1.1** Creep Allowance: **10ºC**

5.4.12 AAAC 1120 Full 22% NBL Mechanical Forces per Conductor

SPAN LENGTH (m)	CONDUCTOR TENSION (kN)	
	FLUORINE (7/3.00)	
	No Wind	Max Wind
50	2.86	4.35
60		4.74
70		5.11
80		5.46
90		5.80
100		6.13
110		6.44
120		6.74
130		7.03
140		7.30
150		7.56
160		7.83
170		8.09
180		8.33
190		8.56
200		8.80
210		9.03
220		9.24
230		9.45
240		9.66
250		9.86
260		10.06
270		10.25
280		10.44
290		10.61
300		10.80
310		10.98
320		11.14

MES = Span Length. No Wind tension is at 5°C and includes 1.1 Load Factor. Max Wind (900Pa) tension is at 15°C and includes 1.25 Load Factor.

5.5 ACSR/GZ Low Steel Content

5.5.1 ACSR/GZ Low Steel Limited 10% NBL 50m MES

	SAG (m)																BLOW OUT (m)
SPAN LENGTH (m)	Temperature																
	-5ºC	0ºC		5ºC		10ºC		15ºC		20ºC		25ºC		30ºC		50ºC	60ºC	
	FINAL	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL	FINAL	FINAL	
30	0.09	0.09	0.11	0.11	0.13	0.13	0.15	0.15	0.17	0.17	0.19	0.19	0.21	0.21	0.23	0.31	0.34	0.23
35	0.13	0.13	0.15	0.15	0.17	0.17	0.20	0.20	0.23	0.23	0.26	0.26	0.29	0.29	0.32	0.42	0.46	0.32
40	0.17	0.17	0.19	0.19	0.23	0.23	0.26	0.26	0.30	0.30	0.34	0.34	0.37	0.37	0.41	0.55	0.61	0.41
45	0.21	0.21	0.24	0.24	0.28	0.28	0.33	0.33	0.38	0.38	0.43	0.43	0.47	0.47	0.52	0.69	0.77	0.52
50	0.26	0.26	0.30	0.30	0.35	0.35	0.41	0.41	0.47	0.47	0.53	0.53	0.59	0.59	0.64	0.85	0.95	0.64
55	0.32	0.32	0.37	0.37	0.43	0.43	0.49	0.49	0.56	0.56	0.64	0.64	0.71	0.71	0.78	1.03	1.14	0.78
60	0.38	0.38	0.44	0.44	0.51	0.51	0.59	0.59	0.67	0.67	0.76	0.76	0.84	0.84	0.93	1.23	1.36	0.93
65	0.44	0.44	0.51	0.51	0.59	0.59	0.69	0.69	0.79	0.79	0.89	0.89	0.99	0.99	1.09	1.44	1.60	1.09
70	0.51	0.51	0.59	0.59	0.69	0.69	0.80	0.80	0.91	0.91	1.03	1.03	1.15	1.15	1.26	1.67	1.86	1.26
75	0.59	0.59	0.68	0.68	0.79	0.79	0.92	0.92	1.05	1.05	1.18	1.18	1.32	1.32	1.45	1.92	2.13	1.45
80	0.67	0.67	0.77	0.77	0.90	0.90	1.04	1.04	1.19	1.19	1.35	1.35	1.50	1.50	1.65	2.19	2.42	1.65
CONDUCTOR	**NO WIND TENSION (kN)**																
ALMOND (6/1/2.50)	1.42	1.42	1.22	1.22	1.05	1.05	0.91	0.91	0.79	0.79	0.70	0.70	0.63	0.63	0.57	0.43	0.39	
APPLE (6/1/3.00)	2.01	2.01	1.73	1.73	1.49	1.49	1.29	1.29	1.12	1.12	1.00	1.00	0.89	0.89	0.81	0.61	0.55	
BANANA (6/1/3.75)	3.06	3.06	2.64	2.64	2.27	2.27	1.97	1.97	1.72	1.72	1.53	1.53	1.38	1.38	1.26	0.95	0.86	
CHERRY (6/4.75+7/1.60)	4.52	4.52	3.87	3.87	3.32	3.32	2.87	2.87	2.51	2.51	2.23	2.23	2.01	2.01	1.84	1.40	1.27	

Sag and Blowout Calculations for APPLE. **Refer NOTES Section 5.1.1** Creep Allowance: **5ºC**

5.5.2 ACSR/GZ Low Steel Limited 10% NBL 75m MES

SPAN LENGTH (m)	SAG (m)																BLOW OUT (m)
	Temperature																
	-5ºC	0ºC		5ºC		10ºC		15ºC		20ºC		25ºC		30ºC		50ºC	60ºC	
	FINAL	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	**FINAL**	**FINAL**	
40	0.18	0.18	0.20	0.20	0.23	0.23	0.25	0.25	0.27	0.27	0.29	0.29	0.31	0.31	0.33	0.41	0.45	0.34
45	0.23	0.23	0.26	0.26	0.28	0.28	0.31	0.31	0.34	0.34	0.37	0.37	0.40	0.40	0.42	0.52	0.57	0.43
50	0.28	0.28	0.32	0.32	0.35	0.35	0.39	0.39	0.42	0.42	0.46	0.46	0.49	0.49	0.52	0.64	0.70	0.53
55	0.34	0.34	0.38	0.38	0.43	0.43	0.47	0.47	0.51	0.51	0.55	0.55	0.59	0.59	0.63	0.78	0.84	0.65
60	0.41	0.41	0.46	0.46	0.51	0.51	0.56	0.56	0.61	0.61	0.66	0.66	0.71	0.71	0.75	0.93	1.01	0.77
65	0.48	0.48	0.54	0.54	0.59	0.59	0.65	0.65	0.71	0.71	0.77	0.77	0.83	0.83	0.88	1.09	1.18	0.90
70	0.56	0.56	0.62	0.62	0.69	0.69	0.76	0.76	0.83	0.83	0.89	0.89	0.96	0.96	1.02	1.26	1.37	1.05
75	0.64	0.64	0.71	0.71	0.79	0.79	0.87	0.87	0.95	0.95	1.03	1.03	1.10	1.10	1.18	1.45	1.57	1.20
80	0.73	0.73	0.81	0.81	0.90	0.90	0.99	0.99	1.08	1.08	1.17	1.17	1.25	1.25	1.34	1.65	1.79	1.37
85	0.82	0.82	0.92	0.92	1.02	1.02	1.12	1.12	1.22	1.22	1.32	1.32	1.42	1.42	1.51	1.86	2.02	1.55
90	0.92	0.92	1.03	1.03	1.14	1.14	1.25	1.25	1.37	1.37	1.48	1.48	1.59	1.59	1.69	2.09	2.26	1.73
95	1.03	1.03	1.15	1.15	1.27	1.27	1.40	1.40	1.52	1.52	1.65	1.65	1.77	1.77	1.89	2.32	2.52	1.93
100	1.14	1.14	1.27	1.27	1.41	1.41	1.55	1.55	1.69	1.69	1.83	1.83	1.96	1.96	2.09	2.57	2.79	2.14
105	1.25	1.25	1.40	1.40	1.55	1.55	1.71	1.71	1.86	1.86	2.01	2.01	2.16	2.16	2.31	2.84	3.08	2.36
110	1.38	1.38	1.54	1.54	1.70	1.70	1.87	1.87	2.04	2.04	2.21	2.21	2.37	2.37	2.53	3.12	3.38	2.59
115	1.50	1.50	1.68	1.68	1.86	1.86	2.05	2.05	2.23	2.23	2.41	2.41	2.59	2.59	2.77	3.41	3.70	2.83
CONDUCTOR	**NO WIND TENSION (kN)**																
ALMOND (6/1/2.50)	1.30	1.30	1.16	1.16	1.05	1.05	0.95	0.95	0.87	0.87	0.81	0.81	0.75	0.75	0.70	0.57	0.53	
APPLE (6/1/3.00)	1.84	1.84	1.65	1.65	1.49	1.49	1.36	1.36	1.24	1.24	1.15	1.15	1.07	1.07	1.00	0.81	0.75	
BANANA (6/1/3.75)	2.80	2.80	2.51	2.51	2.27	2.27	2.07	2.07	1.90	1.90	1.76	1.76	1.65	1.65	1.55	1.26	1.16	
CHERRY (6/4.75+7/1.60)	4.10	4.10	3.67	3.67	3.32	3.32	3.03	3.03	2.78	2.78	2.58	2.58	2.41	2.41	2.27	1.86	1.71	

Sag and Blowout Calculations for APPLE. **Refer NOTES Section 5.1.1** Creep Allowance: **5ºC**

5.5.3 ACSR/GZ Low Steel Limited 10% NBL 100m MES

SPAN LENGTH (m)	SAG (m) Temperature -5ºC	0ºC		5ºC		10ºC		15ºC		20ºC		25ºC		30ºC		50ºC	60ºC	BLOW OUT (m)
	FINAL	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	**FINAL**	**FINAL**	
50	0.30	0.30	0.33	0.33	0.35	0.35	0.38	0.38	0.40	0.40	0.42	0.42	0.44	0.44	0.46	0.54	0.58	0.48
55	0.37	0.37	0.40	0.40	0.43	0.43	0.45	0.45	0.48	0.48	0.51	0.51	0.54	0.54	0.56	0.66	0.70	0.58
60	0.44	0.44	0.47	0.47	0.51	0.51	0.54	0.54	0.57	0.57	0.61	0.61	0.64	0.64	0.67	0.78	0.84	0.68
65	0.51	0.51	0.55	0.55	0.59	0.59	0.63	0.63	0.67	0.67	0.71	0.71	0.75	0.75	0.78	0.92	0.98	0.80
70	0.60	0.60	0.64	0.64	0.69	0.69	0.74	0.74	0.78	0.78	0.82	0.82	0.87	0.87	0.91	1.07	1.14	0.93
75	0.68	0.68	0.74	0.74	0.79	0.79	0.84	0.84	0.90	0.90	0.95	0.95	1.00	1.00	1.04	1.22	1.31	1.07
80	0.78	0.78	0.84	0.84	0.90	0.90	0.96	0.96	1.02	1.02	1.08	1.08	1.13	1.13	1.19	1.39	1.49	1.22
85	0.88	0.88	0.95	0.95	1.02	1.02	1.08	1.08	1.15	1.15	1.22	1.22	1.28	1.28	1.34	1.57	1.68	1.37
90	0.99	0.99	1.06	1.06	1.14	1.14	1.22	1.22	1.29	1.29	1.36	1.36	1.43	1.43	1.50	1.76	1.88	1.54
95	1.10	1.10	1.18	1.18	1.27	1.27	1.35	1.35	1.44	1.44	1.52	1.52	1.60	1.60	1.68	1.96	2.10	1.72
100	1.22	1.22	1.31	1.31	1.41	1.41	1.50	1.50	1.59	1.59	1.68	1.68	1.77	1.77	1.86	2.18	2.32	1.90
105	1.34	1.34	1.45	1.45	1.55	1.55	1.65	1.65	1.76	1.76	1.86	1.86	1.95	1.95	2.05	2.40	2.56	2.10
110	1.47	1.47	1.59	1.59	1.70	1.70	1.82	1.82	1.93	1.93	2.04	2.04	2.14	2.14	2.25	2.63	2.81	2.30
115	1.61	1.61	1.74	1.74	1.86	1.86	1.99	1.99	2.11	2.11	2.23	2.23	2.34	2.34	2.46	2.88	3.08	2.52
120	1.75	1.75	1.89	1.89	2.03	2.03	2.16	2.16	2.29	2.29	2.42	2.42	2.55	2.55	2.67	3.14	3.35	2.74
125	1.90	1.90	2.05	2.05	2.20	2.20	2.35	2.35	2.49	2.49	2.63	2.63	2.77	2.77	2.90	3.40	3.63	2.97
130	2.06	2.06	2.22	2.22	2.38	2.38	2.54	2.54	2.69	2.69	2.85	2.85	2.99	2.99	3.14	3.68	3.93	3.22
135	2.22	2.22	2.39	2.39	2.57	2.57	2.74	2.74	2.90	2.90	3.07	3.07	3.23	3.23	3.38	3.97	4.24	3.47
140	2.38	2.38	2.57	2.57	2.76	2.76	2.94	2.94	3.12	3.12	3.30	3.30	3.47	3.47	3.64	4.27	4.56	3.73
145	2.56	2.56	2.76	2.76	2.96	2.96	3.16	3.16	3.35	3.35	3.54	3.54	3.73	3.73	3.91	4.58	4.89	4.00
150	2.74	2.74	2.95	2.95	3.17	3.17	3.38	3.38	3.59	3.59	3.79	3.79	3.99	3.99	4.18	4.90	5.24	4.28
CONDUCTOR	**NO WIND TENSION (kN)**																	
ALMOND (6/1/2.50)	1.22	1.22	1.13	1.13	1.05	1.05	0.98	0.98	0.93	0.93	0.88	0.88	0.83	0.83	0.79	0.68	0.63	
APPLE (6/1/3.00)	1.72	1.72	1.60	1.60	1.49	1.49	1.40	1.40	1.32	1.32	1.25	1.25	1.18	1.18	1.13	0.96	0.90	
BANANA (6/1/3.75)	2.61	2.61	2.43	2.43	2.27	2.27	2.13	2.13	2.01	2.01	1.91	1.91	1.82	1.82	1.74	1.49	1.40	
CHERRY (6/4.75+7/1.60)	3.82	3.82	3.55	3.55	3.32	3.32	3.12	3.12	2.95	2.95	2.80	2.80	2.67	2.67	2.55	2.19	2.05	

Sag and Blowout Calculations for APPLE. **Refer NOTES Section 5.1.1** Creep Allowance: **5ºC**

5.5.4 ACSR/GZ Low Steel Limited 10% NBL Mechanical Forces per Conductor

SPAN LENGTH (m)	CONDUCTOR TENSION (kN)							
	ALMOND (6/1/2.50)		APPLE (6/1/3.00)		BANANA (6/1/3.75)		CHERRY (6/4.75+7/1.60)	
	No Wind	Max Wind	No Wind	Max Wind	No Wind	Max Wind	No Wind	Max Wind
30	1.16	2.30	1.64	2.96	2.51	4.05	3.67	5.45
40		2.71		3.48		4.73		6.33
50		3.06		3.91		5.30		7.09
60		3.39		4.31		5.83		7.75
70		3.68		4.68		6.28		8.34
80		3.94		5.00		6.69		8.86
90		4.18		5.29		7.06		9.33
100		4.40		5.56		7.39		9.73
110		4.61		5.80		7.70		10.10
120		4.80		6.03		7.96		10.43
130		4.98		6.23		8.21		10.73
140		5.13		6.41		8.44		11.00
150		5.28		6.59		8.64		11.24

MES = Span Length. No Wind tension is at 5°C and includes 1.1 Load Factor. Max Wind (900Pa) tension is at 15°C and includes 1.25 Load Factor.

5.5.5 ACSR/GZ Low Steel Medium 18% NBL 100m MES

SPAN LENGTH (m)	SAG (m)																	BLOW OUT (m)
	Temperature																	
	-5ºC	0ºC		5ºC		10ºC		15ºC		20ºC		25ºC		30ºC		50ºC	60ºC	
	FINAL	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL	FINAL	FINAL	
50	0.16	0.15	0.18	0.16	0.20	0.18	0.21	0.20	0.24	0.21	0.26	0.24	0.28	0.26	0.31	0.40	0.44	0.37
55	0.20	0.18	0.21	0.20	0.24	0.21	0.26	0.24	0.29	0.26	0.31	0.29	0.34	0.31	0.37	0.48	0.54	0.44
60	0.23	0.21	0.26	0.23	0.28	0.26	0.31	0.28	0.34	0.31	0.37	0.34	0.41	0.37	0.44	0.58	0.64	0.53
65	0.27	0.25	0.30	0.27	0.33	0.30	0.36	0.33	0.40	0.36	0.44	0.40	0.48	0.44	0.52	0.68	0.75	0.62
70	0.32	0.29	0.35	0.32	0.38	0.35	0.42	0.38	0.46	0.42	0.51	0.46	0.55	0.51	0.60	0.78	0.87	0.72
75	0.36	0.33	0.40	0.36	0.44	0.40	0.48	0.44	0.53	0.48	0.58	0.53	0.63	0.58	0.69	0.90	1.00	0.82
80	0.41	0.38	0.45	0.41	0.50	0.45	0.55	0.50	0.60	0.55	0.66	0.60	0.72	0.66	0.78	1.02	1.14	0.94
85	0.47	0.43	0.51	0.47	0.56	0.51	0.62	0.56	0.68	0.62	0.75	0.68	0.81	0.75	0.88	1.15	1.28	1.06
90	0.52	0.48	0.58	0.52	0.63	0.58	0.70	0.63	0.76	0.70	0.84	0.76	0.91	0.84	0.99	1.29	1.44	1.19
95	0.58	0.53	0.64	0.58	0.71	0.64	0.78	0.71	0.85	0.78	0.93	0.85	1.02	0.93	1.10	1.44	1.60	1.32
100	0.65	0.59	0.71	0.65	0.78	0.71	0.86	0.78	0.94	0.86	1.03	0.94	1.13	1.03	1.22	1.60	1.78	1.47
105	0.71	0.65	0.78	0.71	0.86	0.78	0.95	0.86	1.04	0.95	1.14	1.04	1.24	1.14	1.35	1.76	1.96	1.62
110	0.78	0.72	0.86	0.78	0.95	0.86	1.04	0.95	1.14	1.04	1.25	1.14	1.36	1.25	1.48	1.93	2.15	1.77
115	0.86	0.78	0.94	0.86	1.03	0.94	1.14	1.03	1.25	1.14	1.37	1.25	1.49	1.37	1.62	2.11	2.35	1.94
120	0.93	0.85	1.02	0.93	1.13	1.02	1.24	1.13	1.36	1.24	1.49	1.36	1.62	1.49	1.76	2.30	2.56	2.11
125	1.01	0.92	1.11	1.01	1.22	1.11	1.34	1.22	1.48	1.34	1.62	1.48	1.76	1.62	1.91	2.50	2.78	2.29
130	1.09	1.00	1.20	1.09	1.32	1.20	1.45	1.32	1.60	1.45	1.75	1.60	1.91	1.75	2.07	2.70	3.00	2.48
135	1.18	1.08	1.30	1.18	1.42	1.30	1.57	1.42	1.72	1.57	1.88	1.72	2.05	1.88	2.23	2.91	3.24	2.67
140	1.27	1.16	1.39	1.27	1.53	1.39	1.69	1.53	1.85	1.69	2.03	1.85	2.21	2.03	2.40	3.13	3.48	2.87
145	1.36	1.24	1.49	1.36	1.64	1.49	1.81	1.64	1.99	1.81	2.17	1.99	2.37	2.17	2.57	3.36	3.74	3.08
150	1.46	1.33	1.60	1.46	1.76	1.60	1.93	1.76	2.13	1.93	2.33	2.13	2.54	2.33	2.75	3.60	4.00	3.30
CONDUCTOR	**NO WIND TENSION (kN)**																	
ALMOND (6/1/2.50)	2.28	2.49	2.08	2.28	1.89	2.08	1.72	1.89	1.56	1.72	1.43	1.56	1.31	1.43	1.21	0.92	0.83	
APPLE (6/1/3.00)	3.24	3.54	2.95	3.24	2.68	2.95	2.44	2.68	2.22	2.44	2.03	2.22	1.86	2.03	1.72	1.31	1.18	
BANANA (6/1/3.75)	4.93	5.40	4.49	4.93	4.09	4.49	3.72	4.09	3.39	3.72	3.39	3.39	2.85	3.39	2.63	2.02	1.83	
CHERRY (6/4.75+7/1.60)	7.26	7.97	6.59	7.26	5.98	6.59	5.42	5.98	4.94	5.42	4.51	4.94	4.14	4.51	3.83	2.96	2.67	

Sag and Blowout Calculations for APPLE. **Refer NOTES Section 5.1.1** Creep Allowance: **10ºC**

5.5.6 ACSR/GZ Low Steel Medium 18% NBL 150m MES

SPAN LENGTH (m)	SAG (m) Temperature																BLOW OUT (m)
	-5ºC	0ºC		5ºC		10ºC		15ºC		20ºC		25ºC		30ºC		50ºC	60ºC	
	FINAL	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL	FINAL	FINAL	
80	0.43	0.40	0.47	0.43	0.50	0.47	0.53	0.50	0.57	0.53	0.61	0.57	0.64	0.61	0.68	0.81	0.88	0.78
90	0.55	0.51	0.59	0.55	0.63	0.59	0.68	0.63	0.72	0.68	0.77	0.72	0.81	0.77	0.86	1.03	1.11	0.99
100	0.68	0.63	0.73	0.68	0.78	0.73	0.84	0.78	0.89	0.84	0.95	0.89	1.00	0.95	1.06	1.27	1.37	1.23
110	0.82	0.76	0.88	0.82	0.95	0.88	1.01	0.95	1.08	1.01	1.14	1.08	1.21	1.14	1.28	1.54	1.66	1.48
120	0.98	0.91	1.05	0.98	1.13	1.05	1.20	1.13	1.28	1.20	1.36	1.28	1.44	1.36	1.52	1.83	1.98	1.76
130	1.15	1.07	1.23	1.15	1.32	1.23	1.41	1.32	1.51	1.41	1.60	1.51	1.69	1.60	1.79	2.15	2.32	2.07
140	1.33	1.24	1.43	1.33	1.53	1.43	1.64	1.53	1.75	1.64	1.85	1.75	1.96	1.85	2.07	2.49	2.69	2.40
150	1.53	1.42	1.64	1.53	1.76	1.64	1.88	1.76	2.00	1.88	2.13	2.00	2.25	2.13	2.38	2.86	3.09	2.76
160	1.74	1.62	1.87	1.74	2.00	1.87	2.14	2.00	2.28	2.14	2.42	2.28	2.57	2.42	2.71	3.26	3.52	3.14
170	1.96	1.83	2.11	1.96	2.26	2.11	2.42	2.26	2.57	2.42	2.73	2.57	2.90	2.73	3.06	3.68	3.97	3.54
180	2.20	2.05	2.36	2.20	2.53	2.36	2.71	2.53	2.89	2.71	3.07	2.89	3.25	3.07	3.43	4.12	4.45	3.97
190	2.45	2.28	2.63	2.45	2.82	2.63	3.02	2.82	3.22	3.02	3.42	3.22	3.62	3.42	3.82	4.60	4.96	4.43
200	2.72	2.53	2.92	2.72	3.13	2.92	3.34	3.13	3.56	3.34	3.79	3.56	4.01	3.79	4.23	5.09	5.50	4.90
210	3.00	2.79	3.22	3.00	3.45	3.22	3.69	3.45	3.93	3.69	4.17	3.93	4.42	4.17	4.66	5.61	6.07	5.41
220	3.29	3.06	3.53	3.29	3.78	3.53	4.05	3.78	4.31	4.05	4.58	4.31	4.85	4.58	5.12	6.16	6.66	5.94k
CONDUCTOR	NO WIND TENSION (kN)																	
ALMOND (6/1/2.50)	2.18	2.34	2.03	2.18	1.89	2.03	1.77	1.89	1.66	1.77	1.56	1.66	1.47	1.56	1.39	1.16	1.07	
APPLE (6/1/3.00)	3.09	3.32	2.87	3.09	2.68	2.87	2.51	2.68	2.35	2.51	2.22	2.35	2.09	2.22	1.98	1.65	1.53	
BANANA (6/1/3.75)	4.69	5.04	4.37	4.69	4.09	4.37	3.83	4.09	3.60	3.83	3.39	3.83	3.21	3.39	3.04	2.54	2.36	
CHERRY (6/4.75+7/1.60)	6.88	7.40	6.40	6.88	5.98	6.40	5.60	5.98	5.26	5.60	4.96	5.26	4.69	4.96	4.45	3.72	3.46	

Sag and Blowout Calculations for APPLE. **Refer NOTES Section 5.1.1** Creep Allowance: **10ºC**

5.5.7 ACSR/GZ Low Steel Medium 18% NBL Mechanical Forces per Conductor

SPAN LENGTH (m)	CONDUCTOR TENSION (kN)							
	ALMOND (6/1/2.50)		APPLE (6/1/3.00)		BANANA (6/1/3.75)		CHERRY (6/4.75+7/1.60)	
	No Wind	Max Wind	No Wind	Max Wind	No Wind	Max Wind	No Wind	Max Wind
50	2.08	3.61	2.95	4.71	4.51	6.58	6.61	8.98
60		3.96		5.15		7.15		9.74
70		4.29		5.56		7.69		10.44
80		4.60		5.95		8.19		11.10
90		4.90		6.33		8.68		11.73
100		5.18		6.66		9.13		12.31
110		5.44		7.00		9.55		12.86
120		5.69		7.31		9.96		13.39
130		5.94		7.61		10.35		13.89
140		6.16		7.90		10.71		14.36
150		6.39		8.18		11.06		14.80
160		6.60		8.44		11.40		15.23
170		6.81		8.69		11.73		15.63
180		7.01		8.93		12.03		16.01
190		7.20		9.16		12.33		16.38
200		7.39		9.39		12.60		16.73
210		7.56		9.60		12.86		17.05
220		7.74		9.80		13.13		17.38

MES = Span Length. No Wind tension is at 5°C and includes 1.1 Load Factor. Max Wind (900Pa) tension is at 15°C and includes 1.25 Load Factor.

5.5.8 ACSR/GZ Low Steel Full 22% NBL 100m MES

SPAN LENGTH (m)	SAG (m)																BLOW OUT (m)
	Temperature																
	-5ºC	0ºC		5ºC		10ºC		15ºC		20ºC		25ºC		30ºC		50ºC	60ºC	
	FINAL	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	**FINAL**	**FINAL**	
50	0.13	0.12	0.15	0.13	0.16	0.15	0.18	0.16	0.19	0.18	0.21	0.19	0.23	0.21	0.26	0.35	0.40	0.33
55	0.16	0.15	0.18	0.16	0.19	0.18	0.21	0.19	0.23	0.21	0.26	0.23	0.28	0.26	0.31	0.42	0.48	0.40
60	0.19	0.18	0.21	0.19	0.23	0.21	0.25	0.23	0.28	0.25	0.31	0.28	0.34	0.31	0.37	0.50	0.57	0.48
65	0.23	0.21	0.25	0.23	0.27	0.25	0.30	0.27	0.33	0.30	0.36	0.33	0.39	0.36	0.43	0.59	0.67	0.56
70	0.26	0.24	0.29	0.26	0.31	0.29	0.34	0.31	0.38	0.34	0.42	0.38	0.46	0.42	0.50	0.69	0.78	0.65
75	0.30	0.28	0.33	0.30	0.36	0.33	0.39	0.36	0.43	0.39	0.48	0.43	0.52	0.48	0.57	0.79	0.89	0.75
80	0.34	0.32	0.37	0.34	0.41	0.37	0.45	0.41	0.49	0.45	0.54	0.49	0.60	0.54	0.65	0.90	1.01	0.85
85	0.39	0.36	0.42	0.39	0.46	0.42	0.51	0.46	0.56	0.51	0.61	0.56	0.67	0.61	0.74	1.01	1.15	0.96
90	0.43	0.40	0.47	0.43	0.52	0.47	0.57	0.52	0.62	0.57	0.69	0.62	0.76	0.69	0.83	1.13	1.28	1.08
95	0.48	0.45	0.53	0.48	0.58	0.53	0.63	0.58	0.70	0.63	0.77	0.70	0.84	0.77	0.92	1.26	1.43	1.21
100	0.54	0.49	0.58	0.54	0.64	0.58	0.70	0.64	0.77	0.70	0.85	0.77	0.93	0.85	1.02	1.40	1.59	1.34
105	0.59	0.55	0.64	0.59	0.71	0.64	0.77	0.71	0.85	0.77	0.94	0.85	1.03	0.94	1.13	1.54	1.75	1.47
110	0.65	0.60	0.71	0.65	0.77	0.71	0.85	0.77	0.93	0.85	1.03	0.93	1.13	1.03	1.24	1.69	1.92	1.62
115	0.71	0.65	0.77	0.71	0.85	0.77	0.93	0.85	1.02	0.93	1.12	1.02	1.23	1.12	1.35	1.85	2.10	1.77
120	0.77	0.71	0.84	0.77	0.92	0.84	1.01	0.92	1.11	1.01	1.22	1.11	1.34	1.22	1.47	2.02	2.28	1.92
125	0.84	0.77	0.91	0.84	1.00	0.91	1.10	1.00	1.21	1.10	1.33	1.21	1.46	1.33	1.60	2.19	2.48	2.09
130	0.91	0.84	0.99	0.91	1.08	0.99	1.19	1.08	1.30	1.19	1.43	1.30	1.58	1.43	1.73	2.37	2.68	2.26
135	0.98	0.90	1.07	0.98	1.17	1.07	1.28	1.17	1.41	1.28	1.55	1.41	1.70	1.55	1.86	2.55	2.89	2.43
140	1.05	0.97	1.15	1.05	1.25	1.15	1.38	1.25	1.51	1.38	1.66	1.51	1.83	1.66	2.00	2.74	3.11	2.62
145	1.13	1.04	1.23	1.13	1.34	1.23	1.48	1.34	1.62	1.48	1.78	1.62	1.96	1.78	2.15	2.94	3.34	2.81
150	1.21	1.11	1.32	1.21	1.44	1.32	1.58	1.44	1.74	1.58	1.91	1.74	2.10	1.91	2.30	3.15	3.57	3.01
CONDUCTOR	**NO WIND TENSION (kN)**																
ALMOND (6/1/2.50)	2.75	2.98	2.53	2.75	2.31	2.53	2.11	2.31	1.92	2.11	1.74	1.92	1.59	1.74	1.45	1.05	0.93	
APPLE (6/1/3.00)	3.91	4.24	3.59	3.91	3.28	3.59	2.99	3.28	2.72	2.99	2.47	2.72	2.25	2.47	2.05	1.50	1.32	
BANANA (6/1/3.75)	5.96	6.48	5.47	5.96	4.99	5.47	4.55	4.99	4.14	4.55	3.76	4.14	3.43	3.76	3.13	2.30	2.04	
CHERRY (6/4.75+7/1.60)	8.78	9.57	8.02	8.78	7.30	8.02	6.63	7.30	6.01	6.63	5.46	6.01	4.97	5.46	4.54	3.34	2.97	

Sag and Blowout Calculations for APPLE. **Refer NOTES Section 5.1.1** Creep Allowance: **10ºC**

5.5.9 ACSR/GZ Low Steel Full 22% NBL 150m MES

SPAN LENGTH (m)	SAG (m)																BLOW OUT (m)
	Temperature																
	-5ºC	0ºC		5ºC		10ºC		15ºC		20ºC		25ºC		30ºC		50ºC	60ºC	
	FINAL	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	**FINAL**	**FINAL**	
80	0.35	0.33	0.38	0.35	0.41	0.38	0.44	0.41	0.47	0.44	0.51	0.47	0.54	0.51	0.58	0.72	0.79	0.72
90	0.45	0.42	0.48	0.45	0.52	0.48	0.56	0.52	0.60	0.56	0.64	0.60	0.68	0.64	0.73	0.91	0.99	0.92
100	0.55	0.51	0.59	0.55	0.64	0.59	0.69	0.64	0.74	0.69	0.79	0.74	0.84	0.79	0.90	1.12	1.23	1.13
110	0.67	0.62	0.72	0.67	0.77	0.72	0.83	0.77	0.89	0.83	0.96	0.89	1.02	0.96	1.09	1.36	1.49	1.37
120	0.80	0.74	0.86	0.80	0.92	0.86	0.99	0.92	1.06	0.99	1.14	1.06	1.22	1.14	1.30	1.61	1.77	1.63
130	0.93	0.87	1.00	0.93	1.08	1.00	1.16	1.08	1.25	1.16	1.34	1.25	1.43	1.34	1.52	1.89	2.08	1.91
140	1.08	1.01	1.17	1.08	1.25	1.17	1.35	1.25	1.45	1.35	1.55	1.45	1.66	1.55	1.76	2.20	2.41	2.22
150	1.24	1.16	1.34	1.24	1.44	1.34	1.55	1.44	1.66	1.55	1.78	1.66	1.90	1.78	2.02	2.52	2.76	2.54
160	1.42	1.32	1.52	1.42	1.64	1.52	1.76	1.64	1.89	1.76	2.02	1.89	2.16	2.02	2.30	2.87	3.15	2.90
170	1.60	1.49	1.72	1.60	1.85	1.72	1.99	1.85	2.13	1.99	2.28	2.13	2.44	2.28	2.60	3.24	3.55	3.27
180	1.79	1.67	1.93	1.79	2.07	1.93	2.23	2.07	2.39	2.23	2.56	2.39	2.74	2.56	2.92	3.63	3.98	3.66
190	2.00	1.86	2.15	2.00	2.31	2.15	2.48	2.31	2.66	2.48	2.85	2.66	3.05	2.85	3.25	4.05	4.44	4.08
200	2.21	2.06	2.38	2.21	2.56	2.38	2.75	2.56	2.95	2.75	3.16	2.95	3.38	3.16	3.60	4.49	4.92	4.53
210	2.44	2.27	2.62	2.44	2.82	2.62	3.03	2.82	3.26	3.03	3.49	3.26	3.73	3.49	3.97	4.95	5.42	4.99
220	2.68	2.49	2.88	2.68	3.10	2.88	3.33	3.10	3.57	3.33	3.83	3.57	4.09	3.83	4.36	5.43	5.95	5.48
230	2.93	2.72	3.15	2.93	3.38	3.15	3.64	3.38	3.90	3.64	4.18	3.90	4.47	4.18	4.76	5.94	6.50	5.99
CONDUCTOR	**NO WIND TENSION (kN)**																
ALMOND (6/1/2.50)	2.67	2.87	2.48	2.67	2.31	2.48	2.15	2.31	2.00	2.15	1.87	2.00	1.75	1.87	1.64	1.31	1.20	
APPLE (6/1/3.00)	3.79	4.07	3.53	3.79	3.28	3.53	3.05	3.28	2.84	3.05	2.65	2.84	2.48	2.65	2.33	1.87	1.71	
BANANA (6/1/3.75)	5.77	6.21	5.37	5.77	4.99	5.37	4.65	4.99	4.33	4.65	4.05	4.33	3.80	4.05	3.57	2.88	2.63	
CHERRY (6/4.75+7/1.60)	8.48	9.13	7.87	8.48	7.30	7.87	6.79	7.30	6.32	6.79	5.91	6.32	5.53	5.91	5.20	4.20	3.85	

Sag and Blowout Calculations for APPLE. **Refer NOTES Section 5.1.1** Creep Allowance: **10ºC**

5.5.10 ACSR/GZ Low Steel Full 22% NBL 200m MES

SPAN LENGTH (m)	SAG (m)																	BLOW OUT (m)
	Temperature																	
	-5ºC	0ºC		5ºC		10ºC		15ºC		20ºC		25ºC		30ºC		50ºC	60ºC	
	FINAL	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	**FINAL**	**FINAL**	
100	0.57	0.54	0.60	0.57	0.64	0.60	0.68	0.64	0.71	0.68	0.75	0.71	0.79	0.75	0.83	0.98	1.05	1.00
110	0.69	0.65	0.73	0.69	0.77	0.73	0.82	0.77	0.86	0.82	0.91	0.86	0.95	0.91	1.00	1.18	1.27	1.22
120	0.82	0.77	0.87	0.82	0.92	0.87	0.97	0.92	1.03	0.97	1.08	1.03	1.14	1.08	1.19	1.41	1.51	1.45
130	0.96	0.91	1.02	0.96	1.08	1.02	1.14	1.08	1.21	1.14	1.27	1.21	1.33	1.27	1.40	1.65	1.77	1.70
140	1.12	1.05	1.18	1.12	1.25	1.18	1.33	1.25	1.40	1.33	1.47	1.40	1.55	1.47	1.62	1.91	2.05	1.97
150	1.28	1.21	1.36	1.28	1.44	1.36	1.52	1.44	1.61	1.52	1.69	1.61	1.78	1.69	1.86	2.20	2.36	2.26
160	1.46	1.37	1.55	1.46	1.64	1.55	1.73	1.64	1.83	1.73	1.92	1.83	2.02	1.92	2.12	2.50	2.68	2.57
170	1.65	1.55	1.75	1.65	1.85	1.75	1.95	1.85	2.06	1.95	2.17	2.06	2.28	2.17	2.39	2.82	3.03	2.90
180	1.85	1.74	1.96	1.85	2.07	1.96	2.19	2.07	2.31	2.19	2.43	2.31	2.56	2.43	2.68	3.16	3.40	3.25
190	2.06	1.94	2.18	2.06	2.31	2.18	2.44	2.31	2.58	2.44	2.71	2.58	2.85	2.71	2.99	3.52	3.78	3.63
200	2.28	2.15	2.42	2.28	2.56	2.42	2.70	2.56	2.85	2.70	3.00	2.85	3.16	3.00	3.31	3.91	4.19	4.02
210	2.51	2.37	2.66	2.51	2.82	2.66	2.98	2.82	3.15	2.98	3.31	3.15	3.48	3.31	3.65	4.31	4.62	4.43
220	2.76	2.60	2.92	2.76	3.10	2.92	3.27	3.10	3.45	3.27	3.64	3.45	3.82	3.64	4.00	4.73	5.08	4.86
230	3.01	2.84	3.20	3.01	3.38	3.20	3.58	3.38	3.77	3.58	3.97	3.77	4.17	3.97	4.38	5.17	5.55	5.32
240	3.28	3.09	3.48	3.28	3.68	3.48	3.90	3.68	4.11	3.90	4.33	4.11	4.55	4.33	4.76	5.63	6.04	5.79
250	3.56	3.35	3.78	3.56	4.00	3.78	4.23	4.00	4.46	4.23	4.70	4.46	4.93	4.70	5.17	6.10	6.55	6.28
260	3.85	3.63	4.08	3.85	4.32	4.08	4.57	4.32	4.82	4.57	5.08	4.82	5.34	5.08	5.59	6.60	7.09	6.79
270	4.15	3.91	4.40	4.15	4.66	4.40	4.93	4.66	5.20	4.93	5.48	5.20	5.75	5.48	6.03	7.12	7.65	7.33
280	4.47	4.21	4.74	4.47	5.02	4.74	5.30	5.02	5.59	5.30	5.89	5.59	6.19	5.89	6.49	7.66	8.22	7.88
290	4.79	4.51	5.08	4.79	5.38	5.08	5.69	5.38	6.00	5.69	6.32	6.00	6.64	6.32	6.96	8.22	8.82	8.45
300	5.13	4.83	5.44	5.13	5.76	5.44	6.09	5.76	6.42	6.09	6.76	6.42	7.10	6.76	7.45	8.79	9.44	9.05
CONDUCTOR	**NO WIND TENSION (kN)**																	
ALMOND (6/1/2.50)	2.59	2.75	2.45	2.59	2.31	2.45	2.18	2.31	2.07	2.18	1.96	2.07	1.87	1.96	1.78	1.51	1.40	
APPLE (6/1/3.00)	3.68	3.91	3.47	3.68	3.28	3.47	3.10	3.28	2.94	3.10	2.79	2.94	2.66	2.79	2.54	2.15	2.00	
BANANA (6/1/3.75)	5.60	5.94	5.28	5.60	4.99	5.28	4.73	4.99	4.49	4.73	4.27	4.49	4.07	4.27	3.89	3.31	3.08	
CHERRY (6/4.75+7/1.60)	8.20	8.71	7.73	8.20	7.30	7.73	6.91	7.30	6.56	6.91	6.24	6.56	5.95	6.24	5.68	4.84	4.52	

Sag and Blowout Calculations for APPLE. **Refer NOTES Section 5.1.1** Creep Allowance: **10ºC**

5.5.11 ACSR/GZ Low Steel Full 22% NBL 250m MES

SPAN LENGTH (m)	SAG (m)																BLOW OUT (m)
	Temperature																
	-5ºC	0ºC		5ºC		10ºC		15ºC		20ºC		25ºC		30ºC		50ºC	60ºC
	FINAL	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL	FINAL	FINAL
130	0.99	0.94	1.03	0.99	1.08	1.03	1.13	1.08	1.18	1.13	1.22	1.18	1.27	1.22	1.32	1.50	1.59	1.55
140	1.14	1.09	1.20	1.14	1.25	1.20	1.31	1.25	1.36	1.31	1.42	1.36	1.47	1.42	1.53	1.74	1.84	1.80
150	1.31	1.25	1.38	1.31	1.44	1.38	1.50	1.44	1.57	1.50	1.63	1.57	1.69	1.63	1.75	2.00	2.12	2.07
160	1.49	1.43	1.57	1.49	1.64	1.57	1.71	1.64	1.78	1.71	1.85	1.78	1.93	1.85	2.00	2.27	2.41	2.35
170	1.69	1.61	1.77	1.69	1.85	1.77	1.93	1.85	2.01	1.93	2.09	2.01	2.17	2.09	2.25	2.57	2.72	2.66
180	1.89	1.80	1.98	1.89	2.07	1.98	2.16	2.07	2.25	2.16	2.35	2.25	2.44	2.35	2.53	2.88	3.05	2.98
190	2.11	2.01	2.21	2.11	2.31	2.21	2.41	2.31	2.51	2.41	2.61	2.51	2.72	2.61	2.82	3.21	3.40	3.32
200	2.34	2.23	2.45	2.34	2.56	2.45	2.67	2.56	2.78	2.67	2.90	2.78	3.01	2.90	3.12	3.56	3.76	3.68
210	2.58	2.46	2.70	2.58	2.82	2.70	2.94	2.82	3.07	2.94	3.19	3.07	3.32	3.19	3.44	3.92	4.15	4.05
220	2.83	2.69	2.96	2.83	3.10	2.96	3.23	3.10	3.37	3.23	3.50	3.37	3.64	3.50	3.78	4.30	4.56	4.45
230	3.09	2.95	3.24	3.09	3.38	3.24	3.53	3.38	3.68	3.53	3.83	3.68	3.98	3.83	4.13	4.70	4.98	4.86
240	3.36	3.21	3.52	3.36	3.68	3.52	3.85	3.68	4.01	3.85	4.17	4.01	4.33	4.17	4.49	5.12	5.42	5.30
250	3.65	3.48	3.82	3.65	4.00	3.82	4.17	4.00	4.35	4.17	4.53	4.35	4.70	4.53	4.88	5.56	5.88	5.75
260	3.95	3.76	4.14	3.95	4.32	4.14	4.51	4.32	4.71	4.51	4.90	4.71	5.09	4.90	5.27	6.01	6.36	6.22
270	4.26	4.06	4.46	4.26	4.66	4.46	4.87	4.66	5.07	4.87	5.28	5.07	5.48	5.28	5.69	6.48	6.86	6.71
280	4.58	4.37	4.80	4.58	5.02	4.80	5.24	5.02	5.46	5.24	5.68	5.46	5.90	5.68	6.12	6.97	7.38	7.21
290	4.91	4.68	5.15	4.91	5.38	5.15	5.62	5.38	5.85	5.62	6.09	5.85	6.33	6.09	6.56	7.48	7.92	7.74
300	5.26	5.01	5.51	5.26	5.76	5.51	6.01	5.76	6.27	6.01	6.52	6.27	6.77	6.52	7.02	8.00	8.48	8.28
310	5.61	5.35	5.88	5.61	6.15	5.88	6.42	6.15	6.69	6.42	6.96	6.69	7.23	6.96	7.50	8.55	9.05	8.84
320	5.98	5.70	6.27	5.98	6.55	6.27	6.84	6.55	7.13	6.84	7.42	7.13	7.71	7.42	7.99	9.11	9.64	9.42
330	6.36	6.06	6.66	6.36	6.97	6.66	7.27	6.97	7.58	7.27	7.89	7.58	8.20	7.89	8.50	9.69	10.26	10.02
340	6.75	6.44	7.07	6.75	7.40	7.07	7.72	7.40	8.05	7.72	8.38	8.05	8.70	8.38	9.02	10.28	10.89	10.64
CONDUCTOR	**NO WIND TENSION (kN)**																
ALMOND (6/1/2.50)	2.53	2.66	2.42	2.53	2.31	2.42	2.21	2.31	2.12	2.21	2.04	2.12	1.96	2.04	1.89	1.66	1.56	
APPLE (6/1/3.00)	3.59	3.77	3.43	3.59	3.28	3.43	3.14	3.28	3.01	3.14	2.90	3.01	2.79	2.90	2.69	2.36	2.23	
BANANA (6/1/3.75)	5.46	5.72	5.22	5.46	4.99	5.22	4.79	4.99	4.60	4.79	4.43	4.60	4.27	4.43	4.12	3.63	3.43	
CHERRY (6/4.75+7/1.60)	7.98	8.37	7.63	7.98	7.30	7.63	7.00	7.30	6.73	7.00	6.48	6.73	6.24	6.48	6.03	5.32	5.03	

Sag and Blowout Calculations for APPLE. **Refer NOTES Section 5.1.1** Creep Allowance: **10ºC**

5.5.12 ACSR/GZ Low Steel Medium 22% NBL Mechanical Forces per Conductor

SPAN LENGTH (m)	CONDUCTOR TENSION (kN)							
	ALMOND (6/1/2.50)		APPLE (6/1/3.00)		BANANA (6/1/3.75)		CHERRY (6/4.75+7/1.60)	
	No Wind	Max Wind	No Wind	Max Wind	No Wind	Max Wind	No Wind	Max Wind
50	2.54	3.90	3.61	5.14	5.52	7.24	8.09	9.99
60		4.24		5.56		7.80		10.71
70		4.56		5.98		8.34		11.41
80		4.88		6.36		8.85		12.09
90		5.18		6.74		9.34		12.73
100		5.46		7.09		9.80		13.33
110		5.74		7.44		10.25		13.91
120		6.00		7.76		10.68		14.46
130		6.26		8.08		11.09		15.00
140		6.50		8.39		11.49		15.51
150		6.74		8.68		11.86		16.00
160		6.96		8.96		12.23		16.46
170		7.19		9.24		12.58		16.91
180		7.40		9.50		12.93		17.35
190		7.61		9.75		13.25		17.76
200		7.81		10.00		13.56		18.18
210		8.01		10.24		13.88		18.55
220		8.20		10.48		14.16		18.93
230		8.39		10.70		14.45		19.29
240		8.56		10.91		14.73		19.63
250		8.74		11.13		14.99		19.96
260		8.90		11.34		15.25		20.28
270		9.08		11.54		15.50		20.59
280		9.23		11.73		15.74		20.89
290		9.39		11.91		15.98		21.18
300		9.54		12.10		16.20		21.45
310		9.69		12.28		16.41		21.71
320		9.84		12.45		16.63		21.98

MES = Span Length. No Wind tension is at 5°C and includes 1.1 Load Factor. Max Wind (900Pa) tension is at 15°C and includes 1.25 Load Factor.

5.6 ACSR/GZ High Steel Content

5.6.1 ACSR/GZ High Steel Limited 10% NBL 50m MES

SPAN LENGTH (m)	SAG (m)																	BLOW OUT (m)
	Temperature																	
	-5ºC	0ºC		5ºC		10ºC		15ºC		20ºC		25ºC		30ºC		50ºC	60ºC	
	FINAL	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	**FINAL**	**FINAL**	
30	0.07	0.07	0.08	0.08	0.09	0.09	0.10	0.10	0.11	0.11	0.12	0.12	0.14	0.14	0.15	0.22	0.25	0.16
35	0.10	0.10	0.11	0.11	0.12	0.12	0.13	0.13	0.15	0.15	0.17	0.17	0.19	0.19	0.21	0.29	0.33	0.21
40	0.13	0.13	0.14	0.14	0.16	0.16	0.17	0.17	0.20	0.20	0.22	0.22	0.24	0.24	0.27	0.38	0.44	0.28
45	0.16	0.16	0.18	0.18	0.20	0.20	0.22	0.22	0.25	0.25	0.28	0.28	0.31	0.31	0.34	0.48	0.55	0.35
50	0.20	0.20	0.22	0.22	0.24	0.24	0.27	0.27	0.31	0.31	0.34	0.34	0.38	0.38	0.42	0.60	0.68	0.44
55	0.24	0.24	0.27	0.27	0.30	0.30	0.33	0.33	0.37	0.37	0.41	0.41	0.46	0.46	0.51	0.72	0.82	0.53
60	0.29	0.29	0.32	0.32	0.35	0.35	0.39	0.39	0.44	0.44	0.49	0.49	0.55	0.55	0.61	0.86	0.98	0.63
65	0.34	0.34	0.37	0.37	0.41	0.41	0.46	0.46	0.52	0.52	0.58	0.58	0.64	0.64	0.72	1.01	1.15	0.74
70	0.39	0.39	0.43	0.43	0.48	0.48	0.54	0.54	0.60	0.60	0.67	0.67	0.75	0.75	0.83	1.17	1.33	0.86
75	0.45	0.45	0.50	0.50	0.55	0.55	0.61	0.61	0.69	0.69	0.77	0.77	0.86	0.86	0.95	1.35	1.53	0.98
80	0.51	0.51	0.56	0.56	0.63	0.63	0.70	0.70	0.78	0.78	0.88	0.88	0.98	0.98	1.08	1.53	1.74	1.12
CONDUCTOR	**NO WIND TENSION (kN)**																	
RAISIN (3/4/2.50)	2.99	2.99	2.71	2.71	2.44	2.44	2.19	2.19	1.96	1.96	1.75	1.75	1.57	1.57	1.41	1.00	0.88	

Sag and Blowout Calculations for RAISIN. **Refer NOTES Section 5.1.1** Creep Allowance: **5ºC**

5.6.2 ACSR/GZ High Steel Limited 10% NBL 75m MES

SPAN LENGTH (m)	SAG (m) Temperature -5ºC	0ºC		5ºC		10ºC		15ºC		20ºC		25ºC		30ºC		50ºC	60ºC	BLOW OUT (m)
	FINAL	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL	FINAL	FINAL	
40	0.13	0.13	0.14	0.14	0.16	0.16	0.17	0.17	0.19	0.19	0.20	0.20	0.22	0.22	0.23	0.30	0.33	0.24
45	0.17	0.17	0.18	0.18	0.20	0.20	0.22	0.22	0.23	0.23	0.25	0.25	0.27	0.27	0.30	0.38	0.42	0.30
50	0.21	0.21	0.22	0.22	0.24	0.24	0.27	0.27	0.29	0.29	0.31	0.31	0.34	0.34	0.37	0.47	0.51	0.38
55	0.25	0.25	0.27	0.27	0.30	0.30	0.32	0.32	0.35	0.35	0.38	0.38	0.41	0.41	0.44	0.56	0.62	0.46
60	0.30	0.30	0.32	0.32	0.35	0.35	0.38	0.38	0.42	0.42	0.45	0.45	0.49	0.49	0.53	0.67	0.74	0.54
65	0.35	0.35	0.38	0.38	0.41	0.41	0.45	0.45	0.49	0.49	0.53	0.53	0.57	0.57	0.62	0.79	0.87	0.64
70	0.40	0.40	0.44	0.44	0.48	0.48	0.52	0.52	0.57	0.57	0.62	0.62	0.67	0.67	0.72	0.91	1.01	0.74
75	0.46	0.46	0.51	0.51	0.55	0.55	0.60	0.60	0.65	0.65	0.71	0.71	0.76	0.76	0.82	1.05	1.16	0.85
80	0.53	0.53	0.58	0.58	0.63	0.63	0.68	0.68	0.74	0.74	0.80	0.80	0.87	0.87	0.93	1.19	1.32	0.96
85	0.60	0.60	0.65	0.65	0.71	0.71	0.77	0.77	0.84	0.84	0.91	0.91	0.98	0.98	1.06	1.35	1.49	1.09
90	0.67	0.67	0.73	0.73	0.79	0.79	0.86	0.86	0.94	0.94	1.02	1.02	1.10	1.10	1.18	1.51	1.67	1.22
95	0.75	0.75	0.81	0.81	0.88	0.88	0.96	0.96	1.05	1.05	1.14	1.14	1.23	1.23	1.32	1.68	1.86	1.36
100	0.83	0.83	0.90	0.90	0.98	0.98	1.07	1.07	1.16	1.16	1.26	1.26	1.36	1.36	1.46	1.87	2.06	1.50
105	0.91	0.91	0.99	0.99	1.08	1.08	1.18	1.18	1.28	1.28	1.39	1.39	1.50	1.50	1.61	2.06	2.27	1.66
110	1.00	1.00	1.09	1.09	1.19	1.19	1.29	1.29	1.40	1.40	1.52	1.52	1.64	1.64	1.77	2.26	2.49	1.82
115	1.09	1.09	1.19	1.19	1.30	1.30	1.41	1.41	1.53	1.53	1.66	1.66	1.80	1.80	1.93	2.47	2.72	1.99
CONDUCTOR	**NO WIND TENSION (kN)**																	
RAISIN (3/4/2.50)	2.90	2.90	2.66	2.66	2.44	2.44	2.24	2.24	2.06	2.06	1.90	1.90	1.76	1.76	1.64	1.28	1.16	

Sag and Blowout Calculations for RAISIN. **Refer NOTES Section 5.1.1** Creep Allowance: **5ºC**

5.6.3 ACSR/GZ High Steel Limited 10% NBL 100m MES

SPAN LENGTH (m)	SAG (m) Temperature -5ºC	0ºC		5ºC		10ºC		15ºC		20ºC		25ºC		30ºC		50ºC	60ºC	BLOW OUT (m)
	FINAL	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	**FINAL**	**FINAL**	
50	0.21	0.21	0.23	0.23	0.24	0.24	0.26	0.26	0.28	0.28	0.30	0.30	0.31	0.31	0.33	0.40	0.43	0.34
55	0.26	0.26	0.28	0.28	0.30	0.30	0.32	0.32	0.34	0.34	0.36	0.36	0.38	0.38	0.40	0.48	0.52	0.41
60	0.31	0.31	0.33	0.33	0.35	0.35	0.38	0.38	0.40	0.40	0.43	0.43	0.45	0.45	0.48	0.57	0.62	0.49
65	0.36	0.36	0.39	0.39	0.41	0.41	0.44	0.44	0.47	0.47	0.50	0.50	0.53	0.53	0.56	0.67	0.73	0.57
70	0.42	0.42	0.45	0.45	0.48	0.48	0.51	0.51	0.55	0.55	0.58	0.58	0.61	0.61	0.65	0.78	0.85	0.66
75	0.48	0.48	0.51	0.51	0.55	0.55	0.59	0.59	0.63	0.63	0.67	0.67	0.71	0.71	0.74	0.90	0.97	0.76
80	0.55	0.55	0.59	0.59	0.63	0.63	0.67	0.67	0.71	0.71	0.76	0.76	0.80	0.80	0.85	1.02	1.11	0.87
85	0.62	0.62	0.66	0.66	0.71	0.71	0.76	0.76	0.81	0.81	0.86	0.86	0.91	0.91	0.96	1.15	1.25	0.98
90	0.69	0.69	0.74	0.74	0.79	0.79	0.85	0.85	0.90	0.90	0.96	0.96	1.02	1.02	1.07	1.29	1.40	1.10
95	0.77	0.77	0.83	0.83	0.88	0.88	0.94	0.94	1.01	1.01	1.07	1.07	1.13	1.13	1.20	1.44	1.56	1.22
100	0.85	0.85	0.92	0.92	0.98	0.98	1.05	1.05	1.12	1.12	1.18	1.18	1.25	1.25	1.32	1.60	1.73	1.35
105	0.94	0.94	1.01	1.01	1.08	1.08	1.15	1.15	1.23	1.23	1.31	1.31	1.38	1.38	1.46	1.76	1.90	1.49
110	1.03	1.03	1.11	1.11	1.19	1.19	1.27	1.27	1.35	1.35	1.43	1.43	1.52	1.52	1.60	1.93	2.09	1.64
115	1.13	1.13	1.21	1.21	1.30	1.30	1.38	1.38	1.48	1.48	1.57	1.57	1.66	1.66	1.75	2.11	2.28	1.79
120	1.23	1.23	1.32	1.32	1.41	1.41	1.51	1.51	1.61	1.61	1.71	1.71	1.81	1.81	1.91	2.30	2.49	1.95
125	1.33	1.33	1.43	1.43	1.53	1.53	1.64	1.64	1.74	1.74	1.85	1.85	1.96	1.96	2.07	2.50	2.70	2.11
130	1.44	1.44	1.55	1.55	1.66	1.66	1.77	1.77	1.89	1.89	2.00	2.00	2.12	2.12	2.24	2.70	2.92	2.29
135	1.56	1.56	1.67	1.67	1.79	1.79	1.91	1.91	2.03	2.03	2.16	2.16	2.29	2.29	2.41	2.91	3.15	2.47
140	1.67	1.67	1.79	1.79	1.92	1.92	2.05	2.05	2.19	2.19	2.32	2.32	2.46	2.46	2.60	3.13	3.39	2.65
145	1.79	1.79	1.92	1.92	2.06	2.06	2.20	2.20	2.35	2.35	2.49	2.49	2.64	2.64	2.79	3.36	3.63	2.85
150	1.92	1.92	2.06	2.06	2.20	2.20	2.36	2.36	2.51	2.51	2.67	2.67	2.82	2.82	2.98	3.60	3.89	3.05
CONDUCTOR	**NO WIND TENSION (kN)**																	
RAISIN (3/4/2.50)	2.80	2.80	2.61	2.61	2.44	2.44	2.28	2.28	2.14	2.14	2.02	2.02	1.91	1.91	1.81	1.50	1.38	

Sag and Blowout Calculations for RAISIN. **Refer NOTES Section 5.1.1** Creep Allowance: **5ºC**

5.6.4 ACSR/GZ High Steel Limited 10% NBL Mechanical Forces per Conductor

SPAN LENGTH (m)	CONDUCTOR TENSION (kN)	
	RAISIN (3/4/2.50)	
	No Wind	Max Wind
30	2.68	3.49
40		3.94
50		4.34
60		4.73
70		5.08
80		5.40
90		5.70
100		5.98
110		6.24
120		6.49
130		6.71
140		6.94
150		7.14

MES = Span Length. No Wind tension is at 5°C and includes 1.1 Load Factor. Max Wind (900Pa) tension is at 15°C and includes 1.25 Load Factor.

5.6.5 ACSR/GZ High Steel Full 22% NBL 100m MES

SPAN LENGTH (m)	SAG (m)																BLOW OUT (m)
	Temperature																
	-5ºC	0ºC		5ºC		10ºC		15ºC		20ºC		25ºC		30ºC		50ºC	60ºC	
	FINAL	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	**FINAL**	**FINAL**	
50	0.10	0.10	0.11	0.10	0.11	0.11	0.12	0.11	0.12	0.12	0.13	0.12	0.14	0.13	0.15	0.20	0.23	0.21
55	0.12	0.12	0.13	0.12	0.13	0.13	0.14	0.13	0.15	0.14	0.16	0.15	0.17	0.16	0.18	0.24	0.28	0.25
60	0.14	0.14	0.15	0.14	0.16	0.15	0.17	0.16	0.18	0.17	0.19	0.18	0.20	0.19	0.22	0.29	0.33	0.30
65	0.17	0.16	0.18	0.17	0.19	0.18	0.20	0.19	0.21	0.20	0.22	0.21	0.24	0.22	0.26	0.34	0.39	0.36
70	0.20	0.19	0.21	0.20	0.22	0.21	0.23	0.22	0.24	0.23	0.26	0.24	0.28	0.26	0.30	0.39	0.45	0.41
75	0.23	0.21	0.24	0.23	0.25	0.24	0.27	0.25	0.28	0.27	0.30	0.28	0.32	0.30	0.34	0.45	0.52	0.47
80	0.26	0.24	0.27	0.26	0.28	0.27	0.30	0.28	0.32	0.30	0.34	0.32	0.36	0.34	0.39	0.51	0.59	0.54
85	0.29	0.28	0.30	0.29	0.32	0.30	0.34	0.32	0.36	0.34	0.38	0.36	0.41	0.38	0.44	0.58	0.66	0.61
90	0.32	0.31	0.34	0.32	0.36	0.34	0.38	0.36	0.40	0.38	0.43	0.40	0.46	0.43	0.49	0.65	0.74	0.68
95	0.36	0.34	0.38	0.36	0.40	0.38	0.43	0.40	0.45	0.43	0.48	0.45	0.51	0.48	0.55	0.72	0.83	0.76
100	0.40	0.38	0.42	0.40	0.45	0.42	0.47	0.45	0.50	0.47	0.53	0.50	0.57	0.53	0.60	0.80	0.92	0.84
105	0.44	0.42	0.46	0.44	0.49	0.46	0.52	0.49	0.55	0.52	0.59	0.55	0.62	0.59	0.67	0.88	1.01	0.93
110	0.48	0.46	0.51	0.48	0.54	0.51	0.57	0.54	0.60	0.57	0.64	0.60	0.69	0.64	0.73	0.97	1.11	1.02
115	0.53	0.50	0.56	0.53	0.59	0.56	0.62	0.59	0.66	0.62	0.70	0.66	0.75	0.70	0.80	1.06	1.22	1.11
120	0.58	0.55	0.61	0.58	0.64	0.61	0.68	0.64	0.72	0.68	0.77	0.72	0.82	0.77	0.87	1.15	1.32	1.21
125	0.63	0.60	0.66	0.63	0.70	0.66	0.74	0.70	0.78	0.74	0.83	0.78	0.89	0.83	0.95	1.25	1.44	1.31
130	0.68	0.64	0.71	0.68	0.75	0.71	0.80	0.75	0.84	0.80	0.90	0.84	0.96	0.90	1.02	1.35	1.55	1.42
135	0.73	0.69	0.77	0.73	0.81	0.77	0.86	0.81	0.91	0.86	0.97	0.91	1.03	0.97	1.10	1.46	1.68	1.53
140	0.78	0.75	0.83	0.78	0.87	0.83	0.92	0.87	0.98	0.92	1.04	0.98	1.11	1.04	1.19	1.57	1.80	1.65
145	0.84	0.80	0.89	0.84	0.94	0.89	0.99	0.94	1.05	0.99	1.12	1.05	1.19	1.12	1.27	1.68	1.93	1.77
150	0.90	0.86	0.95	0.90	1.00	0.95	1.06	1.00	1.12	1.06	1.20	1.12	1.27	1.20	1.36	1.80	2.07	1.89
155	0.96	0.91	1.01	0.96	1.07	1.01	1.13	1.07	1.20	1.13	1.28	1.20	1.36	1.28	1.45	1.92	2.21	2.02
160	1.02	0.97	1.08	1.02	1.14	1.08	1.21	1.14	1.28	1.21	1.36	1.28	1.45	1.36	1.55	2.05	2.35	2.15
CONDUCTOR	**NO WIND TENSION (kN)**																
RAISIN (3/4/2.50)	5.97	6.28	5.67	5.97	5.37	5.67	5.07	5.37	4.78	5.07	4.50	4.78	4.22	4.50	3.95	2.99	2.60	

Sag and Blowout Calculations for RAISIN. **Refer NOTES Section 5.1.1** Creep Allowance: **10ºC**

5.6.6 ACSR/GZ High Steel Full 22% NBL 150m MES

SPAN LENGTH (m)	SAG (m) Temperature -5ºC	0ºC		5ºC		10ºC		15ºC		20ºC		25ºC		30ºC		50ºC	60ºC	BLOW OUT (m)
	FINAL	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	**FINAL**	**FINAL**	
80	0.26	0.25	0.27	0.26	0.28	0.27	0.30	0.28	0.32	0.30	0.33	0.32	0.35	0.33	0.37	0.46	0.51	0.48
90	0.33	0.31	0.34	0.33	0.36	0.34	0.38	0.36	0.40	0.38	0.42	0.40	0.44	0.42	0.47	0.58	0.64	0.61
100	0.40	0.39	0.42	0.40	0.45	0.42	0.47	0.45	0.49	0.47	0.52	0.49	0.55	0.52	0.58	0.72	0.79	0.76
110	0.49	0.47	0.51	0.49	0.54	0.51	0.57	0.54	0.60	0.57	0.63	0.60	0.66	0.63	0.70	0.87	0.96	0.92
120	0.58	0.55	0.61	0.58	0.64	0.61	0.67	0.64	0.71	0.67	0.75	0.71	0.79	0.75	0.83	1.03	1.14	1.09
130	0.68	0.65	0.72	0.68	0.75	0.72	0.79	0.75	0.83	0.79	0.88	0.83	0.93	0.88	0.98	1.21	1.34	1.28
140	0.79	0.76	0.83	0.79	0.87	0.83	0.92	0.87	0.97	0.92	1.02	0.97	1.08	1.02	1.14	1.41	1.56	1.48
150	0.91	0.87	0.95	0.91	1.00	0.95	1.05	1.00	1.11	1.05	1.17	1.11	1.23	1.17	1.30	1.61	1.79	1.70
160	1.03	0.99	1.08	1.03	1.14	1.08	1.20	1.14	1.26	1.20	1.33	1.26	1.40	1.33	1.48	1.84	2.03	1.94
170	1.17	1.11	1.22	1.17	1.29	1.22	1.35	1.29	1.43	1.35	1.50	1.43	1.59	1.50	1.67	2.07	2.30	2.19
180	1.31	1.25	1.37	1.31	1.44	1.37	1.52	1.44	1.60	1.52	1.69	1.60	1.78	1.69	1.88	2.33	2.58	2.45
190	1.46	1.39	1.53	1.46	1.61	1.53	1.69	1.61	1.78	1.69	1.88	1.78	1.98	1.88	2.09	2.59	2.87	2.74
200	1.62	1.54	1.70	1.62	1.78	1.70	1.87	1.78	1.97	1.87	2.08	1.97	2.20	2.08	2.32	2.87	3.18	3.03
210	1.78	1.70	1.87	1.78	1.96	1.87	2.07	1.96	2.18	2.07	2.29	2.18	2.42	2.29	2.55	3.17	3.51	3.34
220	1.95	1.87	2.05	1.95	2.16	2.05	2.27	2.16	2.39	2.27	2.52	2.39	2.66	2.52	2.80	3.47	3.85	3.67
230	2.14	2.04	2.24	2.14	2.36	2.24	2.48	2.36	2.61	2.48	2.75	2.61	2.90	2.75	3.06	3.80	4.21	4.01
240	2.33	2.22	2.44	2.33	2.57	2.44	2.70	2.57	2.84	2.70	3.00	2.84	3.16	3.00	3.34	4.13	4.58	4.37
CONDUCTOR	**NO WIND TENSION (kN)**																	
RAISIN (3/4/2.50)	5.92	6.20	5.64	5.92	5.37	5.64	5.10	5.37	4.84	5.10	4.60	4.84	4.36	4.60	4.13	3.33	3.01	

Sag and Blowout Calculations for RAISIN. **Refer NOTES Section 5.1.1** Creep Allowance: **10ºC**

5.6.7 ACSR/GZ High Steel Full 22% NBL 200m MES

SPAN LENGTH (m)	SAG (m)																	BLOW OUT (m)
	Temperature																	
	-5ºC	0ºC		5ºC		10ºC		15ºC		20ºC		25ºC		30ºC		50ºC	60ºC	
	FINAL	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	**FINAL**	**FINAL**	
100	0.41	0.39	0.43	0.41	0.45	0.43	0.47	0.45	0.49	0.47	0.51	0.49	0.53	0.51	0.56	0.66	0.71	0.69
110	0.49	0.47	0.52	0.49	0.54	0.52	0.56	0.54	0.59	0.56	0.62	0.59	0.64	0.62	0.67	0.80	0.86	0.84
120	0.59	0.56	0.61	0.59	0.64	0.61	0.67	0.64	0.70	0.67	0.73	0.70	0.77	0.73	0.80	0.95	1.03	1.00
130	0.69	0.66	0.72	0.69	0.75	0.72	0.79	0.75	0.82	0.79	0.86	0.82	0.90	0.86	0.94	1.11	1.21	1.17
140	0.80	0.77	0.84	0.80	0.87	0.84	0.91	0.87	0.95	0.91	1.00	0.95	1.04	1.00	1.09	1.29	1.40	1.36
150	0.92	0.88	0.96	0.92	1.00	0.96	1.05	1.00	1.10	1.05	1.15	1.10	1.20	1.15	1.25	1.48	1.61	1.56
160	1.04	1.00	1.09	1.04	1.14	1.09	1.19	1.14	1.25	1.19	1.30	1.25	1.36	1.30	1.42	1.69	1.83	1.78
170	1.18	1.13	1.23	1.18	1.29	1.23	1.35	1.29	1.41	1.35	1.47	1.41	1.54	1.47	1.61	1.91	2.06	2.01
180	1.32	1.27	1.38	1.32	1.44	1.38	1.51	1.44	1.58	1.51	1.65	1.58	1.72	1.65	1.80	2.14	2.31	2.25
190	1.47	1.41	1.54	1.47	1.61	1.54	1.68	1.61	1.76	1.68	1.84	1.76	1.92	1.84	2.01	2.38	2.58	2.51
200	1.63	1.56	1.70	1.63	1.78	1.70	1.86	1.78	1.95	1.86	2.04	1.95	2.13	2.04	2.23	2.64	2.86	2.78
210	1.80	1.72	1.88	1.80	1.96	1.88	2.05	1.96	2.15	2.05	2.25	2.15	2.35	2.25	2.45	2.91	3.15	3.06
220	1.97	1.89	2.06	1.97	2.16	2.06	2.25	2.16	2.36	2.25	2.46	2.36	2.58	2.46	2.69	3.19	3.46	3.36
230	2.16	2.07	2.25	2.16	2.36	2.25	2.46	2.36	2.58	2.46	2.69	2.58	2.82	2.69	2.94	3.49	3.78	3.67
240	2.35	2.25	2.45	2.35	2.57	2.45	2.68	2.57	2.80	2.68	2.93	2.80	3.07	2.93	3.20	3.80	4.11	4.00
250	2.55	2.44	2.66	2.55	2.78	2.66	2.91	2.78	3.04	2.91	3.18	3.04	3.33	3.18	3.48	4.12	4.46	4.34
260	2.76	2.64	2.88	2.76	3.01	2.88	3.15	3.01	3.29	3.15	3.44	3.29	3.60	3.44	3.76	4.46	4.83	4.69
270	2.97	2.85	3.11	2.97	3.25	3.11	3.39	3.25	3.55	3.39	3.71	3.55	3.88	3.71	4.06	4.81	5.21	5.06
280	3.20	3.06	3.34	3.20	3.49	3.34	3.65	3.49	3.82	3.65	3.99	3.82	4.17	3.99	4.36	5.17	5.60	5.44
290	3.43	3.29	3.58	3.43	3.75	3.58	3.92	3.75	4.09	3.92	4.28	4.09	4.48	4.28	4.68	5.55	6.01	5.84
300	3.67	3.52	3.84	3.67	4.01	3.84	4.19	4.01	4.38	4.19	4.58	4.38	4.79	4.58	5.01	5.94	6.43	6.25
310	3.92	3.76	4.10	3.92	4.28	4.10	4.47	4.28	4.68	4.47	4.89	4.68	5.12	4.89	5.35	6.34	6.87	6.68
320	4.18	4.00	4.36	4.18	4.56	4.36	4.77	4.56	4.99	4.77	5.21	4.99	5.45	5.21	5.70	6.76	7.32	7.11
CONDUCTOR	**NO WIND TENSION (kN)**																	
RAISIN (3/4/2.50)	5.86	6.12	5.61	5.86	5.37	5.61	5.13	5.37	4.91	5.13	4.70	4.91	4.49	4.70	4.30	3.62	3.35	

Sag and Blowout Calculations for RAISIN. **Refer NOTES Section 5.1.1** Creep Allowance: **10ºC**

5.6.8 ACSR/GZ High Steel Full 22% NBL 250m MES

SPAN LENGTH (m)	SAG (m) Temperature -5ºC	0ºC		5ºC		10ºC		15ºC		20ºC		25ºC		30ºC		50ºC	60ºC	BLOW OUT (m)
	FINAL	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL	FINAL	FINAL	
130	0.70	0.67	0.72	0.70	0.75	0.72	0.78	0.75	0.81	0.78	0.84	0.81	0.88	0.84	0.91	1.04	1.11	1.09
140	0.81	0.78	0.84	0.81	0.87	0.84	0.91	0.87	0.94	0.91	0.98	0.94	1.02	0.98	1.05	1.21	1.29	1.27
150	0.93	0.89	0.96	0.93	1.00	0.96	1.04	1.00	1.08	1.04	1.12	1.08	1.17	1.12	1.21	1.39	1.48	1.45
160	1.06	1.02	1.10	1.06	1.14	1.10	1.18	1.14	1.23	1.18	1.28	1.23	1.33	1.28	1.38	1.58	1.69	1.65
170	1.19	1.15	1.24	1.19	1.29	1.24	1.34	1.29	1.39	1.34	1.44	1.39	1.50	1.44	1.55	1.79	1.90	1.87
180	1.34	1.29	1.39	1.34	1.44	1.39	1.50	1.44	1.56	1.50	1.62	1.56	1.68	1.62	1.74	2.00	2.13	2.09
190	1.49	1.43	1.55	1.49	1.61	1.55	1.67	1.61	1.74	1.67	1.80	1.74	1.87	1.80	1.94	2.23	2.38	2.33
200	1.65	1.59	1.71	1.65	1.78	1.71	1.85	1.78	1.92	1.85	2.00	1.92	2.07	2.00	2.15	2.47	2.64	2.58
210	1.82	1.75	1.89	1.82	1.96	1.89	2.04	1.96	2.12	2.04	2.20	2.12	2.29	2.20	2.37	2.72	2.91	2.85
220	2.00	1.92	2.07	2.00	2.16	2.07	2.24	2.16	2.33	2.24	2.42	2.33	2.51	2.42	2.60	2.99	3.19	3.13
230	2.18	2.10	2.27	2.18	2.36	2.27	2.45	2.36	2.54	2.45	2.64	2.54	2.74	2.64	2.84	3.27	3.49	3.42
240	2.38	2.29	2.47	2.38	2.57	2.47	2.67	2.57	2.77	2.67	2.88	2.77	2.98	2.88	3.10	3.56	3.80	3.72
250	2.58	2.48	2.68	2.58	2.78	2.68	2.89	2.78	3.00	2.89	3.12	3.00	3.24	3.12	3.36	3.86	4.12	4.04
260	2.79	2.68	2.90	2.79	3.01	2.90	3.13	3.01	3.25	3.13	3.37	3.25	3.50	3.37	3.63	4.18	4.45	4.37
270	3.01	2.89	3.12	3.01	3.25	3.12	3.37	3.25	3.50	3.37	3.64	3.50	3.78	3.64	3.92	4.50	4.80	4.71
280	3.23	3.11	3.36	3.23	3.49	3.36	3.63	3.49	3.77	3.63	3.91	3.77	4.06	3.91	4.21	4.84	5.17	5.06
290	3.47	3.34	3.60	3.47	3.75	3.60	3.89	3.75	4.04	3.89	4.20	4.04	4.36	4.20	4.52	5.20	5.54	5.43
300	3.71	3.57	3.86	3.71	4.01	3.86	4.17	4.01	4.33	4.17	4.49	4.33	4.66	4.49	4.84	5.56	5.93	5.81
310	3.96	3.81	4.12	3.96	4.28	4.12	4.45	4.28	4.62	4.45	4.80	4.62	4.98	4.80	5.17	5.94	6.33	6.21
320	4.22	4.06	4.39	4.22	4.56	4.39	4.74	4.56	4.92	4.74	5.11	4.92	5.31	5.11	5.51	6.33	6.75	6.62
330	4.49	4.32	4.67	4.49	4.85	4.67	5.04	4.85	5.24	5.04	5.44	5.24	5.64	5.44	5.85	6.73	7.18	7.04
340	4.77	4.59	4.95	4.77	5.15	4.95	5.35	5.15	5.56	5.35	5.77	5.56	5.99	5.77	6.22	7.14	7.62	7.47
350	5.05	4.86	5.25	5.05	5.46	5.25	5.67	5.46	5.89	5.67	6.12	5.89	6.35	6.12	6.59	7.57	8.07	7.91
CONDUCTOR	**NO WIND TENSION (kN)**																	
RAISIN (3/4/2.50)	5.80	6.02	5.58	5.80	5.37	5.58	5.17	5.37	4.97	5.17	4.79	4.97	4.61	4.79	4.45	3.87	3.63	

Sag and Blowout Calculations for RAISIN. **Refer NOTES Section 5.1.1** Creep Allowance: **10ºC**

5.6.9 ACSR/GZ High Steel Full 22% NBL Mechanical Forces per Conductor

SPAN LENGTH (m)	CONDUCTOR TENSION (kN) RAISIN (3/4/2.50)	
	No Wind	Max Wind
50	5.91	6.83
60		7.11
70		7.41
80		7.71
90		8.01
100		8.30
110		8.59
120		8.88
130		9.15
140		9.43
150		9.69
160		9.95
170		10.20
180		10.45
190		10.69
200		10.93
210		11.16
220		11.39
230		11.61
240		11.83
250		12.04
260		12.24
270		12.45
280		12.65
290		12.84
300		13.03
310		13.21
320		13.40
330		13.58
340		13.75
350		13.93

MES = Span Length. No Wind tension is at 5°C and includes 1.1 Load Factor. Max Wind (900Pa) tension is at 15°C and includes 1.25 Load Factor.

5.7 SC/GZ Galvanized Steel

5.7.1 SC/GZ Limited 10% NBL 50m MES

SPAN LENGTH (m)	SAG (m) Temperature										BLOW OUT (m)
	-5ºC	0ºC	5ºC	10ºC	15ºC	20ºC	25ºC	30ºC	50ºC	60ºC	
30	0.06	0.06	0.07	0.07	0.08	0.09	0.10	0.11	0.16	0.18	0.14
35	0.08	0.09	0.09	0.10	0.11	0.12	0.13	0.15	0.21	0.25	0.19
40	0.11	0.11	0.12	0.13	0.15	0.16	0.17	0.19	0.28	0.32	0.25
45	0.13	0.14	0.16	0.17	0.18	0.20	0.22	0.24	0.35	0.41	0.32
50	0.17	0.18	0.19	0.21	0.23	0.25	0.27	0.30	0.43	0.51	0.39
55	0.20	0.21	0.23	0.25	0.27	0.30	0.33	0.36	0.52	0.61	0.47
60	0.24	0.26	0.28	0.30	0.33	0.36	0.39	0.43	0.62	0.73	0.56
65	0.28	0.30	0.32	0.35	0.38	0.42	0.46	0.51	0.73	0.85	0.66
70	0.32	0.35	0.38	0.41	0.44	0.49	0.53	0.59	0.85	0.99	0.77
75	0.37	0.40	0.43	0.47	0.51	0.56	0.61	0.67	0.97	1.14	0.88
80	0.42	0.45	0.49	0.53	0.58	0.64	0.70	0.77	1.11	1.29	1.00
CONDUCTOR	**NO WIND TENSION (kN)**										
3/2.75	2.58	2.40	2.22	2.05	1.88	1.72	1.56	1.42	0.99	0.84	

Sag and Blowout Calculations for 3/2.75. **Refer NOTES Section 5.1.1** Creep Allowance: **Nil**

5.7.2 SC/GZ Limited 10% NBL 75m MES

SPAN LENGTH (m)	SAG (m) Temperature -5ºC	0ºC	5ºC	10ºC	15ºC	20ºC	25ºC	30ºC	50ºC	60ºC	BLOW OUT (m)
40	0.11	0.11	0.12	0.13	0.14	0.15	0.16	0.18	0.23	0.26	0.22
45	0.14	0.15	0.16	0.17	0.18	0.19	0.21	0.22	0.29	0.32	0.28
50	0.17	0.18	0.19	0.21	0.22	0.24	0.26	0.27	0.36	0.40	0.34
55	0.20	0.22	0.23	0.25	0.27	0.29	0.31	0.33	0.43	0.49	0.42
60	0.24	0.26	0.28	0.30	0.32	0.34	0.37	0.40	0.52	0.58	0.49
65	0.28	0.30	0.32	0.35	0.37	0.40	0.43	0.46	0.60	0.68	0.58
70	0.33	0.35	0.38	0.40	0.43	0.47	0.50	0.54	0.70	0.79	0.67
75	0.38	0.40	0.43	0.46	0.50	0.54	0.58	0.62	0.81	0.90	0.77
80	0.43	0.46	0.49	0.53	0.57	0.61	0.66	0.70	0.92	1.03	0.88
90	0.48	0.52	0.55	0.60	0.64	0.69	0.74	0.79	1.03	1.16	0.99
95	0.54	0.58	0.62	0.67	0.72	0.77	0.83	0.89	1.16	1.30	1.11
100	0.60	0.65	0.69	0.74	0.80	0.86	0.92	0.99	1.29	1.45	1.24
105	0.67	0.72	0.77	0.82	0.89	0.95	1.02	1.10	1.43	1.60	1.37
110	0.74	0.79	0.85	0.91	0.98	1.05	1.13	1.21	1.58	1.77	1.51
115	0.81	0.87	0.93	1.00	1.07	1.15	1.24	1.33	1.73	1.94	1.66
120	0.89	0.95	1.02	1.09	1.17	1.26	1.35	1.45	1.89	2.12	1.82
CONDUCTOR	**NO WIND TENSION (kN)**										
3/2.75	2.54	2.38	2.22	2.07	1.92	1.79	1.66	1.55	1.19	1.06	

Sag and Blowout Calculations for 3/2.75. **Refer NOTES Section 5.1.1** Creep Allowance: **Nil**

5.7.3 SC/GZ Limited 10% NBL 100m MES

SPAN LENGTH (m)	SAG (m) Temperature -5ºC	0ºC	5ºC	10ºC	15ºC	20ºC	25ºC	30ºC	50ºC	60ºC	BLOW OUT (m)
50	0.17	0.18	0.19	0.20	0.22	0.23	0.24	0.26	0.32	0.34	0.31
55	0.21	0.22	0.23	0.25	0.26	0.28	0.29	0.31	0.38	0.42	0.38
60	0.25	0.26	0.28	0.29	0.31	0.33	0.35	0.37	0.45	0.50	0.45
65	0.29	0.31	0.32	0.34	0.37	0.39	0.41	0.43	0.53	0.58	0.52
70	0.33	0.35	0.38	0.40	0.42	0.45	0.48	0.50	0.62	0.67	0.61
75	0.38	0.41	0.43	0.46	0.49	0.52	0.55	0.58	0.71	0.77	0.70
80	0.44	0.46	0.49	0.52	0.55	0.59	0.62	0.66	0.81	0.88	0.79
90	0.49	0.52	0.55	0.59	0.63	0.66	0.70	0.74	0.91	0.99	0.90
95	0.55	0.59	0.62	0.66	0.70	0.74	0.79	0.83	1.02	1.12	1.00
100	0.61	0.65	0.69	0.74	0.78	0.83	0.88	0.93	1.14	1.24	1.12
105	0.68	0.72	0.77	0.82	0.87	0.92	0.97	1.03	1.26	1.38	1.24
110	0.75	0.80	0.85	0.90	0.95	1.01	1.07	1.13	1.39	1.52	1.37
115	0.82	0.87	0.93	0.99	1.05	1.11	1.18	1.24	1.52	1.67	1.50
120	0.90	0.96	1.02	1.08	1.14	1.21	1.29	1.36	1.67	1.82	1.64
125	0.98	1.04	1.11	1.17	1.25	1.32	1.40	1.48	1.81	1.98	1.79
130	1.06	1.13	1.20	1.27	1.35	1.43	1.52	1.61	1.97	2.15	1.94
135	1.15	1.22	1.30	1.38	1.46	1.55	1.64	1.74	2.13	2.33	2.10
140	1.24	1.32	1.40	1.49	1.58	1.67	1.77	1.87	2.30	2.51	2.26
145	1.34	1.42	1.50	1.60	1.70	1.80	1.91	2.02	2.47	2.70	2.43
150	1.43	1.52	1.61	1.71	1.82	1.93	2.04	2.16	2.65	2.90	2.61
CONDUCTOR	**NO WIND TENSION (kN)**										
3/2.75	2.50	2.36	2.22	2.09	1.97	1.86	1.75	1.66	1.35	1.24	

Sag and Blowout Calculations for 3/2.75. **Refer NOTES Section 5.1.1** Creep Allowance: **Nil**

5.7.4 SC/GZ Limited 10% NBL Mechanical Forces per Conductor

SPAN LENGTH (m)	CONDUCTOR TENSION (kN)	
	3/2.75	
	No Wind	Max Wind
30	2.44	3.04
40		3.36
50		3.68
60		3.98
70		4.25
80		4.51
90		4.76
100		5.00
110		5.23
120		5.44
130		5.64
140		5.84
150		6.03

MES = Span Length. No Wind tension is at 5°C and includes 1.1 Load Factor. Max Wind (900Pa) tension is at 15°C and includes 1.25 Load Factor.

5.7.5 SC/GZ Full 22% NBL 150m MES

SPAN LENGTH (m)	SAG (m) Temperature -5ºC	0ºC	5ºC	10ºC	15ºC	20ºC	25ºC	30ºC	50ºC	60ºC	BLOW OUT (m)
80	0.21	0.22	0.22	0.23	0.24	0.25	0.26	0.27	0.32	0.35	0.44
90	0.26	0.27	0.28	0.29	0.30	0.32	0.33	0.34	0.41	0.45	0.56
100	0.32	0.34	0.35	0.36	0.38	0.39	0.41	0.42	0.50	0.55	0.69
110	0.39	0.41	0.42	0.44	0.46	0.47	0.49	0.51	0.61	0.67	0.83
120	0.47	0.48	0.50	0.52	0.54	0.56	0.59	0.61	0.73	0.80	0.99
130	0.55	0.57	0.59	0.61	0.64	0.66	0.69	0.72	0.85	0.93	1.16
140	0.64	0.66	0.68	0.71	0.74	0.77	0.80	0.83	0.99	1.08	1.34
150	0.73	0.76	0.78	0.81	0.85	0.88	0.92	0.96	1.14	1.24	1.54
160	0.83	0.86	0.89	0.93	0.96	1.00	1.04	1.09	1.29	1.42	1.75
170	0.94	0.97	1.01	1.05	1.09	1.13	1.18	1.23	1.46	1.60	1.98
180	1.05	1.09	1.13	1.17	1.22	1.27	1.32	1.38	1.64	1.79	2.22
190	1.17	1.21	1.26	1.31	1.36	1.41	1.47	1.53	1.82	2.00	2.47
200	1.30	1.35	1.40	1.45	1.51	1.57	1.63	1.70	2.02	2.21	2.74
210	1.43	1.48	1.54	1.60	1.66	1.73	1.80	1.87	2.23	2.44	3.02
220	1.57	1.63	1.69	1.75	1.82	1.89	1.97	2.06	2.44	2.68	3.32
230	1.72	1.78	1.85	1.92	1.99	2.07	2.16	2.25	2.67	2.92	3.63
240	1.87	1.94	2.01	2.09	2.17	2.25	2.35	2.45	2.91	3.18	3.95
CONDUCTOR	**NO WIND TENSION (kN)**										
3/2.75	5.25	5.06	4.88	4.71	4.53	4.35	4.18	4.01	3.37	3.08	

Sag and Blowout Calculations for 3/2.75. **Refer NOTES Section 5.1.1** Creep Allowance: **Nil**

5.7.6 SC/GZ Full 22% NBL 200m MES

SPAN LENGTH (m)	SAG (m) Temperature -5ºC	0ºC	5ºC	10ºC	15ºC	20ºC	25ºC	30ºC	50ºC	60ºC	BLOW OUT (m)
100	0.33	0.34	0.35	0.36	0.37	0.39	0.40	0.42	0.48	0.52	0.64
110	0.39	0.41	0.42	0.44	0.45	0.47	0.49	0.50	0.59	0.63	0.77
120	0.47	0.49	0.50	0.52	0.54	0.56	0.58	0.60	0.70	0.75	0.91
130	0.55	0.57	0.59	0.61	0.63	0.66	0.68	0.71	0.82	0.88	1.07
140	0.64	0.66	0.68	0.71	0.73	0.76	0.79	0.82	0.95	1.02	1.25
150	0.73	0.76	0.78	0.81	0.84	0.87	0.90	0.94	1.09	1.18	1.43
160	0.83	0.86	0.89	0.92	0.96	0.99	1.03	1.07	1.24	1.34	1.63
170	0.94	0.97	1.01	1.04	1.08	1.12	1.16	1.21	1.40	1.51	1.84
180	1.06	1.09	1.13	1.17	1.21	1.26	1.30	1.35	1.57	1.69	2.06
190	1.18	1.22	1.26	1.30	1.35	1.40	1.45	1.51	1.75	1.89	2.29
200	1.30	1.35	1.40	1.44	1.50	1.55	1.61	1.67	1.94	2.09	2.54
210	1.44	1.49	1.54	1.59	1.65	1.71	1.77	1.84	2.14	2.31	2.80
220	1.58	1.63	1.69	1.75	1.81	1.88	1.95	2.02	2.35	2.53	3.08
230	1.73	1.78	1.85	1.91	1.98	2.05	2.13	2.21	2.56	2.77	3.36
240	1.88	1.94	2.01	2.08	2.16	2.23	2.32	2.40	2.79	3.01	3.66
250	2.04	2.11	2.18	2.26	2.34	2.42	2.51	2.61	3.03	3.27	3.97
260	2.20	2.28	2.36	2.44	2.53	2.62	2.72	2.82	3.28	3.53	4.30
270	2.38	2.46	2.54	2.63	2.73	2.83	2.93	3.04	3.53	3.81	4.63
280	2.56	2.64	2.74	2.83	2.93	3.04	3.15	3.27	3.80	4.10	4.98
290	2.74	2.84	2.93	3.04	3.15	3.26	3.38	3.51	4.08	4.40	5.35
300	2.94	3.04	3.14	3.25	3.37	3.49	3.62	3.76	4.36	4.71	5.72
310	3.13	3.24	3.35	3.47	3.60	3.73	3.87	4.01	4.66	5.03	6.11
320	3.34	3.45	3.57	3.70	3.83	3.97	4.12	4.27	4.97	5.36	6.51
CONDUCTOR	**NO WIND TENSION (kN)**										
3/2.75	5.22	5.05	4.88	4.72	4.55	4.39	4.24	4.08	3.52	3.26	

Sag and Blowout Calculations for 3/2.75. **Refer NOTES Section 5.1.1** Creep Allowance: **Nil**

5.7.7 SC/GZ Full 22% NBL 250m MES

SPAN LENGTH (m)	SAG (m) Temperature										BLOW OUT (m)
	-5ºC	0ºC	5ºC	10ºC	15ºC	20ºC	25ºC	30ºC	50ºC	60ºC	
130	0.55	0.57	0.59	0.61	0.63	0.65	0.67	0.69	0.79	0.84	1.00
140	0.64	0.66	0.68	0.71	0.73	0.75	0.78	0.80	0.91	0.98	1.16
150	0.74	0.76	0.78	0.81	0.84	0.86	0.89	0.92	1.05	1.12	1.34
160	0.84	0.87	0.89	0.92	0.95	0.98	1.02	1.05	1.19	1.27	1.52
170	0.95	0.98	1.01	1.04	1.07	1.11	1.15	1.18	1.35	1.44	1.72
180	1.06	1.10	1.13	1.17	1.20	1.24	1.29	1.33	1.51	1.61	1.93
190	1.18	1.22	1.26	1.30	1.34	1.39	1.43	1.48	1.69	1.80	2.14
200	1.31	1.35	1.40	1.44	1.49	1.54	1.59	1.64	1.87	1.99	2.38
210	1.45	1.49	1.54	1.59	1.64	1.69	1.75	1.81	2.06	2.19	2.62
220	1.59	1.64	1.69	1.74	1.80	1.86	1.92	1.98	2.26	2.41	2.88
230	1.73	1.79	1.85	1.91	1.97	2.03	2.10	2.17	2.47	2.63	3.14
240	1.89	1.95	2.01	2.07	2.14	2.21	2.29	2.36	2.69	2.87	3.42
250	2.05	2.11	2.18	2.25	2.32	2.40	2.48	2.56	2.92	3.11	3.71
260	2.22	2.29	2.36	2.43	2.51	2.60	2.68	2.77	3.16	3.36	4.02
270	2.39	2.46	2.54	2.63	2.71	2.80	2.89	2.99	3.40	3.63	4.33
280	2.57	2.65	2.74	2.82	2.92	3.01	3.11	3.21	3.66	3.90	4.66
290	2.76	2.84	2.93	3.03	3.13	3.23	3.34	3.45	3.93	4.19	5.00
300	2.95	3.04	3.14	3.24	3.35	3.46	3.57	3.69	4.20	4.48	5.35
310	3.15	3.25	3.35	3.46	3.57	3.69	3.81	3.94	4.49	4.78	5.71
320	3.36	3.46	3.57	3.69	3.81	3.93	4.06	4.20	4.78	5.10	6.09
330	3.57	3.68	3.80	3.92	4.05	4.18	4.32	4.46	5.08	5.42	6.47
340	3.79	3.91	4.03	4.16	4.30	4.44	4.59	4.74	5.40	5.75	6.87
350	4.02	4.14	4.27	4.41	4.56	4.71	4.86	5.02	5.72	6.10	7.28
CONDUCTOR	**NO WIND TENSION (kN)**										
3/2.75	5.20	5.04	4.88	4.73	4.58	4.44	4.30	4.16	3.65	3.42	

Sag and Blowout Calculations for 3/2.75. **Refer NOTES Section 5.1.1** Creep Allowance: **Nil**

5.7.8 SC/GZ Full 22% NBL 300m MES

SPAN LENGTH (m)	SAG (m) Temperature -5ºC	0ºC	5ºC	10ºC	15ºC	20ºC	25ºC	30ºC	50ºC	60ºC	BLOW OUT (m)
170	0.95	0.98	1.01	1.04	1.07	1.10	1.13	1.16	1.30	1.38	1.62
180	1.07	1.10	1.13	1.16	1.20	1.23	1.27	1.31	1.46	1.54	1.81
190	1.19	1.22	1.26	1.30	1.33	1.37	1.41	1.45	1.63	1.72	2.02
200	1.32	1.36	1.40	1.44	1.48	1.52	1.57	1.61	1.81	1.91	2.24
210	1.45	1.50	1.54	1.58	1.63	1.68	1.73	1.78	1.99	2.10	2.47
220	1.59	1.64	1.69	1.74	1.79	1.84	1.90	1.95	2.18	2.31	2.71
230	1.74	1.79	1.85	1.90	1.96	2.01	2.07	2.13	2.39	2.52	2.96
240	1.90	1.95	2.01	2.07	2.13	2.19	2.26	2.32	2.60	2.75	3.23
250	2.06	2.12	2.18	2.24	2.31	2.38	2.45	2.52	2.82	2.98	3.50
260	2.23	2.29	2.36	2.43	2.50	2.57	2.65	2.72	3.05	3.22	3.79
270	2.40	2.47	2.54	2.62	2.69	2.77	2.85	2.94	3.29	3.48	4.08
280	2.58	2.66	2.74	2.82	2.90	2.98	3.07	3.16	3.54	3.74	4.39
290	2.77	2.85	2.93	3.02	3.11	3.20	3.29	3.39	3.80	4.01	4.71
300	2.97	3.05	3.14	3.23	3.33	3.42	3.52	3.63	4.06	4.29	5.04
310	3.17	3.26	3.35	3.45	3.55	3.66	3.76	3.87	4.34	4.58	5.38
320	3.37	3.47	3.57	3.68	3.79	3.90	4.01	4.13	4.62	4.88	5.74
330	3.59	3.69	3.80	3.91	4.03	4.14	4.27	4.39	4.92	5.19	6.10
340	3.81	3.92	4.03	4.15	4.27	4.40	4.53	4.66	5.22	5.51	6.48
350	4.04	4.15	4.27	4.40	4.53	4.66	4.80	4.94	5.53	5.84	6.87
360	4.27	4.39	4.52	4.65	4.79	4.93	5.08	5.22	5.85	6.18	7.26
370	4.51	4.64	4.78	4.92	5.06	5.21	5.36	5.52	6.18	6.53	7.67
380	4.76	4.90	5.04	5.19	5.34	5.49	5.66	5.82	6.52	6.89	8.09
390	5.01	5.16	5.31	5.46	5.62	5.79	5.96	6.13	6.87	7.25	8.53
400	5.27	5.43	5.58	5.75	5.92	6.09	6.27	6.45	7.22	7.63	8.97
410	5.54	5.70	5.87	6.04	6.21	6.40	6.58	6.78	7.59	8.02	9.42
420	5.81	5.98	6.16	6.34	6.52	6.71	6.91	7.11	7.96	8.41	9.89
CONDUCTOR	**NO WIND TENSION (kN)**										
3/2.75	5.17	5.03	4.88	4.75	4.61	4.48	4.35	4.23	3.78	3.57	

Sag and Blowout Calculations for 3/2.75. **Refer NOTES Section 5.1.1** Creep Allowance: **Nil**

5.7.9 SC/GZ Full 22% NBL 350m MES

SPAN LENGTH (m)	SAG (m) Temperature										BLOW OUT (m)
	-5ºC	0ºC	5ºC	10ºC	15ºC	20ºC	25ºC	30ºC	50ºC	60ºC	
200	1.32	1.36	1.40	1.43	1.47	1.51	1.55	1.59	1.75	1.84	2.13
210	1.46	1.50	1.54	1.58	1.62	1.66	1.71	1.75	1.93	2.03	2.35
220	1.60	1.65	1.69	1.73	1.78	1.83	1.87	1.92	2.12	2.22	2.58
230	1.75	1.80	1.85	1.89	1.94	1.99	2.05	2.10	2.32	2.43	2.81
240	1.91	1.96	2.01	2.06	2.12	2.17	2.23	2.29	2.52	2.65	3.06
250	2.07	2.12	2.18	2.24	2.30	2.36	2.42	2.48	2.74	2.87	3.33
260	2.24	2.30	2.36	2.42	2.48	2.55	2.62	2.68	2.96	3.11	3.60
270	2.41	2.48	2.54	2.61	2.68	2.75	2.82	2.89	3.19	3.35	3.88
280	2.60	2.67	2.74	2.81	2.88	2.96	3.03	3.11	3.44	3.60	4.17
290	2.79	2.86	2.93	3.01	3.09	3.17	3.25	3.34	3.69	3.87	4.48
300	2.98	3.06	3.14	3.22	3.31	3.39	3.48	3.57	3.94	4.14	4.79
310	3.18	3.27	3.35	3.44	3.53	3.62	3.72	3.81	4.21	4.42	5.11
320	3.39	3.48	3.57	3.67	3.76	3.86	3.96	4.06	4.49	4.71	5.45
330	3.61	3.70	3.80	3.90	4.00	4.11	4.21	4.32	4.77	5.01	5.80
340	3.83	3.93	4.03	4.14	4.25	4.36	4.47	4.59	5.07	5.31	6.15
350	4.06	4.16	4.27	4.39	4.50	4.62	4.74	4.86	5.37	5.63	6.52
360	4.29	4.41	4.52	4.64	4.76	4.89	5.01	5.14	5.68	5.96	6.90
370	4.53	4.65	4.78	4.90	5.03	5.16	5.30	5.43	6.00	6.29	7.29
380	4.78	4.91	5.04	5.17	5.31	5.45	5.59	5.73	6.33	6.64	7.69
390	5.04	5.17	5.31	5.45	5.59	5.74	5.89	6.04	6.67	6.99	8.10
400	5.30	5.44	5.58	5.73	5.88	6.03	6.19	6.35	7.01	7.36	8.52
410	5.57	5.72	5.87	6.02	6.18	6.34	6.51	6.67	7.37	7.73	8.95
420	5.84	6.00	6.16	6.32	6.48	6.65	6.83	7.00	7.73	8.11	9.39
CONDUCTOR	**NO WIND TENSION (kN)**										
3/2.75	5.15	5.01	4.88	4.76	4.64	4.52	4.40	4.29	3.89	3.71	

Sag and Blowout Calculations for 3/2.75. **Refer NOTES Section 5.1.1** Creep Allowance: **Nil**

5.7.10 SC/GZ Full 22% NBL 400m MES

SPAN LENGTH (m)	SAG (m) Temperature -5ºC	0ºC	5ºC	10ºC	15ºC	20ºC	25ºC	30ºC	50ºC	60ºC	BLOW OUT (m)
220	1.61	1.65	1.69	1.73	1.77	1.81	1.85	1.89	2.07	2.16	2.46
240	1.92	1.96	2.01	2.06	2.11	2.15	2.20	2.25	2.46	2.57	2.93
260	2.25	2.30	2.36	2.41	2.47	2.53	2.59	2.65	2.89	3.01	3.44
280	2.61	2.67	2.74	2.80	2.87	2.93	3.00	3.07	3.35	3.49	3.99
300	3.00	3.07	3.14	3.21	3.29	3.37	3.44	3.52	3.84	4.01	4.58
320	3.41	3.49	3.57	3.66	3.74	3.83	3.92	4.01	4.37	4.56	5.21
340	3.85	3.94	4.03	4.13	4.23	4.32	4.42	4.53	4.94	5.15	5.88
360	4.31	4.42	4.52	4.63	4.74	4.85	4.96	5.07	5.54	5.77	6.59
380	4.81	4.92	5.04	5.16	5.28	5.40	5.53	5.65	6.17	6.43	7.34
400	5.33	5.45	5.58	5.72	5.85	5.99	6.12	6.26	6.84	7.13	8.14
420	5.87	6.01	6.16	6.30	6.45	6.60	6.75	6.91	7.54	7.86	8.97
440	6.44	6.60	6.76	6.92	7.08	7.24	7.41	7.58	8.27	8.62	9.85
460	7.04	7.21	7.38	7.56	7.74	7.92	8.10	8.28	9.04	9.43	10.77
480	7.67	7.85	8.04	8.23	8.42	8.62	8.82	9.02	9.85	10.27	11.72
500	8.32	8.52	8.73	8.93	9.14	9.35	9.57	9.79	10.68	11.14	12.72
CONDUCTOR	**NO WIND TENSION (kN)**										
3/2.75	5.12	5.00	4.88	4.77	4.66	4.56	4.45	4.35	3.99	3.83	

Sag and Blowout Calculations for 3/2.75. **Refer NOTES Section 5.1.1** Creep Allowance: **Nil**

5.7.11 SC/GZ Full 22% NBL Mechanical Forces per Conductor

SPAN LENGTH (m)	CONDUCTOR TENSION (kN)	
	3/2.75	
	No Wind	Max Wind
60	5.37	6.33
80		6.73
100		7.14
120		7.55
140		7.96
160		8.36
180		8.75
200		9.13
220		9.49
240		9.85
260		10.19
280		10.53
300		10.85
320		11.16
340		11.46
360		11.75
380		12.04
400		12.31
420		12.59
440		12.85
460		13.10
480		13.35
500		13.59

MES = Span Length. No Wind tension is at 5°C and includes 1.1 Load Factor. Max Wind (900Pa) tension is at 15°C and includes 1.25 Load Factor.

5.8 HDC Hard Drawn Copper

5.8.1 HDC Slack 2% NBL 20m MES

SPAN LENGTH (m)	SAG (m) Temperature -5ºC	0ºC	5ºC	10ºC	15ºC	20ºC	25ºC	30ºC	50ºC	60ºC	BLOW OUT (m)
10	0.13	0.13	0.14	0.14	0.14	0.15	0.15	0.15	0.16	0.17	0.10
15	0.30	0.30	0.31	0.32	0.32	0.33	0.33	0.34	0.36	0.37	0.22
20	0.53	0.54	0.55	0.56	0.57	0.58	0.60	0.61	0.65	0.67	0.40
25	0.83	0.84	0.86	0.88	0.90	0.91	0.93	0.95	1.01	1.04	0.62
30	1.19	1.22	1.24	1.27	1.29	1.32	1.34	1.37	1.46	1.50	0.90
35	1.62	1.66	1.69	1.73	1.76	1.79	1.83	1.86	1.99	2.05	1.23
CONDUCTOR	**NO WIND TENSION (kN)**										
7/1.25	0.08	0.07	0.07	0.07	0.07	0.07	0.07	0.06	0.06	0.06	
7/1.75	0.14	0.14	0.14	0.13	0.13	0.13	0.13	0.12	0.12	0.11	
7/2.00	0.18	0.18	0.18	0.17	0.17	0.17	0.16	0.16	0.15	0.15	
19/1.75	0.38	0.37	0.37	0.36	0.35	0.35	0.34	0.33	0.31	0.30	
19/2.00	0.49	0.48	0.47	0.46	0.45	0.45	0.44	0.43	0.40	0.39	
19/2.75	0.90	0.88	0.86	0.85	0.83	0.82	0.80	0.79	0.75	0.73	

Sag and Blowout Calculations for 19/2.00. **Refer NOTES Section 5.1.1** Creep Allowance: **Nil**
OBSOLETE Conductor Type – for reference only

5.8.2 HDC Slack 2% NBL Mechanical Forces per Conductor

SPAN LENGTH (m)	CONDUCTOR TENSION (kN) 7/1.75 No Wind	7/1.75 Max Wind	7/2.00 No Wind	7/2.00 Max Wind	19/1.75 No Wind	19/1.75 Max Wind	19/2.00 No Wind	19/2.00 Max Wind	19/2.75 No Wind	19/2.75 Max Wind
10	0.15	0.46	0.20	0.53	0.41	0.84	0.52	0.99	0.95	1.49
20		0.54		0.61		0.95		1.11		1.65
30		0.55		0.64		0.98		1.15		1.69
40		0.56		0.64		0.99		1.16		1.70

MES = Span Length. No Wind tension is at 5°C and includes 1.1 Load Factor. Max Wind (900Pa) tension is at 15°C and includes 1.25 Load Factor.

5.8.3 HDC Urban 6% NBL 40m MES

SPAN LENGTH (m)	SAG (m) Temperature -5ºC	0ºC	5ºC	10ºC	15ºC	20ºC	25ºC	30ºC	50ºC	60ºC	BLOW OUT (m)
20	0.17	0.18	0.18	0.19	0.20	0.21	0.21	0.22	0.25	0.26	0.14
25	0.26	0.27	0.29	0.30	0.31	0.32	0.33	0.34	0.38	0.40	0.22
30	0.38	0.40	0.41	0.43	0.45	0.46	0.48	0.50	0.55	0.58	0.32
35	0.51	0.54	0.56	0.59	0.61	0.63	0.65	0.67	0.75	0.79	0.43
40	0.67	0.70	0.73	0.77	0.80	0.82	0.85	0.88	0.99	1.03	0.57
45	0.85	0.89	0.93	0.97	1.01	1.04	1.08	1.12	1.25	1.31	0.72
50	1.05	1.10	1.15	1.20	1.24	1.29	1.33	1.38	1.54	1.62	0.89
55	1.27	1.33	1.39	1.45	1.50	1.56	1.61	1.67	1.86	1.96	1.08
60	1.51	1.58	1.65	1.72	1.79	1.86	1.92	1.98	2.22	2.33	1.28
65	1.77	1.86	1.94	2.02	2.10	2.18	2.26	2.33	2.60	2.73	1.50
70	2.06	2.16	2.26	2.35	2.44	2.53	2.62	2.71	3.03	3.18	1.74
CONDUCTOR	**NO WIND TENSION (kN)**										
7/1.25	0.24	0.23	0.22	0.21	0.20	0.19	0.18	0.18	0.16	0.15	
7/1.75	0.46	0.43	0.41	0.40	0.38	0.37	0.35	0.34	0.31	0.29	
7/2.00	0.58	0.55	0.53	0.51	0.49	0.47	0.45	0.44	0.39	0.37	
19/1.75	1.20	1.15	1.10	1.05	1.01	0.98	0.95	0.92	0.82	0.78	
19/2.00	1.55	1.48	1.42	1.36	1.31	1.26	1.22	1.18	1.06	1.01	
19/2.75	2.81	2.69	2.59	2.49	2.40	2.33	2.25	2.19	1.97	1.88	

Sag and Blowout Calculations for 19/2.00. **Refer NOTES Section 5.1.1** Creep Allowance: **Nil**

OBSOLETE Conductor Type – for reference only

5.8.4 HDC Urban 6% NBL 60m MES

SPAN LENGTH (m)	SAG (m) Temperature -5ºC	0ºC	5ºC	10ºC	15ºC	20ºC	25ºC	30ºC	50ºC	60ºC	BLOW OUT (m)
30	0.40	0.40	0.41	0.42	0.43	0.44	0.45	0.45	0.48	0.50	0.30
35	0.54	0.55	0.56	0.57	0.58	0.60	0.61	0.62	0.66	0.68	0.41
40	0.70	0.72	0.73	0.75	0.76	0.78	0.79	0.81	0.86	0.88	0.53
45	0.89	0.91	0.93	0.95	0.97	0.98	1.00	1.02	1.09	1.12	0.68
50	1.10	1.12	1.15	1.17	1.19	1.22	1.24	1.26	1.34	1.38	0.84
55	1.33	1.36	1.39	1.42	1.44	1.47	1.50	1.52	1.62	1.67	1.01
60	1.59	1.62	1.65	1.69	1.72	1.75	1.78	1.81	1.93	1.99	1.21
65	1.86	1.90	1.94	1.98	2.02	2.06	2.09	2.13	2.27	2.34	1.42
70	2.16	2.21	2.25	2.30	2.34	2.38	2.43	2.47	2.63	2.71	1.65
75	2.48	2.53	2.59	2.64	2.69	2.74	2.79	2.84	3.02	3.11	1.89
80	2.82	2.88	2.94	3.00	3.06	3.12	3.17	3.23	3.44	3.54	2.15
85	3.19	3.25	3.32	3.39	3.45	3.52	3.58	3.64	3.88	4.00	2.43
90	3.57	3.65	3.73	3.80	3.87	3.95	4.02	4.09	4.36	4.49	2.72
CONDUCTOR	**NO WIND TENSION (kN)**										
7/1.25	0.23	0.22	0.22	0.21	0.21	0.20	0.20	0.19	0.18	0.18	
7/1.75	0.43	0.42	0.41	0.40	0.40	0.39	0.38	0.38	0.35	0.34	
7/2.00	0.55	0.54	0.53	0.52	0.51	0.50	0.49	0.48	0.45	0.44	
19/1.75	1.14	1.12	1.10	1.08	1.06	1.04	1.02	1.00	0.94	0.91	
19/2.00	1.48	1.45	1.42	1.39	1.36	1.34	1.31	1.29	1.21	1.18	
19/2.75	2.69	2.63	2.59	2.54	2.50	2.46	2.42	2.38	2.24	2.18	

Sag and Blowout Calculations for 19/2.00. **Refer NOTES Section 5.1.1** Creep Allowance: **Nil**

OBSOLETE Conductor Type – for reference only

5.8.5 HDC Urban 6% NBL Mechanical Forces per Conductor

SPAN LENGTH (m)	CONDUCTOR TENSION (kN)									
	7/1.75		7/2.00		19/1.75		19/2.00		19/2.75	
	No Wind	Max Wind	No Wind	Max Wind	No Wind	Max Wind	No Wind	Max Wind	No Wind	Max Wind
10	0.45	0.73	0.58	0.86	1.21	1.46	1.56	1.76	2.85	2.81
20		1.05		1.23		2.04		2.45		3.83
30		1.24		1.45		2.36		2.83		4.34
40		1.38		1.60		2.56		3.05		4.61
50		1.46		1.69		2.69		3.19		4.78
60		1.53		1.75		2.76		3.28		4.88
70		1.56		1.80		2.81		3.34		4.94
80		1.60		1.83		2.85		3.38		4.99
90		1.63		1.85		2.89		3.41		5.03

MES = Span Length. No Wind tension is at 5°C and includes 1.1 Load Factor. Max Wind (900Pa) tension is at 15°C and includes 1.25 Load Factor.

5.8.6 HDC Limited 10% NBL 50m MES

SPAN LENGTH (m)	SAG (m) Temperature -5ºC	0ºC	5ºC	10ºC	15ºC	20ºC	25ºC	30ºC	50ºC	60ºC	BLOW OUT (m)
25	0.15	0.16	0.17	0.18	0.19	0.20	0.21	0.22	0.26	0.28	0.14
30	0.22	0.23	0.25	0.26	0.28	0.29	0.31	0.32	0.38	0.40	0.20
35	0.29	0.32	0.34	0.36	0.38	0.40	0.42	0.44	0.51	0.55	0.28
40	0.38	0.41	0.44	0.47	0.50	0.52	0.55	0.57	0.67	0.71	0.36
45	0.49	0.52	0.56	0.59	0.63	0.66	0.69	0.73	0.85	0.90	0.46
50	0.60	0.64	0.69	0.73	0.77	0.82	0.86	0.90	1.04	1.11	0.57
55	0.73	0.78	0.83	0.89	0.94	0.99	1.04	1.08	1.26	1.35	0.69
60	0.86	0.93	0.99	1.05	1.12	1.18	1.23	1.29	1.50	1.60	0.82
65	1.01	1.09	1.16	1.24	1.31	1.38	1.45	1.52	1.77	1.88	0.97
70	1.17	1.26	1.35	1.44	1.52	1.60	1.68	1.76	2.05	2.18	1.12
75	1.35	1.45	1.55	1.65	1.74	1.84	1.93	2.02	2.35	2.51	1.29
80	1.53	1.65	1.76	1.88	1.98	2.09	2.20	2.30	2.68	2.85	1.46
CONDUCTOR	**NO WIND TENSION (kN)**										
7/1.25	0.42	0.39	0.36	0.34	0.32	0.30	0.28	0.27	0.23	0.22	
7/1.75	0.79	0.74	0.69	0.65	0.61	0.58	0.55	0.53	0.45	0.42	
7/2.00	1.01	0.94	0.88	0.83	0.78	0.74	0.71	0.68	0.58	0.54	
19/1.75	2.10	1.95	1.83	1.72	1.63	1.55	1.47	1.41	1.21	1.14	
19/2.00	2.71	2.52	2.36	2.22	2.10	1.99	1.90	1.81	1.56	1.46	
19/2.75	4.90	4.59	4.31	4.07	3.86	3.68	3.51	3.37	2.92	2.74	

Sag and Blowout Calculations for 19/2.00. **Refer NOTES Section 5.1.1** Creep Allowance: **Nil**

OBSOLETE Conductor Type – for reference only

5.8.7 HDC Limited 10% NBL 75m MES

SPAN LENGTH (m)	SAG (m)										BLOW OUT (m)
	Temperature										
	-5ºC	0ºC	5ºC	10ºC	15ºC	20ºC	25ºC	30ºC	50ºC	60ºC	
35	0.31	0.33	0.34	0.35	0.36	0.37	0.38	0.39	0.43	0.45	0.26
40	0.41	0.43	0.44	0.45	0.47	0.48	0.50	0.51	0.56	0.58	0.34
45	0.52	0.54	0.56	0.58	0.59	0.61	0.63	0.64	0.71	0.74	0.43
50	0.64	0.67	0.69	0.71	0.73	0.75	0.78	0.80	0.87	0.91	0.53
55	0.78	0.81	0.83	0.86	0.89	0.91	0.94	0.96	1.06	1.10	0.64
60	0.93	0.96	0.99	1.02	1.06	1.09	1.12	1.15	1.26	1.31	0.76
65	1.09	1.13	1.16	1.20	1.24	1.27	1.31	1.35	1.48	1.54	0.90
70	1.26	1.31	1.35	1.39	1.44	1.48	1.52	1.56	1.71	1.79	1.03
75	1.45	1.50	1.55	1.60	1.65	1.70	1.75	1.79	1.97	2.05	1.19
80	1.65	1.70	1.76	1.82	1.88	1.93	1.99	2.04	2.24	2.34	1.35
85	1.86	1.92	1.99	2.06	2.12	2.18	2.24	2.30	2.53	2.64	1.53
90	2.08	2.16	2.23	2.30	2.38	2.45	2.51	2.58	2.84	2.96	1.71
95	2.32	2.40	2.49	2.57	2.65	2.72	2.80	2.88	3.16	3.30	1.90
100	2.57	2.66	2.76	2.85	2.93	3.02	3.10	3.19	3.50	3.65	2.11
105	2.83	2.94	3.04	3.14	3.23	3.33	3.42	3.51	3.86	4.03	2.33
110	3.11	3.22	3.34	3.44	3.55	3.65	3.76	3.86	4.24	4.42	2.55
115	3.40	3.52	3.65	3.76	3.88	4.00	4.11	4.22	4.63	4.83	2.79
120	3.70	3.84	3.97	4.10	4.23	4.35	4.47	4.59	5.05	5.26	3.04
CONDUCTOR	**NO WIND TENSION (kN)**										
7/1.25	0.39	0.37	0.36	0.35	0.34	0.33	0.32	0.31	0.28	0.27	
7/1.75	0.74	0.71	0.69	0.67	0.65	0.63	0.61	0.59	0.54	0.52	
7/2.00	0.94	0.91	0.88	0.85	0.83	0.80	0.78	0.76	0.69	0.66	
19/1.75	1.96	1.89	1.83	1.77	1.72	1.67	1.63	1.59	1.44	1.38	
19/2.00	2.53	2.44	2.36	2.29	2.22	2.15	2.10	2.04	1.86	1.78	
19/2.75	4.59	4.44	4.31	4.19	4.07	3.96	3.86	3.77	3.45	3.32	

Sag and Blowout Calculations for 19/2.00. **Refer NOTES Section 5.1.1** Creep Allowance: **Nil**
OBSOLETE Conductor Type – for reference only

5.8.8 HDC Limited 10% NBL 100m MES

SPAN LENGTH (m)	SAG (m) Temperature -5ºC	0ºC	5ºC	10ºC	15ºC	20ºC	25ºC	30ºC	50ºC	60ºC	BLOW OUT (m)
50	0.66	0.67	0.69	0.70	0.71	0.73	0.74	0.75	0.80	0.83	0.51
55	0.80	0.82	0.83	0.85	0.87	0.88	0.90	0.91	0.97	1.00	0.61
60	0.95	0.97	0.99	1.01	1.03	1.05	1.07	1.08	1.15	1.19	0.73
65	1.12	1.14	1.16	1.19	1.21	1.23	1.25	1.27	1.36	1.40	0.91
70	1.30	1.32	1.35	1.38	1.40	1.43	1.45	1.48	1.57	1.62	1.00
75	1.49	1.52	1.55	1.58	1.61	1.64	1.67	1.70	1.81	1.86	1.14
80	1.69	1.73	1.76	1.80	1.83	1.86	1.90	1.93	2.05	2.11	1.30
85	1.91	1.95	1.99	2.03	2.07	2.10	2.14	2.18	2.32	2.39	1.47
90	2.14	2.19	2.23	2.28	2.32	2.36	2.40	2.44	2.60	2.68	1.65
95	2.39	2.44	2.49	2.54	2.58	2.63	2.68	2.72	2.90	2.98	1.83
100	2.65	2.70	2.76	2.81	2.86	2.91	2.97	3.02	3.21	3.30	2.03
105	2.92	2.98	3.04	3.10	3.16	3.21	3.27	3.33	3.54	3.64	2.24
110	3.20	3.27	3.34	3.40	3.46	3.53	3.59	3.65	3.89	4.00	2.46
115	3.50	3.57	3.65	3.72	3.79	3.86	3.92	3.99	4.25	4.37	2.69
120	3.81	3.89	3.97	4.05	4.12	4.20	4.27	4.35	4.63	4.76	2.93
125	4.14	4.22	4.31	4.39	4.47	4.56	4.64	4.72	5.02	5.17	3.18
130	4.48	4.57	4.66	4.75	4.84	4.93	5.02	5.10	5.43	5.59	3.44
135	4.83	4.93	5.03	5.12	5.22	5.32	5.41	5.50	5.86	6.03	3.71
140	5.19	5.30	5.41	5.51	5.62	5.72	5.82	5.92	6.30	6.49	3.99
145	5.57	5.69	5.80	5.91	6.03	6.13	6.24	6.35	6.76	6.96	4.28
150	5.96	6.09	6.21	6.33	6.45	6.57	6.68	6.80	7.24	7.45	4.58
CONDUCTOR	**NO WIND TENSION (kN)**										
7/1.25	0.38	0.37	0.36	0.35	0.34	0.34	0.33	0.33	0.30	0.30	
7/1.75	0.72	0.70	0.69	0.68	0.66	0.65	0.64	0.63	0.59	0.57	
7/2.00	0.92	0.90	0.88	0.86	0.85	0.83	0.82	0.80	0.76	0.73	
19/1.75	1.90	1.87	1.83	1.80	1.76	1.73	1.70	1.67	1.57	1.53	
19/2.00	2.46	2.41	2.36	2.32	2.27	2.23	2.19	2.16	2.03	1.97	
19/2.75	4.47	4.39	4.31	4.24	4.16	4.10	4.03	3.97	3.75	3.65	

Sag and Blowout Calculations for 19/2.00. **Refer NOTES Section 5.1.1** Creep Allowance: **Nil**
OBSOLETE Conductor Type – for reference only

5.8.9 HDC Limited 10% NBL Mechanical Forces per Conductor

SPAN LENGTH (m)	CONDUCTOR TENSION (kN)									
	7/1.75		7/2.00		19/1.75		19/2.00		19/2.75	
	No Wind	Max Wind	No Wind	Max Wind	No Wind	Max Wind	No Wind	Max Wind	No Wind	Max Wind
20	0.76	1.26	0.97	1.51	2.01	2.61	2.60	3.19	4.74	5.18
30		1.54		1.84		3.13		3.79		6.04
40		1.76		2.09		3.50		4.23		6.64
50		1.94		2.28		3.79		4.55		7.08
60		2.08		2.44		4.00		4.80		7.39
70		2.20		2.56		4.18		4.99		7.63
80		2.29		2.66		4.31		5.14		7.80
90		2.36		2.75		4.41		5.26		7.93
100		2.44		2.81		4.50		5.35		8.04
110		2.49		2.88		4.56		5.43		8.11
120		2.54		2.93		4.63		5.49		8.18
130		2.58		2.96		4.68		5.54		8.24
140		2.60		2.99		4.71		5.59		8.28
150		2.64		3.03		4.74		5.63		8.31

MES = Span Length. No Wind tension is at 5°C and includes 1.1 Load Factor. Max Wind (900Pa) tension is at 15°C and includes 1.25 Load Factor.

5.8.10HDC Medium 18% NBL 100m MES

SPAN LENGTH (m)	SAG (m)										BLOW OUT (m)
	Temperature										
	-5ºC	0ºC	5ºC	10ºC	15ºC	20ºC	25ºC	30ºC	50ºC	60ºC	
60	0.50	0.52	0.55	0.58	0.60	0.63	0.65	0.68	0.77	0.82	0.46
65	0.59	0.62	0.65	0.68	0.71	0.74	0.77	0.79	0.91	0.96	0.54
70	0.68	0.71	0.75	0.78	0.82	0.85	0.89	0.92	1.05	1.11	0.63
75	0.78	0.82	0.86	0.90	0.94	0.98	1.02	1.06	1.21	1.28	0.72
80	0.89	0.93	0.98	1.02	1.07	1.12	1.16	1.20	1.37	1.45	0.81
85	1.00	1.05	1.11	1.16	1.21	1.26	1.31	1.36	1.55	1.64	0.92
90	1.12	1.18	1.24	1.30	1.35	1.41	1.47	1.52	1.74	1.84	1.03
95	1.25	1.32	1.38	1.45	1.51	1.57	1.64	1.70	1.94	2.05	1.14
100	1.39	1.46	1.53	1.60	1.67	1.74	1.81	1.88	2.14	2.27	1.27
105	1.53	1.61	1.69	1.77	1.84	1.92	2.00	2.07	2.36	2.50	1.39
110	1.68	1.76	1.85	1.94	2.02	2.11	2.19	2.28	2.60	2.75	1.53
115	1.83	1.93	2.02	2.12	2.21	2.30	2.40	2.49	2.84	3.00	1.67
120	2.00	2.10	2.20	2.31	2.41	2.51	2.61	2.71	3.09	3.27	1.82
125	2.17	2.28	2.39	2.50	2.61	2.72	2.83	2.94	3.35	3.55	1.98
130	2.34	2.47	2.59	2.71	2.83	2.95	3.06	3.18	3.63	3.84	2.14
135	2.53	2.66	2.79	2.92	3.05	3.18	3.30	3.43	3.91	4.14	2.30
140	2.72	2.86	3.00	3.14	3.28	3.42	3.55	3.69	4.21	4.45	2.48
145	2.92	3.07	3.22	3.37	3.52	3.67	3.81	3.96	4.51	4.78	2.66
150	3.12	3.28	3.44	3.60	3.76	3.92	4.08	4.23	4.83	5.11	2.85
CONDUCTOR	**NO WIND TENSION (kN)**										
7/1.25	0.72	0.68	0.65	0.62	0.59	0.56	0.54	0.52	0.45	0.43	
7/1.75	1.37	1.30	1.24	1.18	1.13	1.09	1.04	1.00	0.88	0.83	
7/2.00	1.74	1.66	1.58	1.51	1.45	1.39	1.34	1.29	1.13	1.07	
19/1.75	3.63	3.45	3.29	3.15	3.02	2.90	2.79	2.69	2.36	2.23	
19/2.00	4.69	4.46	4.25	4.06	3.89	3.73	3.59	3.46	3.03	2.86	
19/2.75	8.51	8.11	7.76	7.43	7.14	6.87	6.62	6.39	5.65	5.35	

Sag and Blowout Calculations for 19/2.00. **Refer NOTES Section 5.1.1** Creep Allowance: **Nil**
OBSOLETE Conductor Type – for reference only

5.8.11HDC Medium 18% NBL 150m MES

SPAN LENGTH (m)	SAG (m) Temperature -5ºC	0ºC	5ºC	10ºC	15ºC	20ºC	25ºC	30ºC	50ºC	60ºC	BLOW OUT (m)
80	0.93	0.95	0.98	1.00	1.03	1.05	1.08	1.10	1.19	1.23	0.75
90	1.18	1.21	1.24	1.27	1.30	1.33	1.36	1.39	1.50	1.56	0.94
100	1.45	1.49	1.53	1.57	1.61	1.64	1.68	1.72	1.86	1.93	1.17
110	1.76	1.80	1.85	1.90	1.94	1.99	2.03	2.08	2.25	2.33	1.42
120	2.09	2.15	2.20	2.26	2.31	2.37	2.42	2.47	2.68	2.77	1.69
130	2.45	2.52	2.59	2.65	2.72	2.78	2.84	2.90	3.14	3.25	1.98
140	2.85	2.92	3.00	3.07	3.15	3.22	3.29	3.37	3.64	3.78	2.30
150	3.27	3.36	3.44	3.53	3.62	3.70	3.78	3.86	4.18	4.33	2.64
160	3.72	3.82	3.92	4.02	4.11	4.21	4.30	4.40	4.76	4.93	3.01
170	4.20	4.31	4.42	4.54	4.64	4.75	4.86	4.96	5.37	5.57	3.39
180	4.71	4.84	4.96	5.09	5.21	5.33	5.45	5.57	6.02	6.24	3.81
190	5.25	5.39	5.53	5.67	5.80	5.94	6.07	6.20	6.71	6.96	4.24
200	5.81	5.97	6.13	6.28	6.43	6.58	6.73	6.87	7.44	7.71	4.70
CONDUCTOR	**NO WIND TENSION (kN)**										
7/1.25	0.68	0.66	0.65	0.63	0.61	0.60	0.58	0.57	0.53	0.51	
7/1.75	1.31	1.27	1.24	1.21	1.18	1.15	1.13	1.10	1.02	0.98	
7/2.00	1.67	1.63	1.58	1.55	1.51	1.47	1.44	1.41	1.31	1.26	
19/1.75	3.47	3.38	3.29	3.21	3.14	3.07	3.00	2.94	2.72	2.62	
19/2.00	4.48	4.36	4.25	4.14	4.05	3.96	3.87	3.79	3.50	3.38	
19/2.75	8.14	7.94	7.76	7.58	7.42	7.26	7.12	6.98	6.48	6.27	

Sag and Blowout Calculations for 19/2.00. **Refer NOTES Section 5.1.1** Creep Allowance: **Nil**
OBSOLETE Conductor Type – for reference only

5.8.12 HDC Medium 18% NBL Mechanical Forces per Conductor

SPAN LENGTH (m)	CONDUCTOR TENSION (kN)									
	7/1.75		7/2.00		19/1.75		19/2.00		19/2.75	
	No Wind	Max Wind	No Wind	Max Wind	No Wind	Max Wind	No Wind	Max Wind	No Wind	Max Wind
50	1.36	2.45	1.74	2.95	3.62	5.18	4.68	6.34	8.54	10.40
60		2.66		3.19		5.54		6.78		10.99
70		2.85		3.40		5.88		7.15		11.50
80		3.03		3.60		6.16		7.48		11.95
90		3.19		3.78		6.41		7.78		12.34
100		3.33		3.94		6.64		8.04		12.66
110		3.45		4.08		6.85		8.26		12.95
120		3.58		4.21		7.03		8.48		13.20
130		3.68		4.33		7.19		8.65		13.43
140		3.78		4.44		7.34		8.81		13.61
150		3.88		4.54		7.46		8.96		13.78
160		3.95		4.63		7.59		9.09		13.93
170		4.03		4.71		7.69		9.21		14.05
180		4.10		4.79		7.79		9.31		14.18
190		4.16		4.85		7.88		9.41		14.28
200		4.23		4.91		7.95		9.50		14.36

MES = Span Length. No Wind tension is at 5°C and includes 1.1 Load Factor. Max Wind (900Pa) tension is at 15°C and includes 1.25 Load Factor.

5.9 LVABC

5.9.1 LVABC Slack 2% NBL 20m MES

SPAN LENGTH (m)	SAG (m) Temperature -5ºC	0ºC	5ºC	10ºC	15ºC	20ºC	25ºC	30ºC	50ºC	75ºC	BLOW OUT (m)
10	0.15	0.15	0.16	0.16	0.16	0.17	0.17	0.17	0.18	0.20	0.13
15	0.33	0.34	0.35	0.36	0.37	0.37	0.38	0.39	0.41	0.45	0.30
20	0.59	0.61	0.62	0.64	0.65	0.66	0.68	0.69	0.74	0.79	0.54
25	0.93	0.95	0.97	1.00	1.02	1.04	1.06	1.08	1.15	1.24	0.84
30	1.34	1.37	1.40	1.43	1.46	1.49	1.52	1.55	1.66	1.79	1.21
35	1.83	1.87	1.91	1.95	2.00	2.04	2.08	2.12	2.27	2.44	1.65
CONDUCTOR	**NO WIND TENSION (kN)**										
2C 50mm²	0.29	0.29	0.28	0.27	0.27	0.26	0.26	0.25	0.24	0.22	
4C 50mm²	0.59	0.57	0.56	0.55	0.54	0.53	0.52	0.51	0.47	0.44	
2C 95mm²	0.56	0.54	0.53	0.52	0.51	0.50	0.49	0.48	0.45	0.42	
4C 95mm²	1.11	1.09	1.06	1.04	1.02	1.00	0.98	0.96	0.90	0.84	
4C 150mm²	1.77	1.72	1.68	1.64	1.60	1.57	1.54	1.50	1.40	1.29	

Sag and Blowout Calculations for 4C 95mm². **Refer NOTES Section 5.1.1** Creep Allowance: **Nil**

5.9.2 LVABC Slack 2% NBL Mechanical Forces

SPAN LENGTH (m)	CONDUCTOR TENSION (kN) 2C 50mm²		4C 50mm²		2C 95mm²		4C 95mm²		4C 150mm²	
	No Wind	Max Wind	No Wind	Max Wind	No Wind	Max Wind	No Wind	Max Wind	No Wind	Max Wind
10	0.31	1.71	0.62	2.20	0.58	2.36	1.17	3.08	1.85	3.98
20		2.04		2.55		2.75		3.51		4.55
30		2.13		2.64		2.88		3.63		4.70
40		2.16		2.68		2.95		3.66		4.75

MES = Span Length. No Wind tension is at 5°C and includes 1.1 Load Factor. Max Wind (900Pa) tension is at 15°C and includes 1.25 Load Factor.

5.9.3 LVABC Urban 6% NBL 40m MES

SPAN LENGTH (m)	SAG (m) Temperature										BLOW OUT (m)
	-5ºC	0ºC	5ºC	10ºC	15ºC	20ºC	25ºC	30ºC	50ºC	75ºC	
20	0.19	0.20	0.21	0.22	0.23	0.24	0.24	0.25	0.28	0.32	0.19
25	0.29	0.31	0.32	0.34	0.35	0.37	0.38	0.39	0.44	0.50	0.30
30	0.42	0.44	0.47	0.49	0.51	0.53	0.55	0.57	0.64	0.72	0.43
35	0.57	0.60	0.64	0.66	0.69	0.72	0.75	0.77	0.87	0.98	0.59
40	0.75	0.79	0.83	0.87	0.91	0.94	0.98	1.01	1.13	1.28	0.77
45	0.95	1.00	1.05	1.10	1.15	1.19	1.24	1.28	1.44	1.61	0.98
50	1.17	1.23	1.30	1.36	1.42	1.47	1.53	1.58	1.77	1.99	1.21
55	1.42	1.49	1.57	1.64	1.71	1.78	1.85	1.91	2.15	2.41	1.46
60	1.69	1.78	1.87	1.96	2.04	2.12	2.20	2.27	2.56	2.87	1.74
65	1.98	2.09	2.19	2.30	2.39	2.49	2.58	2.67	3.00	3.38	2.04
70	2.29	2.42	2.54	2.66	2.78	2.89	2.99	3.10	3.48	3.92	2.37
CONDUCTOR	**NO WIND TENSION (kN)**										
2C 50mm²	0.93	0.88	0.84	0.80	0.77	0.74	0.71	0.69	0.61	0.54	
4C 50mm²	1.87	1.77	1.68	1.60	1.54	1.48	1.42	1.37	1.22	1.08	
2C 95mm²	1.77	1.68	1.60	1.53	1.46	1.41	1.36	1.32	1.17	1.04	
4C 95mm²	3.54	3.35	3.19	3.05	2.93	2.82	2.72	2.63	2.34	2.08	
4C 150mm²	5.65	5.32	5.04	4.80	4.58	4.39	4.22	4.07	3.60	3.18	

Sag and Blowout Calculations for 4C 95mm². **Refer NOTES Section 5.1.1** Creep Allowance: **Nil**

5.9.4 LVABC Urban 6% NBL 60m MES

SPAN LENGTH (m)	SAG (m) Temperature -5ºC	0ºC	5ºC	10ºC	15ºC	20ºC	25ºC	30ºC	50ºC	75ºC	BLOW OUT (m)
30	0.45	0.46	0.47	0.48	0.49	0.50	0.51	0.52	0.55	0.59	0.41
35	0.61	0.62	0.64	0.65	0.66	0.68	0.69	0.70	0.75	0.81	0.56
40	0.79	0.81	0.83	0.85	0.87	0.88	0.90	0.92	0.98	1.05	0.73
45	1.00	1.03	1.05	1.07	1.10	1.12	1.14	1.16	1.24	1.33	0.92
50	1.24	1.27	1.30	1.33	1.35	1.38	1.41	1.43	1.53	1.65	1.13
55	1.50	1.54	1.57	1.60	1.64	1.67	1.70	1.73	1.85	1.99	1.37
60	1.79	1.83	1.87	1.91	1.95	1.99	2.03	2.06	2.21	2.37	1.63
65	2.10	2.15	2.19	2.24	2.29	2.33	2.38	2.42	2.59	2.79	1.92
70	2.43	2.49	2.54	2.60	2.65	2.71	2.76	2.81	3.01	3.23	2.23
75	2.79	2.86	2.92	2.99	3.05	3.11	3.17	3.23	3.45	3.71	2.56
80	3.18	3.25	3.33	3.40	3.47	3.54	3.60	3.67	3.93	4.23	2.91
85	3.59	3.67	3.76	3.84	3.92	3.99	4.07	4.15	4.44	4.78	3.28
90	4.02	4.12	4.21	4.30	4.39	4.48	4.57	4.65	4.98	5.36	3.68
CONDUCTOR	**NO WIND TENSION (kN)**										
2C 50mm²	0.88	0.86	0.84	0.82	0.80	0.79	0.77	0.76	0.71	0.66	
4C 50mm²	1.76	1.72	1.68	1.64	1.61	1.58	1.55	1.52	1.42	1.32	
2C 95mm²	1.67	1.63	1.60	1.56	1.53	1.50	1.47	1.45	1.36	1.26	
4C 95mm²	3.34	3.26	3.19	3.12	3.06	3.00	2.95	2.89	2.70	2.51	
4C 150mm²	5.30	5.17	5.04	4.92	4.81	4.71	4.61	4.52	4.21	3.89	

Sag and Blowout Calculations for 4C 95mm². **Refer NOTES Section 5.1.1** Creep Allowance: **Nil**

5.9.5 LVABC Urban 6% NBL Mechanical Forces

SPAN LENGTH (m)	CONDUCTOR TENSION (kN)									
	2C 50mm²		4C 50mm²		2C 95mm²		4C 95mm²		4C 150mm²	
	No Wind	Max Wind	No Wind	Max Wind	No Wind	Max Wind	No Wind	Max Wind	No Wind	Max Wind
10	0.92	2.49	1.85	3.45	1.76	3.64	3.51	5.10	5.54	6.68
20		3.75		5.11		5.39		7.43		9.75
30		4.55		6.09		6.44		8.73		11.43
40		5.09		6.70		7.11		9.53		12.40
50		5.46		7.10		7.55		10.01		13.00
60		5.73		7.36		7.84		10.26		13.39
70		5.91		7.54		8.05		10.46		13.64
80		6.05		7.66		8.20		10.61		13.83
90		6.15		7.76		8.30		10.71		13.95

MES = Span Length. No Wind tension is at 5°C and includes 1.1 Load Factor. Max Wind (900Pa) tension is at 15°C and includes 1.25 Load Factor.

5.9.6 LVABC Limited 10% NBL 50m MES

	SAG (m)																BLOW OUT (m)
SPAN LENGTH (m)	Temperature																
	-5ºC	0ºC		5ºC		10ºC		15ºC		20ºC		25ºC		30ºC		50ºC	75ºC
	FINAL	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	**FINAL**	**FINAL**	
30	0.24	0.24	0.26	0.26	0.28	0.28	0.30	0.30	0.32	0.32	0.34	0.34	0.36	0.36	0.37	0.44	0.51	0.28
35	0.32	0.32	0.35	0.35	0.38	0.38	0.41	0.41	0.44	0.44	0.46	0.46	0.49	0.49	0.51	0.60	0.69	0.39
40	0.42	0.42	0.46	0.46	0.50	0.50	0.53	0.53	0.57	0.57	0.60	0.60	0.64	0.64	0.67	0.78	0.91	0.51
45	0.53	0.53	0.58	0.58	0.63	0.63	0.68	0.68	0.72	0.72	0.76	0.76	0.80	0.80	0.84	0.99	1.15	0.64
50	0.66	0.66	0.72	0.72	0.78	0.78	0.83	0.83	0.89	0.89	0.94	0.94	0.99	0.99	1.04	1.22	1.42	0.79
55	0.80	0.80	0.87	0.87	0.94	0.94	1.01	1.01	1.08	1.08	1.14	1.14	1.20	1.20	1.26	1.48	1.72	0.96
60	0.95	0.95	1.04	1.04	1.12	1.12	1.20	1.20	1.28	1.28	1.36	1.36	1.43	1.43	1.50	1.76	2.04	1.14
65	1.11	1.11	1.21	1.21	1.31	1.31	1.41	1.41	1.50	1.50	1.59	1.59	1.68	1.68	1.76	2.07	2.40	1.34
70	1.29	1.29	1.41	1.41	1.53	1.53	1.64	1.64	1.74	1.74	1.85	1.85	1.95	1.95	2.04	2.40	2.78	1.55
75	1.48	1.48	1.62	1.62	1.75	1.75	1.88	1.88	2.00	2.00	2.12	2.12	2.24	2.24	2.35	2.75	3.20	1.78
80	1.68	1.68	1.84	1.84	1.99	1.99	2.14	2.14	2.28	2.28	2.41	2.41	2.54	2.54	2.67	3.13	3.64	2.02
CONDUCTOR	**NO WIND TENSION (kN)**																
2C 50mm^2	1.67	1.67	1.52	1.52	1.40	1.40	1.30	1.30	1.22	1.22	1.15	1.15	1.09	1.09	1.04	0.88	0.76	
4C 50mm^2	3.33	3.33	3.04	3.04	2.80	2.80	2.60	2.60	2.44	2.44	2.30	2.30	2.18	2.18	2.08	1.77	1.52	
2C 95mm^2	3.14	3.14	2.88	2.88	2.66	2.66	2.48	2.48	2.33	2.33	2.20	2.20	2.09	2.09	1.99	1.70	1.47	
4C 95mm^2	6.29	6.29	5.76	5.76	5.32	5.32	4.96	4.96	4.65	4.65	4.39	4.39	4.17	4.17	3.97	3.39	2.92	
4C 150mm^2	10.11	10.11	9.16	9.16	8.40	8.40	7.78	7.78	7.26	7.26	6.83	6.83	6.45	6.45	6.13	5.19	4.44	

Sag and Blowout Calculations for 4C 95mm^2. **Refer NOTES Section 5.1.1** Creep Allowance: **5ºC**

5.9.7 LVABC Limited 10% NBL 75m MES

SPAN LENGTH (m)	SAG (m)																	BLOW OUT (m)
	Temperature																	
	-5ºC	0ºC		5ºC		10ºC		15ºC		20ºC		25ºC		30ºC		50ºC	75ºC	
	FINAL	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	**FINAL**	**FINAL**	
40	0.46	0.46	0.48	0.48	0.50	0.50	0.52	0.52	0.53	0.53	0.55	0.55	0.57	0.57	0.58	0.64	0.71	0.46
45	0.58	0.58	0.61	0.61	0.63	0.63	0.65	0.65	0.67	0.67	0.70	0.70	0.72	0.72	0.74	0.82	0.90	0.58
50	0.72	0.72	0.75	0.75	0.78	0.78	0.81	0.81	0.83	0.83	0.86	0.86	0.89	0.89	0.91	1.01	1.12	0.72
55	0.87	0.87	0.91	0.91	0.94	0.94	0.98	0.98	1.01	1.01	1.04	1.04	1.07	1.07	1.10	1.22	1.35	0.87
60	1.04	1.04	1.08	1.08	1.12	1.12	1.16	1.16	1.20	1.20	1.24	1.24	1.28	1.28	1.31	1.45	1.61	1.03
65	1.22	1.22	1.27	1.27	1.31	1.31	1.36	1.36	1.41	1.41	1.45	1.45	1.50	1.50	1.54	1.70	1.89	1.21
70	1.41	1.41	1.47	1.47	1.53	1.53	1.58	1.58	1.63	1.63	1.69	1.69	1.74	1.74	1.79	1.97	2.19	1.41
75	1.62	1.62	1.69	1.69	1.75	1.75	1.81	1.81	1.88	1.88	1.94	1.94	1.99	1.99	2.05	2.27	2.51	1.62
80	1.84	1.84	1.92	1.92	1.99	1.99	2.06	2.06	2.13	2.13	2.20	2.20	2.27	2.27	2.33	2.58	2.86	1.84
85	2.08	2.08	2.17	2.17	2.25	2.25	2.33	2.33	2.41	2.41	2.49	2.49	2.56	2.56	2.64	2.91	3.23	2.08
90	2.33	2.33	2.43	2.43	2.52	2.52	2.61	2.61	2.70	2.70	2.79	2.79	2.87	2.87	2.95	3.27	3.62	2.33
95	2.60	2.60	2.71	2.71	2.81	2.81	2.91	2.91	3.01	3.01	3.11	3.11	3.20	3.20	3.29	3.64	4.04	2.60
100	2.88	2.88	3.00	3.00	3.11	3.11	3.23	3.23	3.34	3.34	3.44	3.44	3.55	3.55	3.65	4.03	4.47	2.88
105	3.18	3.18	3.31	3.31	3.43	3.43	3.56	3.56	3.68	3.68	3.80	3.80	3.91	3.91	4.02	4.45	4.93	3.17
110	3.49	3.49	3.63	3.63	3.77	3.77	3.91	3.91	4.04	4.04	4.17	4.17	4.29	4.29	4.42	4.88	5.42	3.48
115	3.81	3.81	3.97	3.97	4.12	4.12	4.27	4.27	4.41	4.41	4.56	4.56	4.69	4.69	4.83	5.34	5.92	3.81
CONDUCTOR	**NO WIND TENSION (kN)**																	
2C 50mm²	1.52	1.52	1.46	1.46	1.40	1.40	1.35	1.35	1.30	1.30	1.26	1.26	1.23	1.23	1.19	1.08	0.97	
4C 50mm²	3.04	3.04	2.91	2.91	2.80	2.80	2.70	2.70	2.61	2.61	2.53	2.53	2.45	2.45	2.38	2.15	1.94	
2C 95mm²	2.87	2.87	2.76	2.76	2.66	2.66	2.57	2.57	2.49	2.49	2.41	2.41	2.34	2.34	2.28	2.06	1.86	
4C 95mm²	5.75	5.75	5.52	5.52	5.32	5.32	5.14	5.14	4.97	4.97	4.81	4.81	4.67	4.67	4.54	4.11	3.71	
4C 150mm²	9.16	9.16	8.76	8.76	8.40	8.40	8.08	8.08	7.79	7.79	7.53	7.53	7.29	7.29	7.07	6.35	5.70	

Sag and Blowout Calculations for 4C 95mm². **Refer NOTES Section 5.1.1** Creep Allowance: **5ºC**

5.9.8 LVABC Limited 10% NBL 100m MES

SPAN LENGTH (m)	SAG (m) – Temperature -5ºC	0ºC		5ºC		10ºC		15ºC		20ºC		25ºC		30ºC		50ºC	75ºC	BLOW OUT (m)
	FINAL	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	INITIAL	**FINAL**	**FINAL**	**FINAL**	
50	0.74	0.74	0.76	0.76	0.78	0.78	0.79	0.79	0.81	0.81	0.83	0.83	0.84	0.84	0.86	0.92	0.99	0.69
55	0.90	0.90	0.92	0.92	0.94	0.94	0.96	0.96	0.98	0.98	1.00	1.00	1.02	1.02	1.04	1.11	1.19	0.83
60	1.07	1.07	1.10	1.10	1.12	1.12	1.14	1.14	1.17	1.17	1.19	1.19	1.21	1.21	1.23	1.32	1.42	0.99
65	1.26	1.26	1.29	1.29	1.31	1.31	1.34	1.34	1.37	1.37	1.40	1.40	1.42	1.42	1.45	1.55	1.67	1.16
70	1.46	1.46	1.49	1.49	1.53	1.53	1.56	1.56	1.59	1.59	1.62	1.62	1.65	1.65	1.68	1.80	1.93	1.35
75	1.67	1.67	1.71	1.71	1.75	1.75	1.79	1.79	1.82	1.82	1.86	1.86	1.90	1.90	1.93	2.06	2.22	1.55
80	1.91	1.91	1.95	1.95	1.99	1.99	2.03	2.03	2.08	2.08	2.12	2.12	2.16	2.16	2.20	2.35	2.52	1.76
85	2.15	2.15	2.20	2.20	2.25	2.25	2.30	2.30	2.34	2.34	2.39	2.39	2.43	2.43	2.48	2.65	2.85	1.99
90	2.41	2.41	2.47	2.47	2.52	2.52	2.58	2.58	2.63	2.63	2.68	2.68	2.73	2.73	2.78	2.97	3.20	2.23
95	2.69	2.69	2.75	2.75	2.81	2.81	2.87	2.87	2.93	2.93	2.99	2.99	3.04	3.04	3.10	3.31	3.56	2.48
100	2.98	2.98	3.05	3.05	3.11	3.11	3.18	3.18	3.25	3.25	3.31	3.31	3.37	3.37	3.43	3.67	3.95	2.75
105	3.29	3.29	3.36	3.36	3.43	3.43	3.51	3.51	3.58	3.58	3.65	3.65	3.72	3.72	3.79	4.05	4.35	3.03
110	3.61	3.61	3.69	3.69	3.77	3.77	3.85	3.85	3.93	3.93	4.00	4.00	4.08	4.08	4.16	4.44	4.78	3.33
115	3.94	3.94	4.03	4.03	4.12	4.12	4.21	4.21	4.29	4.29	4.38	4.38	4.46	4.46	4.54	4.86	5.22	3.60
120	4.29	4.29	4.39	4.39	4.49	4.49	4.58	4.58	4.68	4.68	4.77	4.77	4.86	4.86	4.95	5.29	5.69	3.96
125	4.66	4.66	4.77	4.77	4.87	4.87	4.97	4.97	5.07	5.07	5.17	5.17	5.27	5.27	5.37	5.74	6.18	4.30
130	5.04	5.04	5.15	5.15	5.27	5.27	5.38	5.38	5.49	5.49	5.60	5.60	5.70	5.70	5.81	6.21	6.68	4.65
135	5.44	5.44	5.56	5.56	5.68	5.68	5.80	5.80	5.92	5.92	6.04	6.04	6.15	6.15	6.26	6.70	7.21	5.02
140	5.85	5.85	5.98	5.98	6.11	6.11	6.24	6.24	6.37	6.37	6.49	6.49	6.62	6.62	6.74	7.21	7.75	5.40
145	6.27	6.27	6.42	6.42	6.56	6.56	6.70	6.70	6.83	6.83	6.97	6.97	7.10	7.10	7.23	7.73	8.32	5.79
150	6.71	6.71	6.87	6.87	7.02	7.02	7.17	7.17	7.31	7.31	7.46	7.46	7.60	7.60	7.74	8.28	8.91	6.20
CONDUCTOR	**NO WIND TENSION (kN)**																	
2C 50mm²	1.47	1.47	1.43	1.43	1.40	1.40	1.37	1.37	1.34	1.34	1.32	1.32	1.29	1.29	1.27	1.18	1.10	
4C 50mm²	2.93	2.93	2.86	2.86	2.80	2.80	2.74	2.74	2.68	2.68	2.63	2.63	2.58	2.58	2.53	2.37	2.20	
2C 95mm²	2.78	2.78	2.72	2.72	2.66	2.66	2.61	2.61	2.55	2.55	2.51	2.51	2.46	2.46	2.42	2.26	2.11	
4C 95mm²	5.56	5.56	5.44	5.44	5.32	5.32	5.21	5.21	5.11	5.11	5.01	5.01	4.92	4.92	4.83	4.52	4.20	
4C 150mm²	8.82	8.82	8.60	8.60	8.40	8.40	8.21	8.21	8.03	8.03	7.86	7.86	7.70	7.70	7.55	7.03	6.50	

Sag and Blowout Calculations for 4C 95mm². **Refer NOTES Section 5.1.1** Creep Allowance: **5ºC**

5.9.9 LVABC Limited 10% NBL Mechanical Forces

SPAN LENGTH (m)	CONDUCTOR TENSION (kN)									
	2C 50mm²		4C 50mm²		2C 95mm²		4C 95mm²		4C 150mm²	
	No Wind	Max Wind	No Wind	Max Wind	No Wind	Max Wind	No Wind	Max Wind	No Wind	Max Wind
20	1.54	4.28	3.08	6.08	2.93	6.34	5.85	9.14	9.24	12.20
30		5.39		7.56		7.90		11.24		14.95
40		6.28		8.70		9.11		12.78		16.94
50		6.99		9.58		10.05		13.93		18.40
60		7.58		10.26		10.80		14.80		19.51
70		8.05		10.80		11.40		15.46		20.35
80		8.45		11.24		11.88		15.99		20.99
90		8.79		11.58		12.26		16.39		21.50
100		9.06		11.86		12.59		16.71		21.90
110		9.30		12.10		12.85		16.98		22.21
120		9.50		12.29		13.08		17.19		22.48
130		9.66		12.45		13.25		17.36		22.69
140		9.81		12.58		13.41		17.51		22.86
150		9.94		12.69		13.54		17.64		23.01

MES = Span Length. No Wind tension is at 5°C and includes 1.1 Load Factor. Max Wind (900Pa) tension is at 15°C and includes 1.25 Load Factor.

5.10 MS HVABC

5.10.1 MSHVABC with SC/GZ Catenary Slack T1000 MES=Span Length

SPAN LENGTH (m)		SAG (m) Catenary Temperature									BLOWOUT (m)	
		-5ºC	0ºC	5ºC	10ºC	15ºC	20ºC	25ºC	30ºC	50ºC	11kV 35mm²	11kV 185mm²
10		0.09	0.09	0.10	0.11	0.11	0.12	0.13	0.13	0.16	0.11	0.10
15		0.21	0.22	0.23	0.23	0.24	0.25	0.26	0.27	0.30	0.21	0.16
20		0.38	0.39	0.40	0.41	0.42	0.43	0.44	0.45	0.48	0.35	0.27
25		0.61	0.62	0.63	0.64	0.65	0.65	0.66	0.67	0.71	0.52	0.41
30		0.88	0.89	0.90	0.91	0.92	0.93	0.94	0.95	0.99	0.73	0.58
35		1.21	1.22	1.23	1.24	1.25	1.26	1.27	1.28	1.32	0.98	0.77
CONDUCTOR	**%NBL**	**NO WIND TENSION (kN)**										
11kV 35mm²+19/2.00SC/GZ	4.02	2.98	2.90	2.83	2.77	2.70	2.65	2.59	2.54	2.36		
22kV 35mm²+19/2.00 SC/GZ	4.80	3.55	3.46	3.38	3.31	3.23	3.17	3.10	3.04	2.83		
11kV 185mm²+19/2.00SC/GZ	8.62	6.35	6.21	6.08	5.96	5.84	5.72	5.62	5.51	5.14		
22kV 185mm²+19/2.00SC/GZ	9.81	7.21	7.06	6.91	6.78	6.64	6.52	6.40	6.28	5.87		

Sag Calculations for 11kV 35mm² cable. Blowout calculations for 11kV cable; blowout is less for heavier 22kV cable. **Refer NOTES Section 5.1.1** Creep Allowance: **Nil**

5.10.2MSHVABC with SC/GZ Catenary Slack T1000 Mechanical Forces

SPAN LENGTH (m)	CONDUCTOR TENSION (kN) 11kV 35mm²		22kV 35mm²		11kV 185mm²		22kV 185mm²	
	No Wind	Max Wind	No Wind	Max Wind	No Wind	Max Wind	No Wind	Max Wind
10	3.11	5.65	3.72	6.53	6.69	9.16	7.60	10.31
15		6.46		7.46		10.20		11.45
20		6.96		8.05		10.88		12.21
25		7.28		8.44		11.33		12.74
30		7.49		8.70		11.64		13.10
35		7.63		8.88		11.85		13.36

MES = Span Length. No Wind tension is at 5°C and includes 1.1 Load Factor. Max Wind (900Pa) tension is at 15°C and includes 1.25 Load Factor.

5.10.3 MSHVABC with SC/GZ Catenary Urban T700 MES=Span Length

SPAN LENGTH (m)		SAG (m) Catenary Temperature									BLOWOUT (m)	
		-5ºC	0ºC	5ºC	10ºC	15ºC	20ºC	25ºC	30ºC	50ºC	11kV 35mm²	11kV 185mm²
20		0.26	0.27	0.28	0.29	0.30	0.31	0.32	0.33	0.38	0.27	0.21
25		0.41	0.43	0.44	0.45	0.46	0.47	0.49	0.50	0.54	0.40	0.31
30		0.60	0.62	0.63	0.64	0.66	0.67	0.68	0.69	0.74	0.55	0.43
35		0.83	0.84	0.86	0.87	0.89	0.90	0.91	0.93	0.98	0.73	0.57
40		1.09	1.11	1.12	1.14	1.15	1.16	1.18	1.19	1.24	0.93	0.73
45		1.39	1.40	1.42	1.43	1.45	1.46	1.48	1.49	1.54	1.16	0.91
50		1.72	1.74	1.75	1.77	1.78	1.80	1.81	1.82	1.88	1.41	1.11
55		2.09	2.11	2.12	2.14	2.15	2.17	2.18	2.19	2.25	1.69	1.33
60		2.50	2.51	2.53	2.54	2.56	2.57	2.59	2.60	2.66	2.00	1.57
65		2.94	2.95	2.97	2.98	3.00	3.01	3.03	3.04	3.10	2.33	1.83
70		3.41	3.43	3.44	3.46	3.47	3.49	3.50	3.52	3.57	2.69	2.12
75		3.92	3.94	3.95	3.97	3.98	4.00	4.01	4.03	4.09	3.07	2.42
80		4.47	4.48	4.50	4.51	4.53	4.54	4.56	4.57	4.63	3.49	2.74
85		5.05	5.07	5.08	5.10	5.11	5.13	5.14	5.16	5.22	3.93	3.09
90		5.67	5.68	5.70	5.72	5.73	5.75	5.76	5.78	5.84	4.39	3.46
CONDUCTOR	**%NBL**	**NO WIND TENSION (kN)**										
11kV 35mm²+19/2.00SC/GZ	**5.74**	4.07	4.06	4.05	4.03	4.02	4.01	4.00	3.99	3.95		
22kV 35mm²+19/2.00 SC/GZ	**6.86**	4.86	4.85	4.83	4.82	4.81	4.79	4.78	4.77	4.72		
11kV 185mm²+19/2.00SC/GZ	**12.32**	8.78	8.74	8.69	8.64	8.59	8.54	8.50	8.45	8.28		
22kV 185mm²+19/2.00SC/GZ	**14.01**	9.99	9.93	9.88	9.82	9.77	9.72	9.66	9.61	9.41		

Sag Calculations for 11kV 35mm² cable. Blowout calculations for 11kV cable; blowout is less for heavier 22kV cable. **Refer NOTES Section 5.1.1** Creep Allowance: **Nil**

5.10.4 MSHVABC with SC/GZ Catenary Urban T700 Mechanical Forces

SPAN LENGTH (m)	CONDUCTOR TENSION (kN)							
	11kV 35mm^2		22kV 35mm^2		11kV 185mm^2		22kV 185mm^2	
	No Wind	Max Wind	No Wind	Max Wind	No Wind	Max Wind	No Wind	Max Wind
20	4.46	8.70	5.31	10.04	9.56	13.90	10.87	15.60
25		9.30		10.74		14.68		16.46
30		9.75		11.28		15.28		17.15
35		10.09		11.68		15.75		17.69
40		10.35		12.00		16.11		18.11
45		10.56		12.25		16.41		18.46
50		10.73		12.45		16.65		18.75
55		10.85		12.61		16.85		18.98
60		10.95		12.74		17.01		19.18
65		11.04		12.85		17.14		19.33
70		11.11		12.94		17.25		19.46
75		11.16		13.01		17.34		19.58
80		11.21		13.08		17.43		19.66
85		11.26		13.14		17.49		19.75
90		11.30		13.18		17.55		19.83

MES = Span Length. No Wind tension is at 5°C and includes 1.1 Load Factor. Max Wind (900Pa) tension is at 15°C and includes 1.25 Load Factor.

5.10.5 MSHVABC with SC/GZ Catenary Limited T400 MES=Span Length

SPAN LENGTH (m)		SAG (m) Catenary Temperature									BLOWOUT (m)
		-5ºC	0ºC	5ºC	10ºC	15ºC	20ºC	25ºC	30ºC	50ºC	
40		0.60	0.62	0.64	0.66	0.68	0.69	0.71	0.73	0.80	0.62
45		0.77	0.79	0.81	0.83	0.85	0.87	0.89	0.91	0.98	0.76
50		0.96	0.98	1.00	1.02	1.04	1.06	1.08	1.10	1.18	0.91
55		1.17	1.19	1.21	1.23	1.25	1.27	1.29	1.32	1.40	1.08
60		1.40	1.42	1.44	1.46	1.48	1.51	1.53	1.55	1.63	1.26
65		1.65	1.67	1.69	1.71	1.74	1.76	1.78	1.80	1.89	1.45
70		1.92	1.94	1.96	1.99	2.01	2.03	2.05	2.08	2.16	1.66
75		2.21	2.23	2.25	2.28	2.30	2.32	2.35	2.37	2.46	1.89
80		2.52	2.54	2.56	2.59	2.61	2.63	2.66	2.68	2.77	2.12
85		2.85	2.87	2.89	2.92	2.94	2.97	2.99	3.01	3.11	2.38
90		3.20	3.22	3.25	3.27	3.29	3.32	3.34	3.37	3.46	2.65
95		3.57	3.59	3.62	3.64	3.67	3.69	3.72	3.74	3.84	2.93
100		3.96	3.98	4.01	4.03	4.06	4.08	4.11	4.13	4.23	3.23
105		4.37	4.40	4.42	4.45	4.47	4.50	4.52	4.55	4.64	3.54
110		4.80	4.83	4.85	4.88	4.90	4.93	4.95	4.98	5.08	3.87
115		5.25	5.28	5.30	5.33	5.36	5.38	5.41	5.43	5.53	4.21
120		5.73	5.75	5.78	5.80	5.83	5.85	5.88	5.91	6.01	4.57
125		6.22	6.24	6.27	6.30	6.32	6.35	6.37	6.40	6.50	4.94
CONDUCTOR	**%NBL**	**NO WIND TENSION (kN)**									
11kV 35mm^2+19/2.00SC/GZ	**10.04**	7.13	7.11	7.08	7.05	7.03	7.00	6.97	6.95	6.85	
22kV 35mm^2+19/2.00 SC/GZ	**12.00**	8.52	8.49	8.46	8.43	8.39	8.36	8.33	8.30	8.18	

Sag Calculations for 11kV 35mm^2 cable. Blowout calculations for 11kV cable; blowout is less for heavier 22kV cable. **Refer NOTES Section 5.1.1** Creep Allowance: **Nil**

5.10.6MSHVABC with SC/GZ Catenary Limited T400 Mechanical Forces

SPAN LENGTH (m)	CONDUCTOR TENSION (kN)			
	11kV 35mm^2		22kV 35mm^2	
	No Wind	Max Wind	No Wind	Max Wind
40	7.79	14.84	9.31	17.09
45		15.40		17.74
50		15.88		18.30
55		16.30		18.80
60		16.68		19.24
65		17.01		19.64
70		17.30		19.99
75		17.56		20.30
80		17.79		20.58
85		17.99		20.83
90		18.18		21.05
95		18.34		21.25
100		18.49		21.44
105		18.63		
110		18.74		
115		18.85		
120		18.95		
125		19.04		

MES = Span Length. No Wind tension is at 5°C and includes 1.1 Load Factor. Max Wind (900Pa) tension is at 15°C and includes 1.25 Load Factor.

5.11 ADSS

5.11.1 ADSS Slack T600 20m MES

SPAN LENGTH (m)		SAG (m) Temperature -5ºC	0ºC	5ºC	10ºC	15ºC	20ºC	25ºC	30ºC			BLOW OUT (m)
10		0.06	0.06	0.06	0.06	0.06	0.07	0.07	0.07			0.06
15		0.12	0.13	0.14	0.14	0.15	0.15	0.16	0.16			0.20
20		0.22	0.23	0.24	0.25	0.26	0.27	0.28	0.28			0.35
25		0.35	0.36	0.38	0.39	0.40	0.42	0.43	0.44			0.55
30		0.50	0.52	0.54	0.56	0.58	0.60	0.62	0.64			0.79
35		0.68	0.71	0.74	0.76	0.79	0.82	0.85	0.87			1.08
CONDUCTOR	**%NBL**	**NO WIND TENSION (kN)**										
ADSS 72SM	**0.88**	0.27	0.26	0.25	0.24	0.23	0.22	0.21	0.21			

Sag and Blowout Calculations for ADSS72SM. **Refer NOTES Section 5.1.1** Creep Allowance: **Nil**

5.11.2ADSS Slack T600 Mechanical Forces

SPAN LENGTH (m)	CONDUCTOR TENSION (kN) ADSS 72SM No Wind	Max Wind
10	0.28	1.18
20		1.70
30		2.04
40		2.28

MES = Span Length. No Wind tension is at 5°C and includes 1.1 Load Factor. Max Wind (900Pa) tension is at 15°C and includes 1.25 Load Factor.

5.11.3 ADSS Urban T300 50m MES

SPAN LENGTH (m)		SAG (m) Temperature -5ºC	0ºC	5ºC	10ºC	15ºC	20ºC	25ºC	30ºC			BLOW OUT (m)
20		0.11	0.12	0.12	0.12	0.13	0.13	0.13	0.13			0.18
25		0.18	0.18	0.19	0.19	0.20	0.20	0.21	0.21			0.28
30		0.26	0.26	0.27	0.28	0.28	0.29	0.30	0.30			0.41
35		0.35	0.36	0.37	0.38	0.38	0.39	0.40	0.41			0.56
40		0.46	0.47	0.48	0.49	0.50	0.51	0.53	0.54			0.73
45		0.58	0.59	0.61	0.62	0.64	0.65	0.66	0.68			0.92
50		0.71	0.73	0.75	0.77	0.79	0.80	0.82	0.84			1.14
55		0.86	0.89	0.91	0.93	0.95	0.97	0.99	1.01			1.38
60		1.03	1.05	1.08	1.11	1.13	1.16	1.18	1.21			1.64
65		1.21	1.24	1.27	1.30	1.33	1.36	1.39	1.42			1.93
70		1.40	1.44	1.47	1.51	1.54	1.58	1.61	1.64			2.24
CONDUCTOR	**%NBL**	**NO WIND TENSION (kN)**										
ADSS 72SM	**1.75**	0.52	0.50	0.49	0.48	0.47	0.46	0.45	0.44			

Sag and Blowout Calculations for ADSS72SM. **Refer NOTES Section 5.1.1** Creep Allowance: **Nil**

5.11.4ADSS Urban T300 Mechanical Forces

SPAN LENGTH (m)	CONDUCTOR TENSION (kN) ADSS 72SM No Wind	Max Wind
20	0.54	1.99
30		2.49
40		2.90
50		3.24
60		3.54
70		3.80

MES = Span Length. No Wind tension is at 5°C and includes 1.1 Load Factor. Max Wind (900Pa) tension is at 15°C and includes 1.25 Load Factor.

5.11.5 ADSS Tight T100 100m MES

SPAN LENGTH (m)		SAG (m) Temperature -5ºC	0ºC	5ºC	10ºC	15ºC	20ºC	25ºC	30ºC			BLOW OUT (m)
50		0.24	0.24	0.25	0.26	0.26	0.27	0.28	0.28			0.58
60		0.34	0.35	0.36	0.37	0.38	0.39	0.40	0.41			0.84
70		0.47	0.48	0.49	0.50	0.51	0.53	0.54	0.55			1.14
80		0.61	0.62	0.64	0.66	0.67	0.69	0.71	0.72			1.49
90		0.77	0.79	0.81	0.83	0.85	0.87	0.89	0.92			1.89
100		0.95	0.98	1.00	1.03	1.05	1.08	1.10	1.13			2.34
110		1.15	1.18	1.21	1.24	1.27	1.30	1.34	1.37			2.83
120		1.37	1.40	1.44	1.48	1.51	1.55	1.59	1.63			3.36
130		1.61	1.65	1.69	1.73	1.78	1.82	1.87	1.91			3.95
140		1.86	1.91	1.96	2.01	2.06	2.11	2.16	2.22			4.58
150		2.14	2.20	2.25	2.31	2.37	2.42	2.48	2.55			5.26
CONDUCTOR	**%NBL**	**NO WIND TENSION (kN)**										
ADSS 72SM	**5.25**	1.55	1.51	1.47	1.43	1.40	1.37	1.33	1.30			

Sag and Blowout Calculations for ADSS72SM. **Refer NOTES Section 5.1.1** Creep Allowance: **Nil**

5.11.6ADSS Tight T100 Mechanical Forces

SPAN LENGTH (m)	CONDUCTOR TENSION (kN) ADSS 72SM No Wind	Max Wind
50	1.62	4.08
60		4.49
70		4.88
80		5.25
90		5.60
100		5.93
110		6.25
120		6.55
130		6.84
140		7.11
150		7.39

MES = Span Length. No Wind tension is at 5°C and includes 1.1 Load Factor. Max Wind (900Pa) tension is at 15°C and includes 1.25 Load Factor.

5.12 Al/XLPE Service Cable

5.12.1 2C 25mm² Al/XLPE Service Slack (to Consumer) MES=Span Length

SPAN LENGTH (m)		SAG (m) Temperature -5ºC	0ºC	5ºC	10ºC	15ºC	20ºC	25ºC	30ºC	50ºC	75 ºC	BLOW OUT (m)
10		0.04	0.06	0.08	0.10	0.12	0.13	0.15	0.16	0.21	0.25	0.13
15		0.13	0.15	0.18	0.20	0.22	0.24	0.26	0.28	0.34	0.40	0.24
20		0.26	0.29	0.32	0.34	0.37	0.39	0.41	0.43	0.50	0.58	0.39
25		0.44	0.47	0.50	0.52	0.55	0.57	0.59	0.62	0.70	0.79	0.50
30		0.66	0.69	0.72	0.74	0.77	0.79	0.82	0.84	0.93	1.02	0.72
35		0.92	0.95	0.98	1.00	1.03	1.05	1.08	1.10	1.19	1.30	1.03
40		1.22	1.25	1.28	1.30	1.33	1.35	1.38	1.40	1.50	1.61	1.32
45		1.56	1.59	1.61	1.64	1.67	1.69	1.72	1.74	1.84	1.96	1.64
50		1.94	1.97	1.99	2.02	2.05	2.07	2.10	2.12	2.22	2.34	2.01
CONDUCTOR	**%NBL**	**NO WIND TENSION (kN)**										
2C 25mm²	**4.4**	0.32	0.31	0.31	0.30	0.30	0.30	0.29	0.29	0.28	0.26	

Sag and Blowout Calculations for 2C 25mm². **Refer NOTES Section 5.1.1. Blowout @ 350Pa 15°C.** Creep Allowance: **Nil**

5.12.2 3C & 4C 25mm² Al/XLPE Service Slack (to Consumer) MES=Span Length

SPAN LENGTH (m)		SAG (m) Temperature -5ºC	0ºC	5ºC	10ºC	15ºC	20ºC	25ºC	30ºC	50ºC	75 ºC	BLOW OUT (m)
10		0.06	0.08	0.10	0.12	0.14	0.15	0.16	0.18	0.22	0.26	0.13
15		0.19	0.21	0.23	0.25	0.27	0.29	0.30	0.32	0.37	0.43	0.25
20		0.37	0.39	0.41	0.43	0.45	0.47	0.49	0.50	0.57	0.64	0.41
25		0.60	0.62	0.64	0.66	0.68	0.70	0.72	0.74	0.81	0.89	0.62
30		0.88	0.91	0.93	0.95	0.97	0.99	1.01	1.03	1.10	1.18	0.88
35		1.22	1.24	1.26	1.28	1.30	1.32	1.34	1.36	1.44	1.53	1.18
CONDUCTOR	**%NBL**	**NO WIND TENSION (kN)**										
3C 25mm²	**3.3**	0.36	0.35	0.35	0.34	0.34	0.33	0.33	0.32	0.30	0.29	
4C 25mm²	**3.4**	0.49	0.48	0.48	0.47	0.46	0.45	0.45	0.44	0.42	0.39	

Sag and Blowout Calculations for 4C 25mm². **Refer NOTES Section 5.1.1. Blowout @ 350Pa 15°C.** Creep Allowance: **Nil**

5.12.3 Al/XLPE Service Urban T625 (Pole to Pole) MES=Span Length

SPAN LENGTH (m)		SAG (m) Temperature										BLOW OUT (m)
		-5ºC	0ºC	5ºC	10ºC	15ºC	20ºC	25ºC	30ºC	50ºC	75 ºC	
10		0.03	0.04	0.06	0.08	0.10	0.12	0.14	0.15	0.20	0.25	0.12
15		0.09	0.11	0.14	0.17	0.19	0.21	0.23	0.25	0.32	0.39	0.14
20		0.19	0.22	0.25	0.28	0.31	0.33	0.35	0.38	0.46	0.54	0.25
25		0.32	0.36	0.39	0.42	0.45	0.48	0.50	0.53	0.62	0.72	0.49
30		0.50	0.53	0.56	0.59	0.62	0.65	0.68	0.71	0.81	0.92	0.66
35		0.70	0.73	0.77	0.80	0.83	0.86	0.89	0.92	1.02	1.14	0.86
40		0.93	0.97	1.00	1.03	1.07	1.10	1.13	1.16	1.27	1.40	1.09
45		1.20	1.23	1.27	1.30	1.33	1.37	1.40	1.43	1.54	1.68	1.35
50		1.50	1.53	1.57	1.60	1.63	1.66	1.70	1.73	1.85	1.99	1.64
55		1.82	1.86	1.89	1.93	1.96	1.99	2.02	2.06	2.09	2.32	1.96
60		2.18	2.22	2.25	2.29	2.32	2.35	2.39	2.42	2.45	2.69	2.30
65		2.58	2.61	2.65	2.68	2.71	2.75	2.78	2.81	2.84	3.09	2.68
70		3.00	3.03	3.07	3.10	3.14	3.17	3.20	3.24	3.27	3.52	3.09
75		3.46	3.49	3.52	3.56	3.59	3.63	3.66	3.69	3.73	3.98	3.52
80		3.94	3.98	4.01	4.05	4.08	4.11	4.15	4.18	4.21	4.47	3.99
CONDUCTOR	**%NBL**	**NO WIND TENSION (kN)**										
2C 25mm²	**5.6**	0.41	0.40	0.39	0.38	0.38	0.37	0.36	0.36	0.33	0.31	
3C 25mm²	**5.6**	0.62	0.60	0.59	0.57	0.56	0.55	0.54	0.53	0.49	0.46	
4C 25mm²	**5.6**	0.82	0.80	0.78	0.77	0.75	0.74	0.72	0.71	0.66	0.62	

Sag and Blowout Calculations for 2C 25mm^2. **Refer NOTES Section 5.1.1. Blowout @ 350Pa 15°C.** Creep Allowance: **Nil**

5.13 NBN

5.13.1 RPX 144F 2% Sag/Span @ 20°C Moderate MES=Span Length

SPAN LENGTH (m)	Temperature																BLOW OUT (m)
	-5ºC		0ºC		5ºC		10ºC		15ºC		20ºC		25ºC		30ºC		
	SAG (m)	TENSION (kN)	SAG (m)	TENSION (kN)	SAG (m)	TENSION (kN)	SAG (m)	TENSION (kN)	SAG (m)	TENSION (kN)	SAG (m)	TENSION (kN)	SAG (m)	TENSION (kN)	SAG (m)	TENSION (kN)	
10	0.19	0.06	0.19	0.06	0.19	0.06	0.20	0.06	0.20	0.06	0.20	0.06	0.20	0.06	0.21	0.06	0.26
15	0.29	0.09	0.28	0.09	0.29	0.09	0.29	0.09	0.30	0.09	0.30	0.09	0.30	0.09	0.31	0.09	0.41
20	0.37	0.12	0.38	0.12	0.38	0.12	0.39	0.12	0.40	0.12	0.40	0.12	0.41	0.11	0.41	0.11	0.58
25	0.47	0.16	0.47	0.15	0.48	0.15	0.49	0.15	0.49	0.15	0.50	0.15	0.51	0.14	0.51	0.14	0.76
30	0.56	0.19	0.57	0.18	0.58	0.18	0.59	0.18	0.59	0.18	0.60	0.17	0.61	0.17	0.61	0.17	0.95
35	0.66	0.22	0.67	0.21	0.68	0.21	0.68	0.21	0.69	0.21	0.70	0.20	0.71	0.20	0.72	0.20	1.15
40	0.75	0.25	0.76	0.24	0.77	0.24	0.78	0.24	0.79	0.24	0.80	0.23	0.81	0.23	0.82	0.23	1.35
45	0.85	0.28	0.86	0.27	0.87	0.27	0.88	0.27	0.89	0.27	0.90	0.26	0.91	0.26	0.92	0.26	1.56
50	0.94	0.31	0.96	0.30	0.97	0.30	0.98	0.30	0.99	0.29	1.00	0.29	1.01	0.29	1.02	0.28	1.78
55	1.04	0.34	1.05	0.33	1.06	0.33	1.08	0.33	1.09	0.32	1.10	0.32	1.11	0.32	1.12	0.31	2.01
60	1.14	0.37	1.15	0.36	1.16	0.36	1.18	0.36	1.19	0.35	1.20	0.35	1.21	0.35	1.23	0.34	2.24
65	1.23	0.40	1.25	0.39	1.26	0.39	1.27	0.39	1.29	0.38	1.30	0.38	1.31	0.37	1.33	0.37	2.47
70	1.33	0.43	1.34	0.42	1.36	0.42	1.37	0.42	1.39	0.41	1.40	0.41	1.42	0.40	1.43	0.40	2.71
75	1.43	0.46	1.44	0.45	1.46	0.45	1.47	0.45	1.49	0.44	1.50	0.44	1.52	0.43	1.53	0.43	2.96
80	1.52	0.49	1.54	0.48	1.55	0.48	1.57	0.48	1.59	0.47	1.60	0.47	1.62	0.46	1.63	0.46	3.21

Refer NOTES Section 5.1.1 Tensions are No Wind condition Creep Allowance: **Nil**

5.13.2 RPX 144F 1% Sag/Span @ 20ºC Tight MES=Span Length

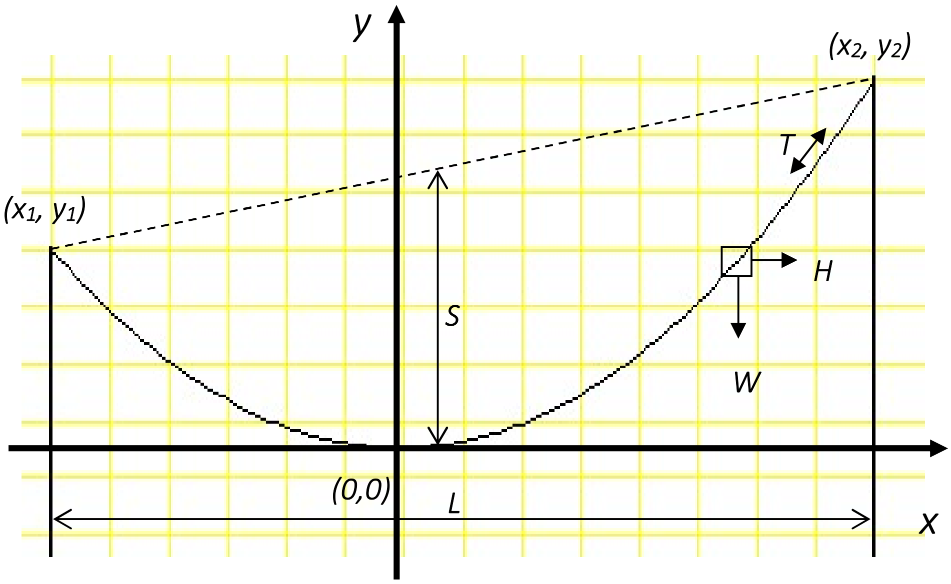
SPAN LENGTH (m)	Temperature																BLOW OUT (m)
	-5ºC		0ºC		5ºC		10ºC		15ºC		20ºC		25ºC		30ºC		
	SAG (m)	TENSION (kN)	SAG (m)	TENSION (kN)	SAG (m)	TENSION (kN)	SAG (m)	TENSION (kN)	SAG (m)	TENSION (kN)	SAG (m)	TENSION (kN)	SAG (m)	TENSION (kN)	SAG (m)	TENSION (kN)	
10	0.08	0.14	0.08	0.14	0.09	0.13	0.09	0.13	0.10	0.12	0.10	0.12	0.10	0.11	0.11	0.11	0.20
15	0.13	0.21	0.13	0.20	0.14	0.19	0.14	0.19	0.15	0.18	0.15	0.17	0.16	0.17	0.16	0.16	0.33
20	0.17	0.27	0.18	0.26	0.18	0.25	0.19	0.25	0.19	0.24	0.20	0.23	0.21	0.23	0.21	0.22	0.48
25	0.22	0.33	0.23	0.32	0.23	0.31	0.24	0.31	0.24	0.30	0.25	0.29	0.26	0.28	0.26	0.28	0.63
30	0.27	0.39	0.27	0.38	0.28	0.37	0.29	0.37	0.29	0.36	0.30	0.35	0.31	0.34	0.31	0.33	0.80
35	0.31	0.45	0.32	0.44	0.33	0.43	0.34	0.43	0.34	0.42	0.35	0.41	0.36	0.40	0.37	0.39	0.97
40	0.36	0.51	0.37	0.50	0.38	0.49	0.38	0.48	0.39	0.47	0.40	0.47	0.41	0.46	0.42	0.45	1.15
45	0.41	0.57	0.42	0.56	0.43	0.55	0.43	0.54	0.44	0.53	0.45	0.52	0.46	0.51	0.47	0.51	1.33
50	0.46	0.63	0.47	0.62	0.48	0.61	0.48	0.60	0.49	0.59	0.50	0.58	0.51	0.57	0.52	0.56	1.52
55	0.51	0.69	0.52	0.68	0.53	0.67	0.53	0.66	0.54	0.65	0.55	0.64	0.56	0.63	0.57	0.62	1.71
60	0.56	0.75	0.57	0.74	0.57	0.73	0.58	0.72	0.59	0.71	0.60	0.70	0.61	0.69	0.62	0.68	1.91
65	0.61	0.81	0.62	0.80	0.62	0.79	0.63	0.78	0.64	0.77	0.65	0.76	0.66	0.75	0.67	0.74	2.12
70	0.66	0.87	0.67	0.86	0.67	0.85	0.68	0.84	0.69	0.83	0.70	0.81	0.71	0.80	0.72	0.79	2.32
75	0.71	0.93	0.71	0.92	0.72	0.91	0.73	0.90	0.74	0.88	0.75	0.87	0.76	0.86	0.77	0.85	2.53
80	0.76	0.99	0.76	0.98	0.77	0.96	0.78	0.95	0.79	0.94	0.80	0.93	0.81	0.92	0.82	0.91	2.75
85	0.80	1.05	0.81	1.03	0.82	1.02	0.83	1.01	0.84	1.00	0.85	0.99	0.86	0.98	0.87	0.97	2.97
90	0.85	1.10	0.86	1.09	0.87	1.08	0.88	1.07	0.89	1.06	0.90	1.05	0.91	1.04	0.92	1.03	3.19
95	0.90	1.16	0.91	1.15	0.92	1.14	0.93	1.13	0.94	1.12	0.95	1.11	0.96	1.09	0.97	1.08	3.41
100	0.95	1.22	0.96	1.21	0.97	1.20	0.98	1.19	0.99	1.18	1.00	1.16	1.01	1.15	1.02	1.14	3.64
105	1.00	1.28	1.01	1.27	1.02	1.26	1.03	1.25	1.04	1.23	1.05	1.22	1.06	1.21	1.07	1.20	3.87
110	1.05	1.34	1.06	1.33	1.07	1.32	1.08	1.30	1.09	1.29	1.10	1.28	1.11	1.27	1.12	1.26	4.10
115	1.10	1.40	1.11	1.39	1.12	1.37	1.13	1.36	1.14	1.35	1.15	1.34	1.16	1.33	1.17	1.32	4.33
120	1.15	1.46	1.16	1.44	1.17	1.43	1.18	1.42	1.19	1.41	1.20	1.40	1.21	1.39	1.22	1.37	4.57

Refer NOTES Section 5.1.1 Tensions are No Wind condition Creep Allowance: **Nil**

5.14 ENGINEERING NOTES

5.14.1 Catenary Curve and Sag-Tension Relationship

The sag in a flexible conductor suspended from two structures depends upon span length, the stringing tension, conductor weight, the elasticity of the conductor material and the temperature. The conductor assumes a shape like that shown below.



The curve is given by the equation:

$$y = C\ (\cosh(x/C) - 1)$$

where:

- x horizontal distance from lowest point in span (m)
- y vertical distance from lowest point of span (m)
- C catenary constant

Under no-wind conditions, the catenary constant is essentially the ratio of the horizontal tension in the conductor to the unit weight:

$$C = H / W$$

where:

- H horizontal component of tension in conductor (N)
- W distributed load on conductor (N/m)

and

$$W = m\,g$$

where:

- m unit mass of conductor (kg/m)
- g gravitational acceleration of 9.81 m/s^2

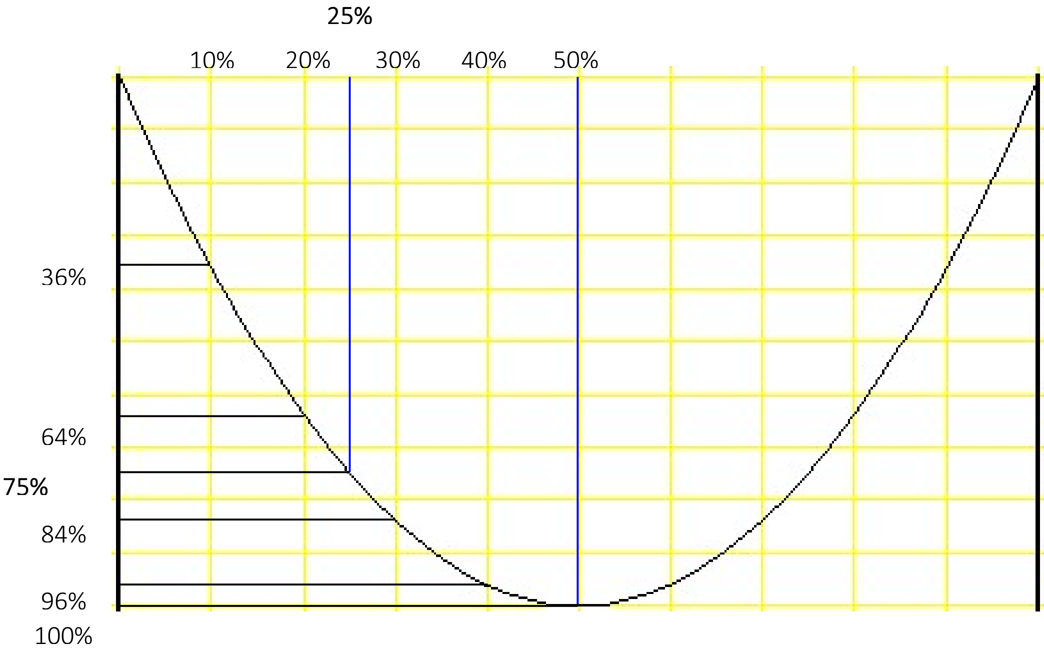
However, for distribution lines where the sag, *S*, is generally less than 10% of the span length L, the shape may be closely approximated by a parabola. Thus, the equation for the catenary curve may be simplified as follows:

$$y = x^2 / 2C$$

Also:

$$C = L^2 / 8S$$

In practical terms, this means that close to the supports the conductor falls away sharply, but is fairly flat in its midsection. At a point 25% of the way along the span, the sag is 75% of its maximum value.



The basic relationship between sag and span length, for an isolated level span, is as follows:

$$S = C\left(\cosh\left(\frac{L}{2C}\right) - 1\right)$$

Where the sag is small compared with the span length, as in the majority of distribution lines, we may treat the catenary shape as parabolic. Conductor tension T is approximately equal to H, the horizontal component of the tension. The sag is then given by the simplified equation:

$$S = \frac{WL^2}{8T}$$

Conversely, the equation may be re-arranged to give tension as a function of sag:

$$T = \frac{WL^2}{8S}$$

For a constant tension, sag varies with the square of span length. So, given a fixed stringing tension, for a doubling of span length there is a quadrupling of the sag.

While having described *W* in the above equation as the unit weight of the conductor, we could have called this 'uniformly distributed load'. In this way, apart from conductor weight, we could include any loading due to snow or ice. Similarly, we could use *W* to represent the horizontal force due to wind action (pressure *x* area) to determine 'horizontal sag' under blowout conditions.

5.14.2 Conductor Length Versus Span Length

For most distribution spans, the true conductor length, L_C, is only marginally greater than the span length, *L*. The true conductor length from the span low point to a given point along the conductor, S, is given by the equation:

$$L_C = C \sinh (x / C)$$

For a level span, the distance from the low point to the end is $x = L/2$. Thus, the total conductor length is:

$$L_C = 2 C \sinh (L / 2C)$$

which can be approximated to:

$$L_C = L + L^3 / 24 C^2$$

Thus the 'slack' in the line, i.e. the difference between actual conductor length and horizontal distance between structures, is given by the expression:

$$Slack = L^3 / 24 C^2$$

or

$$Slack = 8S^2 / 3L$$

For example, consider a 100m span of MERCURY (7/4.50 AAC) strung at 10%NBL, i.e. 1.69kN. The sag will be 2.21m. Using the equation above, we find that the slack is 130mm, i.e. the true conductor length is 100.130m.

Thus, a small change to the amount of 'slack' makes a large difference to the sag in the span. That is why the amount of sag in a span of tight-strung mains is very sensitive to temperature, even though the degree to which the conductor expands or contracts is only a matter of a few millimetres.

5.14.3 Effect of Changes in Conductor Length

The actual length of the conductor is affected by two factors:

- conductor elastic stretch under tension, and
- conductor expansion and contraction according to temperature.

As the length of the conductor changes, so too does the sag in the span.

Conductor elastic stretch is a function of:

- tension, T
- the modulus of elasticity of the conductor material (Young's modulus), E
- the cross-sectional area of the conductor, A.

The modulus of elasticity is the ratio of stress to strain, as follows:

$$E = Stress / Strain$$

i.e.

$$Strain = Stress / E$$

i.e.

$$(L_{Cf} - L_{Ci}) / L_{Ci} = T / EA$$

where:

L_{Cf} final length of conductor (m)
L_{Ci} initial length of conductor (m)
E Modulus of elasticity (Pa)
A Cross-sectional area of the conductor (m^2)

The change in length with temperature is governed by the coefficient of linear expansion, α, for the conductor material. For aluminium, this is only 23 x 10^{-6} per degree Celsius. Nonetheless it is surprising how much variation in sag this small change in conductor length produces.

$$L_{Cf} = L_{Ci} (1 + \alpha (t_f - t_i))$$

where:

t_f final temperature of conductor (ºC)
t_i initial temperature of conductor (ºC)
α coefficient of linear expansion (/ºC)

As temperature increases, the conductor expands in length and therefore its tension decreases, while the sag increases. With the reduction in tension, there is also a reduction in the strain (elastic stretch) in the conductor.

Thus, there is a complicated relationship between temperature and tension. Conductor tension at a given operating temperature can be calculated by iteratively solving the following equation:

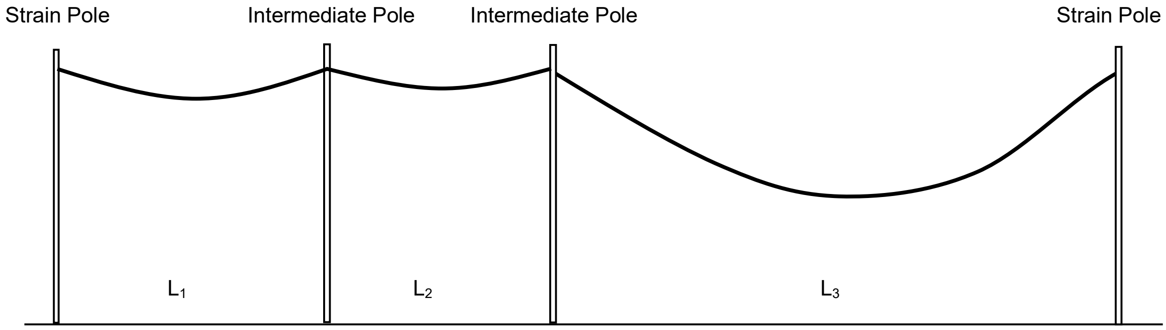
$$T^3 + T^2\left(\frac{(W_0 L)^2 AE}{24T_0} - T_0 + t\alpha AE\right) + \frac{(W_0 L_R)^2 AE}{24} = 0$$

where:

T_0	= initial conductor tension at initial temperature (N)
W_0	= unit weight of conductor at initial temperature (N/m)
t	= temperature change from initial (kg/m)
E	= final modulus of elasticity (Pa)
A	= cross-sectional area of conductor (m^2)
α	= coefficient of linear expansion (/°C)
L_R	= length of ruling span – simply span length L for a single span (m)

5.14.4 Mean Equivalent (or Ruling) Span

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



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

The significance of MES is particularly important in tight-strung lines where the span lengths in a strain section vary significantly. If no correction is made for MES, then sag calculations for the maximum conductor operating temperature may be very inaccurate and lead to clearance violations. Conversely, the effect of MES can be ignored for single level spans and where all the span lengths within a strain section are similar. It is crucial that users of the stringing tables within this manual select the correct table, one having a MES close to that of portion of line that they are considering.

The general formula for MES is as follows:

$$L_R = \sqrt{\frac{L_1^{\;3} + L_2^{\;3} + L_3^{\;3} + \ldots}{L_1 + L_2 + L_3 + \ldots}}$$

Due to taking the cube of the span lengths, this equation gives a MES that is higher than a simple arithmetic mean or average of the span lengths, reflecting the influence of large spans.

For very steep inclines, the formula can be modified as follows:

$$L_R = \sqrt{\frac{\frac{L_1^{\;4}}{I_1} + \frac{L_2^{\;4}}{I_2} + \frac{L_3^{\;4}}{I_3} + \ldots}{I_1 + I_2 + I_3 + \ldots}}$$

where: $I = \sqrt{L^2 + h^2}$

I = inclined span length (m)

h = vertical height difference between ends of span (N/m)

For a single inclined span, this formula can be simplified to: $L_R = \frac{L^2}{I}$

5.14.5 Creep

Most materials subjected to stress will suffer from creep, i.e. permanent elongation or inelastic stretch. The extent of the creep depends upon:

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

Due to creep, the sag in a span of mains will increase following installation and may in time lead to insufficient clearances if not allowed for correctly.

Designers should allow for final sags when determining clearances but ensure that construction crews install the line with lower initial sags, i.e. slightly overtensioned initially, knowing that the tension will fall off with time as creep occurs.

The effect of creep can be modelled by an equivalent change in temperature, i.e. the temperature change which produces the same change in conductor length. Below each stringing table within this section an equivalent temperature correction for creep is given. For simplicity, within TasNetworks the creep adjustment to be applied to aluminium or part aluminium conductors (AAC, AAAC, ACSR, LVABC) on distribution lines has been taken to be:

- 10°C for medium or full tension stringing (18%NBL or 22%NBL)
- 5°C for limited tension stringing (10%NBL)
- Nil for slack or urban tensions (2%NBL or 6%NBL)

For other conductor types (SC/GZ, HDC, Pilot cable, ADSS), no allowance is made for creep.

Where more sophisticated modelling of creep is required, the actual elongation of the conductor can be determined as follows:

$$\varepsilon = \alpha t^{\beta} \sigma^{\gamma} e^{\delta(\theta - 20)}$$

where:

ε	=	unit strain (mm.km^{-1} or μS)
t	=	time (years)
σ	=	average conductor stress (MPa)
θ	=	average conductor temperature (°C)

α, β, γ and δ are constants

If the average temperature over the life of the conductor is assessed to be 20°C, the equation may be reduced to:

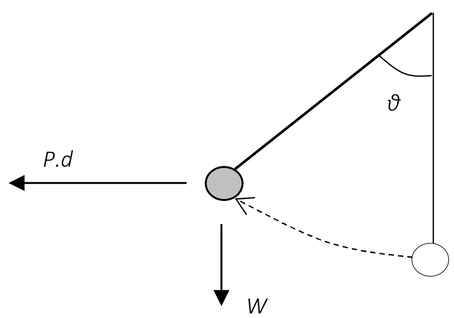
$$\varepsilon = \alpha \, t^{\beta} \sigma^{\gamma}$$

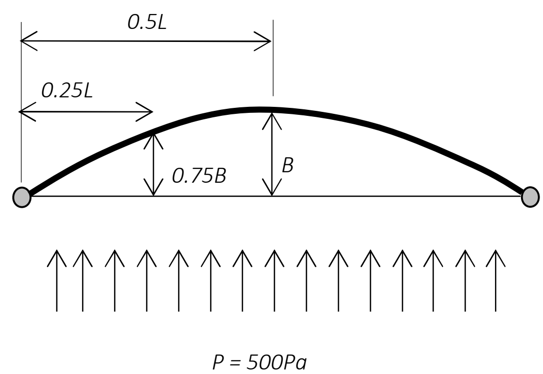
Conductor constants are determined by conductor creep tests as described in *AS 3822*.

When restringing conductor that has already been in service, there is no need to allow for creep.

5.14.6 Blowout

Blowout, or 'horizontal sag', is the displacement of the conductor horizontally under high wind conditions. As a general rule, blowout is of a similar magnitude to vertical sag within a span. Aluminium conductors, which have low weight but large diameter, are particularly susceptible to this and a blowout angle of 65° from the vertical is typical.





The blowout angle may be computed as follows:

$$\theta = \arctan\left(\frac{Pd}{W}\right)$$

where:

P = wind pressure (Pa)—taken to be 500Pa

d = conductor diameter (m)

W = unit weight of conductor (N/m) = 9.81 x unit mass (kg/m)

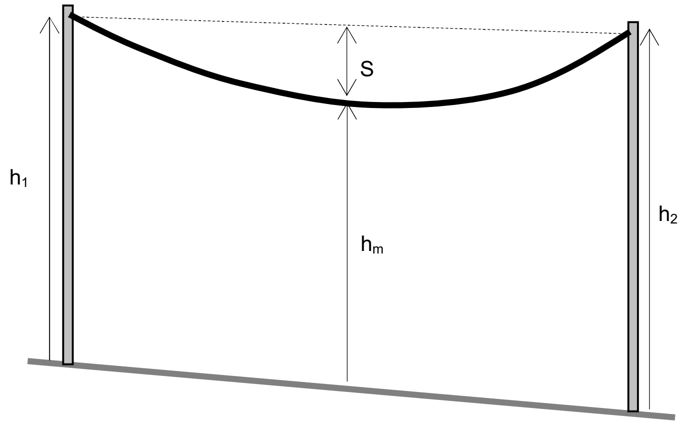
To determine the blowout of the conductor at a point other than the midspan, the shape may be assumed to be parabolic. Thus, at points one quarter of the way from the ends of the span, the blowout will be 75% of that at the middle of the span. At points 10% of the way along span, blowout is 36% of that at midspan.

5.14.7 Determining Sag in Existing Conductors

It is often necessary to measure sag in existing lines to determine the stringing tension that has been used.

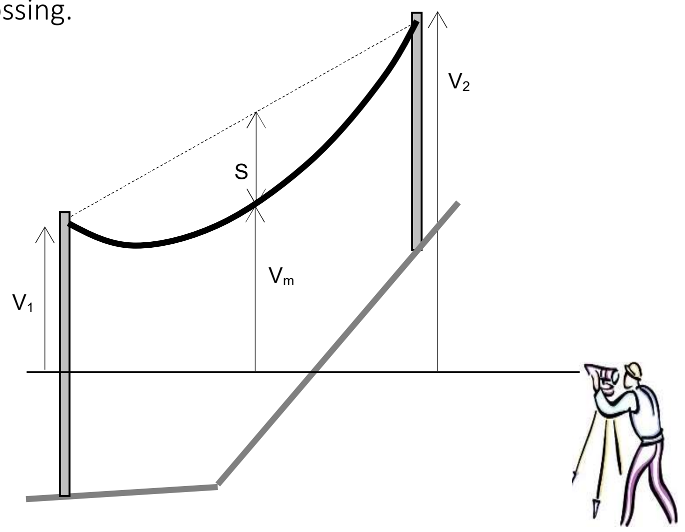
For many distribution situations, the approach illustrated below may be used. The sag is the difference between the average of the two end heights and the mid-span height.

$S = [(h_1 + h_2) / 2] - h_m$



Where the ground line slope varies and there is a dip or hump mid-span, vertical heights may be measured of the ends of the span and the midpoint relative to the position of an observer away from the span. This is also useful where it is impractical to measure conductor height from directly below the conductor, e.g. at a waterway crossing.

$S = [(V_1 + V_2) / 2] - V_m$

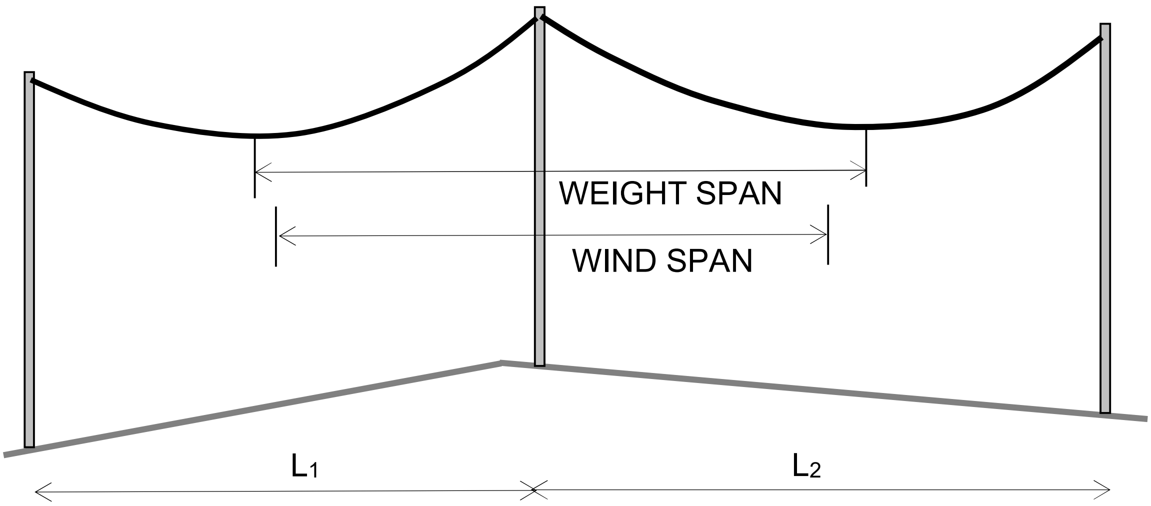


5.14.8 Wind Span and weight span

The wind span on a given pole is the average of the two adjacent span lengths, i.e. $(L_1 + L_2)/2$, or $L_1/2 + L_2/2$.

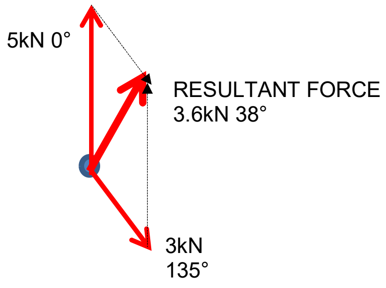
The weight span on a pole is the distance between the lowest points of the conductors in the adjacent spans.

For poles of identical height on flat ground, weight span and wind span will be equal. However, a tall pole or pole on a hill will have a larger weight span than wind span. Conversely, a short pole or pole in a valley may have a smaller weight span than wind span.



5.14.9 Mechanical Forces Applied by Conductors

Forces applied by conductors to the pole are added as vectors – they have magnitude and direction). They cannot be added like scalar quantities unless in the same direction. For example, one circuit may apply 5kN to a pole tip in a northerly direction, while another applies 3kN to a pole in a south-easterly direction. Adding vectorially, we have:

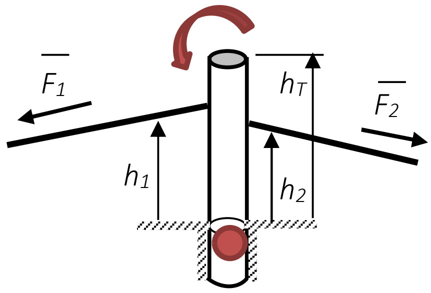


5kN <0° + 3kN <135° = 3.6kN <38°

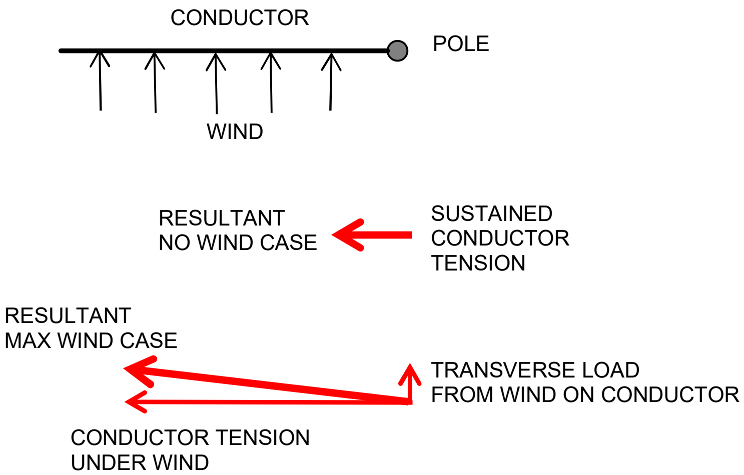
Where we have circuits attached significantly below the pole tip, it is important to remember that we are dealing with overturning *moments* – the product of:

- Force, and
- Distance from the centre of rotation, nominally ground line (but actually a point about 2/3 of the depth of the foundation).

Therefore, the force applied by conductors attached significantly below the tip is scaled down in proportionate to their height of attachment relative to the tip height. For example, a conductor attached 8m high on a pole with a tip height of 10m applying a force of 5kN is equivalent to a conductor attached at the tip applying 8/10 x 5 = 4.0kN.

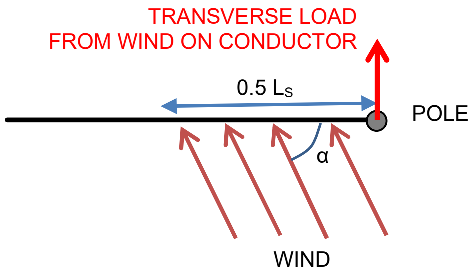


Designers should consider wind direction when calculating forces applied to poles. For simple lines, the worst-case wind direction is perpendicular to the line, applying maximum pressure on the conductors.



However, where circuits come from various directions not in the same line, the wind cannot strike all conductors at right angles. The maximum wind pressure will not be acting on all circuits simultaneously; it will be reduced according to the angle by which it is offset from perpendicular.

The transverse wind force applied to a pole by a conductor terminating on it is:



$$W_c = 0.5\, L_s\ \phi_c\, P_{wc} \sin^2 \alpha$$

where:

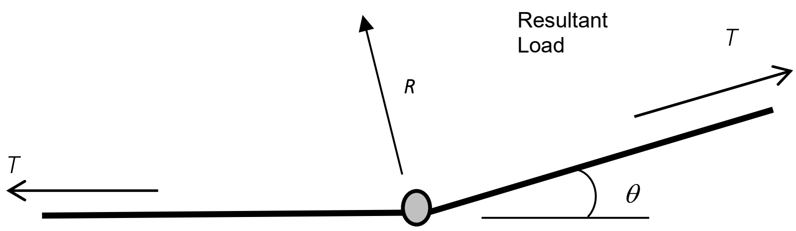
- W_c = transverse force applied to pole due to conductor windage (kN)
- L_s = span length (m)
- ϕ_c = projected diameter of conductor (m)
- P_{wc} = design wind pressure on conductor (kPa) i.e. 0.9kPa
- α = angle between conductor and wind direction – 0.0 when in the same direction and 1.0 when at right angles

The factor of 0.5 is included because only half of each span attached to a pole is considered to load the pole in question; the other half will affect adjacent poles. For a straight-line intermediate pole, the equation becomes:

$$W_c = 0.5\,(L_{S1} + L_{s2})\ \phi_c\, P_{wc} \sin^2 \alpha$$

The resultant force due to a deviation angle in a line is given by the expression:

$$R = 2\,T\,N\ \sin(\theta/2)$$

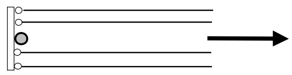
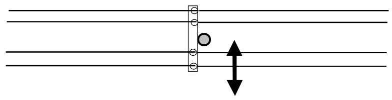
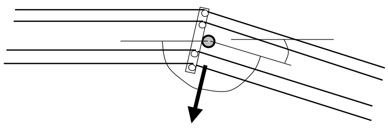
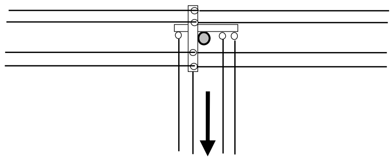
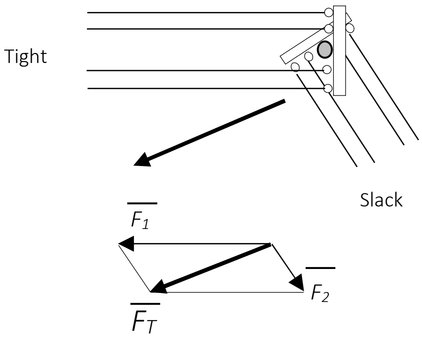


where:

- R is the resultant force
- T is the longitudinal tension in each conductor (horizontal component)
- N is the number of conductors
- θ is the angle of deviation.

For small deviation angles, the worst-case wind direction is one that bisects the deviation angle. However, for large deviation angles, the worst-case wind direction is perpendicular to one of the spans.

The table below shows how various configurations may be considered.

CIRCUIT CONFIGURATION	PLAN VIEW AND RESULTANT FORCE DIRECTION	ANALYSIS
DEAD END		Resultant force is in direction of the circuit.
STRAIGHT LINE INTERMEDIATE		Longitudinal forces on either side will cancel each other out. Sustained load will be nil. Resultant force is due to transverse wind loading and comparatively small. Resultant may be in either direction normal to the line.
DEVIATION ANGLE INTERMEDIATE		Resultant force direction will generally bisect the angle between the two circuits.
TEE-OFF		The through circuit forces can generally be ignored—only need to consider the tee-off circuit. Resultant force will be in direction of the tee-off.
COMPLEX		Treat each circuit as a termination. The force *vectors* corresponding to each circuit need to be summed; do not simply add them arithmetically. Note that resultant force directions for Sustained and Max. Wind conditions may differ slightly.

When analysing a complex pole, it may be useful to prepare a table listing out each circuit, the type of conductor, number of conductors and stringing tension, span length, MES, attachment height and direction or bearing, as exemplified in the table below.

Tip Ht (m)	Bearing (°)	Conductor	No.	Att. Ht. (m)	Span (m)	MES (m)	% NBL	No Wind Load per cond (kN)	Max. Wind Load per cond (kN)	Pole Windage (kN)	Total Load (kN)		Pole Strength (kN)	
											No Wind	Max Wind	No Wind	Max Wind
10.0	270	Apple	3	9.85	102	102	22	3.28	5.73	2.62 @180°	**14.33** @270°	17.44	12.32	21.62
	95	Fluorine	3	9.85	65	107	10	1.18	4.12					
	270	Apple	4	8.47	102	102	22	3.28	5.73					
	95	LVABC 4.95	1	8.24	65	107	10	5.32	13.52					

For simplicity, forces applied by services or small telecommunications cables can generally be ignored.

When using timber poles, forces should be calculated for both *No Wind* (sustained or everyday) limit state and *Maximum Wind* limit state load cases. Usually, it is the Maximum Wind limit state that will be most critical. When using steel or concrete poles, analysing stays, pole stakes or pole foundations, only the Maximum Wind limit state load case need be considered.

The following load factors, or multipliers, need to be applied to conductor load forces:

No Wind case:	1.1
Max. Wind case:	1.25

These are incorporated into the tables of mechanical forces throughout this section.

When calculating pole tip loads or stay loads, the designer needs to consider, not only conductor loads, but also wind force on poles – refer section 6.8.4.

For lines at altitudes where snow and ice loading are a concern, a load factor of 1.1 applies. (Refer section 2.3.9.)

5.15 WORKED EXAMPLES

Example 1 – Single Urban Span

A new 42m span of 4C 95mm² LVABC 11kV mains is to be erected between two poles with a termination at each end.

Determine a suitable stringing tension and the resulting final sag when the conductor is at its maximum design temperature of 75°C. Also, determine the mid-span blowout and the No Wind and Maximum Wind limit state loads applied by the conductor to the pole.

After referring to the table in section 5.1.2, we select 6% NBL as a suitable stringing tension for a 42m span. It is well within the 30m – 80m span range for this tension.

As the span is terminated at each end, the MES for the 'strain section' is the length of the single span itself, 42m.

We now select a suitable stringing table and turn to the index sheet 5.2. We select sheet 5.9.2 for LVABC, 6% NBL and MES/RS of 40m, which is the closest available value to 42m.

5.9.2 LVABC Urban 6% NBL 40m RS

SPAN LENGTH (m)	SAG (m)										BLOW OUT (m)
	Temperature										
	-5⁰C	0⁰C	5⁰C	10⁰C	15⁰C	20⁰C	25⁰C	30⁰C	50⁰C	75⁰C	
20	0.19	0.20	0.21	0.22	0.23	0.24	0.24	0.25	0.28	0.32	0.19
25	0.29	0.31	0.32	0.34	0.35	0.37	0.38	0.39	0.44	0.50	0.30
30	0.42	0.44	0.47	0.49	0.51	0.53	0.55	0.57	0.64	0.72	0.43
35	0.57	0.60	0.64	0.66	0.69	0.72	0.75	0.77	0.87	0.98	0.59
40	0.75	0.79	0.83	0.87	0.91	0.94	0.98	1.01	1.13	1.28	0.77
45	0.95	1.00	1.05	1.10	1.15	1.19	1.24	1.28	1.44	1.61	0.98
50	1.17	1.23	1.30	1.36	1.42	1.47	1.53	1.58	1.77	1.99	1.21

We locate the row for a 40m span and the column for 75°C final sag. We notice that the sag value is 1.28m. Looking at the row below, for a 45m span, we note that sag is 1.61m. We could say that the sag value is approximately 1.4m, or we might try to interpolate between the two values. 42m lies approximately 2/5 of the way between 40m and 45m, as follows:

75°C Final Sag = 1.28 + ((2/5 * (1.61 – 1.28)) = 1.28 + 0.4 * 0.33 = 1.41m

Similarly, we can interpolate between the two values of 0.77m and 0.98m for blowout:

Blowout = 0.77 + ((2/5 * (0.98 – 0.77)) = 0.85m

To determine forces applied by the cable, we turn to table 5.9.5, which related to 6% NBL stringing and find the column for 4C 95mm² cable. The loads given herein include the load factors of 1.1 for No Wind and 1.25 for Max. Wind limit states. We note that the sustained load is 3.51kN. For a 40m span the Max. Wind load is 9.53kN; for 50m 10.01kN. We can interpolate: 9.53 + 2/10 (10.01 – 9.53) = 9.63kN.

Example 2 – Short Rural Extension

A three-span rural 11kV extension using FLUORINE (7/3.00 AAAC 1120) conductor is proposed. The pole positions are aligned with lot boundaries, with span lengths of 130m, 140m and 180m. The ground is reasonably flat.

Determine a suitable stringing tension. Also, assuming that the conductor attachment points are 10.2m high, what will be the worst-case ground clearance for the line? What stringing tension, as indicated by a dynamometer, would the construction crew need to apply if erecting the conductor at a temperature of 20°C?

The MES for the line can be calculated as follows:

$$MES = \sqrt{\left[\frac{(130^3 + 140^3 + 190^3)}{(130 + 140 + 190)}\right]} = 160.2m$$

After referring at the table in section 5.1.2, we find that we may be able to use Medium Tension 18%NBL or Full tension 22%NBL for spans of this range. In this instance we will try the 22%NBL as we are concerned about having sufficient ground clearance in the 190m span.

We now turn to the stringing table 5.4.7, which is for AAAC 1120 conductor, 22%NBL and a MES of 150m, which is close to our MES of 160.2m. (If we had a MES that fell midway between two tables, we may interpolate between them, or take the table with the more conservative values.)

5.4.7 AAAC 1120 Full 22% NBL 150m RS

SPAN LENGTH (m)	SAG (m) Temperature															
	-5ºC	0ºC		5ºC		10ºC		15ºC		20ºC		25ºC		30ºC		50ºC
	FINAL	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL	FINAL
80	0.35	0.32	0.38	0.35	0.41	0.38	0.44	0.41	0.48	0.44	0.52	0.48	0.56	0.52	0.60	0.76
90	0.44	0.41	0.48	0.44	0.52	0.48	0.56	0.52	0.61	0.56	0.65	0.61	0.70	0.65	0.76	0.96
100	0.54	0.50	0.59	0.54	0.64	0.59	0.69	0.64	0.75	0.69	0.81	0.75	0.87	0.81	0.93	1.19
110	0.66	0.61	0.71	0.66	0.77	0.71	0.84	0.77	0.91	0.84	0.98	0.91	1.05	0.98	1.13	1.44
120	0.78	0.72	0.85	0.78	0.92	0.85	1.00	0.92	1.08	1.00	1.16	1.08	1.25	1.16	1.34	1.71
130	0.92	0.85	0.99	0.92	1.08	0.99	1.17	1.08	1.26	1.17	1.37	1.26	1.47	1.37	1.58	2.01
140	1.06	0.98	1.15	1.06	1.25	1.15	1.35	1.25	1.47	1.35	1.58	1.47	1.70	1.58	1.83	2.33
150	1.22	1.13	1.32	1.22	1.43	1.32	1.55	1.43	1.68	1.55	1.82	1.68	1.96	1.82	2.10	2.67
160	1.39	1.29	1.51	1.39	1.63	1.51	1.77	1.63	1.92	1.77	2.07	1.92	2.23	2.07	2.39	3.04
170	1.57	1.45	1.70	1.57	1.84	1.70	2.00	1.84	2.16	2.00	2.34	2.16	2.51	2.34	2.70	3.43
180	1.76	1.63	1.91	1.76	2.07	1.91	2.24	2.07	2.42	2.24	2.62	2.42	2.82	2.62	3.02	3.85
190	1.96	1.81	2.12	1.96	2.30	2.12	2.49	2.30	2.70	2.49	2.92	2.70	3.14	2.92	3.37	4.29
200	2.17	2.01	2.35	2.17	2.55	2.35	2.76	2.55	2.99	2.76	3.23	2.99	3.48	3.23	3.73	4.75
210	2.39	2.21	2.59	2.39	2.81	2.59	3.05	2.81	3.30	3.05	3.56	3.30	3.84	3.56	4.12	5.24
220	2.63	2.43	2.85	2.63	3.09	2.85	3.35	3.09	3.62	3.35	3.91	3.62	4.21	3.91	4.52	5.75
230	2.87	2.66	3.11	2.87	3.37	3.11	3.66	3.37	3.96	3.66	4.28	3.96	4.60	4.28	4.94	6.28
240	3.13	2.89	3.39	3.13	3.67	3.39	3.98	3.67	4.31	3.98	4.66	4.31	5.01	4.66	5.38	6.84
CONDUCTOR	NO WIND TENSION (kN)															
JORINE (7/3.00)	3.05	3.30	2.81	3.05	2.60	2.81	2.40	2.60	2.21	2.40	2.05	2.21	1.90	2.05	1.77	1.39

Sag and Blowout Calculations for FLUORINE. **Refer NOTES Section 5.1.1** Creep Allowance: **10ºC**

For the longest span of 190m, the final sag at the maximum design temperature of 50°C will be 4.29m. Given an attachment height of 10.2m at the poles, the worst-case midspan height will be 5.91m, which is sufficient.

For a conductor temperature of 20°C, the crew will need to use an initial tension of 2.40kN. Over time, the conductor will stretch and the tension will drop slightly.

Example 3 – Determine Tension in Existing Mains

The sag in an existing 45m span of 7/2.00 Copper LV mains is measured at 1.3m. The ambient air temperature is 20°C. The day is sunny and there is only a slight breeze.

We need to guess what stringing tension has been used and see how the sag values for the stringing table compare with actual sag.

Given that the conductor will be secured at each end of the span, either by a termination or being tied off on a pin insulator, we will take the MES to be equal to the span length, i.e. 45m.

Given the day is sunny with little breeze, let us assume that the conductor temp. is 5°C above ambient air temperature, i.e. 25°C.

We first try table 5.8.2 for HDC strung at 6%NBL for a 40m MES/RS.

5.8.2 HDC Urban 6% NBL 40m RS

SPAN LENGTH (m)	SAG (m) Temperature							
	-5°C	0°C	5°C	10°C	15°C	20°C	25°C	30°C
20	0.17	0.18	0.18	0.19	0.20	0.21	0.21	0.22
25	0.26	0.27	0.29	0.30	0.31	0.32	0.33	0.34
30	0.38	0.40	0.41	0.43	0.45	0.46	0.48	0.50
35	0.51	0.54	0.56	0.59	0.61	0.63	0.65	0.67
40	0.67	0.70	0.73	0.77	0.80	0.82	0.85	0.88
45	0.85	0.89	0.93	0.97	1.01	1.04	1.08	1.12
50	1.05	1.10	1.15	1.20	1.24	1.29	1.33	1.38
55	1.27	1.33	1.39	1.45	1.50	1.56	1.61	1.67
60	1.51	1.58	1.65	1.72	1.79	1.86	1.92	1.98
65	1.77	1.86	1.94	2.02	2.10	2.18	2.26	2.33
70	2.06	2.16	2.26	2.35	2.44	2.53	2.62	2.71
CONDUCTOR	**NO WIND TENSION (kN)**							
7/1.25	0.24	0.23	0.22	0.21	0.20	0.19	0.18	0.18
7/1.75	0.46	0.43	0.41	0.40	0.38	0.37	0.35	0.34
7/2.00	0.58	0.55	0.53	0.51	0.49	0.47	0.45	0.44

Looking at the row for a 45m span and 25°C, the sag 1.08m. This is a little less than the measured value of 1.3m, so obviously the stringing tension is slightly less than 6% NBL, but 6% NBL is near enough for our purposes and is on the conservative side.

If we wished to be more precise, we could use the fact that sag varies inversely with tension. Since the measured sag is 1.20 times larger than that shown for 6% NBL stringing, the tension will be 6% divided by 1.20, i.e. 5.0% NBL.

SECTION 6 – POLES

Version: 3.1

TasNetworks

Powering a Bright Future

SECTION 6 - POLES

6.1 POLE SELECTION

6.1.1 Pole Type

Wood Poles

TasNetworks predominately uses CCA-treated (pressure impregnated), round wood poles for distribution lines.

Titan Poles, manufactured by Dulhunty Poles from fibre-reinforced concrete (engineered polymer cement), are non-conductive, high strength, fire resistant and impervious to decay. However, they are more expensive than wood poles and there are limits on where holes may be drilled in them. Their use is warranted in the following situations:

- Supporting heavy plant such as voltage regulators or transformers of 200kV.A and above
- Supporting key infrastructure such as load break switches, capacitor banks or air-break switches
- Locations where enhanced reliability is needed or where replacement would be difficult, e.g. river crossings, multiple-dependency feeders, urban high traffic areas, high outage cost locations
- Landing spans at substations
- Locations where high strength is needed but where it is difficult to install stays
- Bushfire-prone areas.

Although they must be handled with care, Titan poles are approximately one third lighter than wood poles of equivalent strength, making them well-suited to lifting into remote locations by helicopter.

Titan poles should be used for all new pole sites carrying plant such as transformers, regulators, reclosers or other HV switches. (Note that there is no need to replace an existing wood pole in good condition and of adequate strength simply because plant is to be installed on it.)

Other types of steel/concrete poles of various makes (e.g. Stobie, Busck, Rockla) have been used at times by TasNetworks—primarily as emergency replacements for timber poles following bushfires or for bushfire resistance. However, earthing of conductive HV poles can be problematic (refer section 11.4.1) and use of such poles would only be under special circumstances.

Requirements for customer-owned poles are given in Section 1 of the *Overhead Distribution Construction Standard*.

6.1.2 Length

Length	Typical Application
9.5m	Cross-street service poles, stay poles
11m	LV poles
12.5m	HV poles
14m	HV pole-mounted equipment, HV/LV poles with tee-offs

Notes:

1. The table above is intended as a *general guideline only* and applies to typical situations. Designers may need to alter length to suit the precise topography, number of circuits (initial or future), type of pole-top construction, street light mounting requirements, sinking depth etc. Provision should be made on HV poles for LV or communications cable subcircuits or underground cable terminations where these are likely to be required in the future.
2. While additional length may help achieve clearances from ground and between circuits, do not increase pole length beyond what is reasonably required. Longer poles are more expensive to source, transport and erect. Also, they may make access to and operation of pole-top plant more difficult.

6.1.3 Strength Rating

Poles should be sized so that strength/capacity always exceeds applied mechanical load.

In general, heavier poles are used for terminations and line deviations, whereas lighter poles are used for intermediate in-line sites.

For wood poles supporting lighter transformers (<100kVA) or switchgear, use poles of at least 6kN WS / 25kN NBL strength[1]. For wood poles heavy plant such as transformers of 100kV.A or above, regulators or heavy reclosers, use poles of at least 8kN WS / 33kN NBL strength.

For Titan poles supporting voltage regulators or transformers of 200kV.A or above, it is recommended that 12kN WS / 24kN Ult. strength be used.

Use of an unstayed heavy pole is preferable to a light pole that is stayed. Where a stay cannot be avoided, aim to use a pole that can take at least half the load, where practicable.

[1] Very small transformers (25kV.A) with weights <230kg may be attached to existing 10.5 or 12m poles with strength ratings of only 3kN or 4kN WS.

6.2. WOOD POLES

6.2.1 New Wood Pole Sizes

LENGTH (m)	TIP STRENGTH (kN)				S3 Grade Timber		S4 Grade Timber		Approx. Dry Mass (kg)	Nom. Windage Resolved to Tip (kN)
	Nominal Working Stress	Nominal Breaking Load	No Wind (Sustained) Limit State	Max. Wind Limit State	Min. Dia. Tip (mm)	Min. Dia. 2m from butt (mm)	Min. Dia. Tip (mm)	Min. Dia. 2m from butt (mm)		
9.5	4	17	6	10	209	280	234	305	554	1.45
	6	25	9	15	249	320	279	350	746	1.62
	8	33	12	20	279	350	314	385	916	1.78
11.0	4	17	6	10	208	293	236	320	681	1.79
	6	25	9	15	251	335	286	370	937	2.04
	8	33	12	20	286	370	321	405	1142	2.24
12.5	4	17	6	10	215	310	245	340	853	2.17
	6	25	9	15	260	355	280	385	1094	2.46
	8	33	12	20	295	390	330	425	1400	2.72
14.0	4	17	6	10	217	325	242	350	978	2.52
	6	25	9	15	262	370	297	405	1361	2.92
	8	33	12	20	297	405	337	445	1680	3.20
15.5	6	25	9	15	266	385	301	420	1587	3.36
	8	33	12	20	306	425	341	460	1949	3.68
	10	42	15	25	336	455	376	495	2244	3.96

Notes:

1. The limit state tip strengths shown are inclusive of all loads: conductor forces, windage on the pole itself and all attachments, overturning moment due to weight of plant.
2. The tip strengths shown indicate the capacity of the pole to withstand overturning moment. This tends to be the limiting factor for wood poles of this type, rather than compressive or shear strengths.
3. The strengths shown are based on pole lengths for minimum sinking depths.
4. S3 grade timbers include species MS, BG and ST. S4 grade timbers include species AA, WP, MA and MN. Refer Engineering Notes subsection for additional details. Timber species can be determined from pole identification disk. If in doubt as to species or grade, assume S4.
5. Approximate dry mass is based on S4 grade timber dimensions and a density of 950kg/m^3.
6. Pole lengths have been amended to more closely align with the requirements of *AS4676* Appendix J and the existing ranges of mainland utilities.
7. Nominal windage is the contribution to pole tip load due to the wind on the pole, crossarms and insulators. The area is taken to be the product of tip height (assuming min. sinking) and ground-line diameter for an S4 grade pole. No account of the pole taper is made, assuming this reduction in width is offset by the area of the crossarms and insulators. A wind pressure of 1200Pa has been used and the centre of pressure taken to be halfway up the pole.

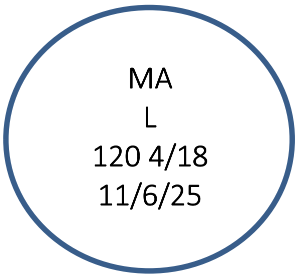
6.2.2 Old Wood Pole Sizes

LENGTH (m)	Nominal Working Stress (kN)	TIP STRENGTH (kN) S3 Grade Timber No Wind (Sustained) Limit State	S3 Grade Timber Max. Wind Limit State	S4 Grade Timber No Wind (Sustained) Limit State	S4 Grade Timber Max. Wind Limit State	Diameter (mm) Tip	Diameter (mm) 2m from butt	Approx. Dry Mass (kg)	Nom. Windage Resolved to Tip (kN)
8	6	8.49	14.89	6.53	11.46	202	286	390	1.12
	8	12.39	21.73	9.53	16.72	226	325	470	1.21
	10	16.38	28.74	12.60	22.11	250	357	560	1.33
9	4	6.27	11.00	4.82	8.46	202	274	400	1.22
	6	9.09	15.94	6.99	12.27	239	310	540	1.37
	8	12.36	21.68	9.51	16.68	272-344	344-392	665	1.69
10.5	4	6.40	11.22	4.92	8.63	208	293	525	1.55
	6	9.20	16.14	7.08	12.41	247	331	705	1.73
	8	12.39	21.73	9.53	16.71	282-366	366-414	850	2.16
12.0	4	6.50	11.41	5.00	8.78	215	310	665	1.89
	6	9.29	16.30	7.15	12.54	255	350	875	2.13
	8	12.32	21.62	9.48	16.63	290-366	385-430	1050	2.62
13.5	4	6.88	12.08	5.29	9.29	223	331	850	2.28
	6	10.15	17.81	7.81	13.70	269	377	1090	2.60
	8	12.77	22.41	9.82	17.24	299-366	407-455	1300	3.14
15	6	9.82	17.23	7.55	13.25	269	388	1175	2.99
	8	12.29	21.55	9.45	16.58	299	419	1485	3.23
	10	14.81	25.99	11.40	20.0	326-374	446-493	1720	3.80

Notes:

1. The limit state tip strengths shown are inclusive of all loads: conductor forces, windage on the pole itself and all attachments, overturning moment due to weight of plant.
2. The tip strengths shown indicate the capacity of the pole to withstand overturning moment. This tends to be the limiting factor for wood poles of this type, rather than compressive or shear strengths.
3. The strengths shown are based on pole lengths for minimum sinking depths.
4. S3 grade timbers include species MS, BG and ST. S4 grade timbers include species AA, WP, MA and MN. Refer Engineering Notes subsection for additional details. Timber species can be determined from pole identification disk. If in doubt as to species or grade, assume S4.
5. Nominal windage is the contribution to pole tip load due to the wind on the pole, crossarms and insulators. The area is taken to be the product of tip height (assuming min. sinking) and ground-line diameter. No account of the pole taper is made, assuming this reduction in width is offset by the area of the crossarms and insulators. A wind pressure of 1200Pa has been used and the centre of pressure taken to be halfway up the pole.

6.2.3 Pole Identification Disc and Preservative Impregnation Specification



Timber species (see Engineering Notes subsection)
Treatment plant identification
Impregnation Batch No. Month/Year
Pole Length (m) /
Nom. Working Load (kN) /
Nom. Breaking Load (kN) – New poles sizes only

Timber poles sourced in Tasmania have durability class 3 or 4 and require full-length preservative treatment for direct contact with soil in accordance with the requirements of *AS3818.11*.

6.2.4 Untreated Wood Poles

In general, it is expected that any existing untreated (natural) wood poles remaining within the network will be replaced rather than modified. However, should the strength of one of these poles need to be calculated, the method set out in sections 6.8.1 and 6.8.2 may be used. The ground line diameter will need to be measured and the pole inspected to check for any hollow due to internal decay. Also, a determination of the pole species will need to be made, erring on the conservative side with regard to strength. Strength factors of 0.5 and 0.3 shall be used for max. wind LS and no wind LS respectively.

6.2.5 Customer Wood Poles

LENGTH (m)	TIP STRENGTH (kN)				Min. Dia. Tip (mm)	Min. Dia. 2m from butt (mm)	Sinking Depth (m)	Tip Height (m)	Nom. Windage Resolved to Tip (kN)
	Nominal Working Stress	Nominal Breaking Load	No Wind (Sustained) Limit State	Max. Wind Limit State					
8.0	4	15.90	5.41	9.54	202	257	1.4	6.6	0.98
	6	21.90	7.45	13.14	202	286	1.5	6.5	1.03
9.0	4	16.52	5.62	9.91	202	273	1.5	7.5	1.16
	6	24.18	8.22	14.51	239	310	1.65	7.35	1.31
10.5	4	17.30	5.88	10.38	208	293	1.65	8.85	1.44
	6	25.38	8.63	15.23	247	331	1.8	8.7	1.63
12.0	4	17.78	6.05	10.67	215	310	1.8	10.2	1.74
	6	25.58	8.70	15.35	255	350	1.8	10.2	2.01

Notes:
1. The limit state tip strengths shown are inclusive of all loads: conductor forces, windage on the pole itself and all attachments.
2. Timber has been assumed to be S4 grade hardwood. For additional details, refer Overhead Construction Standard section 1.3.2.

6.3 TITAN (FIBRE-REINFORCED CONCRETE) POLES

6.3.1 Current Models

These are hollow, round, fibre-reinforced spun concrete construction, manufactured by Dulhunty Poles. They are non-conductive, fire-resistant, lighter than equivalent wood poles and impervious to decay. Poles of 14m length or more comprise two pieces, normally supplied assembled for TasNetworks; the 12.5m poles are a single item.

Designers only need to check the Max. Wind LS condition for concrete poles.

Length	Strength			SI Number	Mfr Product Code	Min. Sinking Depth	Diameter			Typ. Weight	Max. Weight	Nom. Pole Windage Resolved to Tip**
	WS	Ult	Max. Wind LS*				Tip	GL	Butt			
(m)	(kN)	(kN)	(kN)			(m)	(mm)	(mm)	(mm)	(kg)	(kg)	(kN)
12.5	8	16	14.4	325002	P12516HTT1M	1.85	315	434	460	650	700	1.97
	12	24	21.6	325003	P12524HTT1M		325	452	480	880	950	2.05
14	8	16	14.4	325004	P14016HTT2M	2.00	315	409	438	950	1000	2.15
	12	24	21.6	325005	P14024HTT2M		325	377	438	1160	1250	2.08
15.5	12	24	21.6	325006	P15524HTT2M	2.15	325	412	465	1425	1500	2.44

*A strength factor of 0.9 has been applied to the ULS to obtain LS strength. This allows for compression due to any pole-mounted plant.
**10% added as allowance for crossarm and insulators

6.3.2 Previous Models used in Trials

The following pole types were used in early trials of Titan poles. Note that the 12/24kN poles were reinforced to deal with low-speed vehicle impacts.

Length	Strength			Mfr Product Code	Min. Sinking Depth	Diameter			Max. Weight	Nom. Pole Windage Resolved to Tip
	WS	Ult	Max. Wind LS			Tip	GL	Butt		
(m)	(kN)	(kN)	(kN)		(m)	(mm)	(mm)	(mm)	(kg)	(kN)
12.5	8	16	14.4	P12516HTA1M	1.85	250	395	462	1200	1.70
	12	24	21.6	S12524HTA1M		250	410	470	1200	1.74

6.3.3 Titan Pole Identification

The metal tags are 75mm x 50mm and placed 2m above the nominal groundline of the pole and another on the butt. The information included on the ID tag is:

- Manufacturer
- Pole length
- Pole ultimate strength
- Product code
- Month and year of manufacture
- Name of customer
- Weight
- Serial number

6.3.4 Special Considerations

Special care is required when transporting, drilling and attaching to concrete poles.

To spread load and prevent crushing of the hollow pole, large, curved washers or gain blocks must be used where constructions attach to the pole. Volute washers are not required as with wood poles; spring washers should be used instead. In addition to specifying the Titan pole, the designer may specify APLs as set out in the table below. These provide for *additional* materials that may not be included if the construction APL is for a wood pole. Refer also OH Construction Std. sect.10.4.

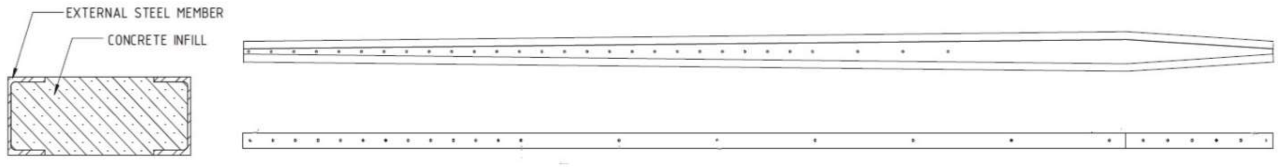
Attachment Type	Application	Extra Hardware Required compared with Wood Pole				APL
		Description	Item Ref	Stock Item No.	Qty	
M20Eyebolt or Kingbolt	Stay attachment, ABC strain or dead end, Plant item, Major steelwork	100 x 100mm gain block, transformer type		323306	1	TITANAT1
		75mm x 75mm square curved M16 washer		066806	1	
		Spring washer M20	T205B		1	
M16 Eyebolt	Conductor termination on pole rather than crossarm	75mm x 75mm square curved M16 washer		066806	2	TITANAT2
		Spring washer M16	T205A		1	
Crossarm, M16 Kingbolt	Gain block already provided	75mm x 75mm square curved M16 washer		066806	1	TITANAT3A
		Spring washer M16	T205A		1	
	Added gain block 100 x 100mm	100 x 100mm gain block, crossarm type	T208A		1	TITANAT3B
		75mm x 75mm square curved M16 washer		066806	1	
		Spring washer M16 T205A			1	
	Added gain block 125 x 125mm	125 x 125mm gain block, crossarm type	T208B		1	TITANAT3C
		75mm x 75mm square curved M16 washer		066806	1	
		Spring washer M16	T205A		1	

Generally, no holes are allowed in the lower third of the pole without reference to Asset Engineering or Dulhunty Poles Pty Ltd. (Holes for supporting transformer or regulator platforms, cable or conduit attachments or minor tek screws are acceptable.)

Foundation material in contact with the pole should be free of rocks (FCR preferred).

6.4 OTHER POLE TYPES

6.4.1 Stobie Poles



New Stobie Poles would only be used in exceptional circumstances. The table below applies to existing Stobie poles within TasNetworks. Parameters for any new Stobie poles to be used should be sourced from SA Power Networks.

The Stobie pole consists of two rolled steels sections (Tapered Flange Channels) with concrete in-fill. The steel sections are considered to carry the full bending and compressive loads. The concrete and bolts between the steel sections provide restraint against buckling of the steel section under compressive load. The bolts also serve to transmit shear loads from the steel to the concrete.

The long (major) axis of the pole should be oriented in the direction of the resultant tip load. Thus, for termination or strain poles, the long axis is aligned with the line conductors, but for intermediate poles, the long axis is set at right angles to the line conductors.

MARK No.	POLE LENGTH (m)	STEEL SECTION (mm)	MAX. WIND LS TIP LOAD CAPACITY (kN)		MASS (kg)	Approx. CoG* (m)	Embedment (mm)	Nom. Windage Resolved to Tip** (kN)	
			Major axis	Minor axis				Wide Face	Narrow Face
1	9	102x51 TFC	13.0	2.6	830	4.2	1600	1.74	0.62
3	9	127x64 TFC	18.0	4.8	1100	4.2	1700	1.71	0.76
7	10.5	127x64 TFC	17.1	5.9	1375	4.8	1700	2.19	0.92
11	10.5	152x76 TFC	20.8	5.9	1635	4.8	1800	2.16	1.09
16	12	152x76 TFC	18.9	5.2	1850	5.5	2000	2.61	1.25
20	13	152x76 TFC	18.0	4.8	1980	6.0	2000	2.96	1.38

*CoG = Centre of Gravity – for lifting purposes ** 10% added as allowance for crossarm and insulators

Designers only need to check the Max. Wind LS condition for steel or concrete poles.

The design loadings applied in both strong and weak directions should not exceed the strength of the pole in either direction. Additionally, the combined loading (K) should not exceed:

- 1.0 for intermediate (in-line or deviation angle) poles, or
- 1.5 for dead-end (termination) poles

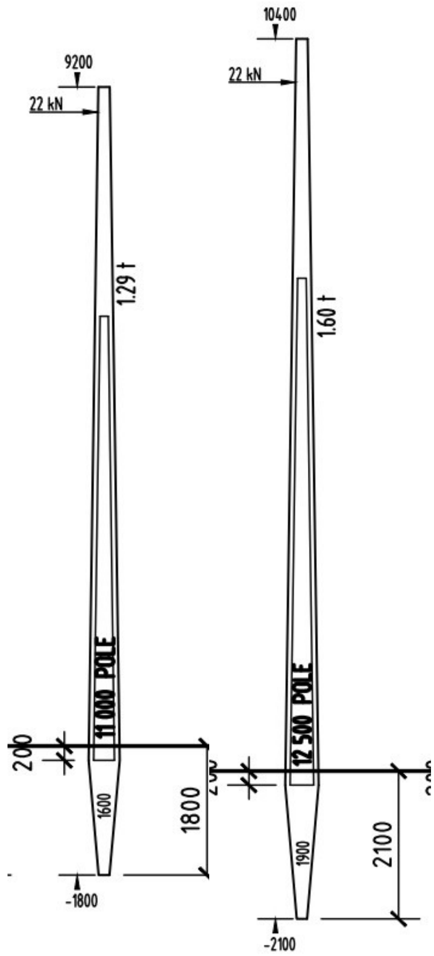
where: $K = \frac{f_S}{F_S} + \frac{f_W}{F_W}$

f_s = applied load in strong direction (along major axis)
F_S = strength in strong direction
f_w = applied load in weak direction (along minor axis)
F_w = strength in weak direction

6.4.2 Busck Poles

There are a number of existing Busck poles in service within the TasNetworks distribution network. These are a prestressed steel/concrete pole manufactured in New Zealand. As with Stobie poles, the long (major) axis of the pole should be oriented in the direction of the resultant tip load, so for termination or strain poles, the long axis is aligned with the line conductors, but for intermediate poles, the long axis is set at right angles to the line conductors.

Designers only need to check the Max. Wind LS condition for steel or concrete poles.



Description	Length	Sinking Depth	Height Above Ground	Width at Ground Line +2m	Width at Ground Line		Tip Load Capacity (Max Wind LS)		Axial Load LS Capacity	Mass	Nom. Windage Resolved to Tip*	
				Major	Major	Minor	Across line	Along line	Minor		Major	Minor
	(m)	(m)	(m)	(mm)	(mm)	(mm)	(kN)	(kN)	(kN)	(kg)	(kN)	(kN)
B11.0	11	1.8	9.2	380	430	240	22	8	640	1290	2.24	0.89
B12.5	12.5	2.1	10.4	420	475	255	22	7	590	1600	2.72	1.04

* 10% added to pole area as allowance for crossarms and insulators

6.4.3 Rockla Spun Concrete Steel-reinforced Poles

There are a number of round spun steel-reinforced concrete poles manufactured by Rockla in service within the TasNetworks distribution network. These poles have a nameplate giving the length, maximum working stress load and the ultimate load capacity of the pole.

Designers only need to check the Max. Wind LS condition for steel or concrete poles.

Rockla Spun Concrete Poles with Steel Reinforcing

Length	Strength			Min. Sinking Depth	Diameter		Auger Size	Mass	Nom. Pole Windage Resolved to Tip*
	WS	LS	Max. Wind LS		Tip	Butt			
(m)	(kN)	(kN)	(kN)	(m)	(mm)	(mm)	(mm)	(kg)	(kN)
11	5	10	9	2.1	195	360	750	1230	1.22
	8	16	14.4		240	405	750	1523	1.42
	12	24	21.6		285	450	750	1818	1.62
	20	40	36		330	495	750	2189	1.82
12.5	5	10	10	2.25	195	383	750	1474	1.47
	8	16	14.4		240	428	750	1815	1.69
	12	24	21.6		285	473	750	2160	1.92
	20	40	36		330	518	900	2593	2.15
14	8	16	14.4	2.4	240	450	750	2126	1.98
	12	24	21.6		285	495	900	2522	2.24
	20	40	36		330	540	900	3027	2.50

* 10% added to pole area as allowance for crossarms and insulators

6.4.4 Bluescope Steel Poles

There are some existing Bluescope steel poles in service within the TasNetworks distribution network. These are a steel tube with no taper. Standard sizes are shown below.

The windage of the pole resolved to the tip (in kilonewtons) can be calculated by multiplying the pole diameter (in metres) by the tip height of the pole by 0.9 (wind pressure in kPa) x 0.5 (centre of pressure is half way up the pole). A multiplier of 1.1 can be applied as an allowance for the area of the crossarms and insulators.

The Max. Wind LS strength can be taken to be equal to the ULS given for each size.

DISTRIBUTION RANGE

Length	ULS	Weight	OD
9.5m	15kN	317kg	273mm
11.0m	14kN	353kg	273mm
12.5m	12kN	420kg	273mm
12.5m	16kN	478kg	323mm
12.5m	24kN	748kg	457mm
14.0m	16kN	651kg	323mm
14.0m	24kN	837kg	457mm
15.5m	12kN	721kg	323mm

SUB-TRANSMISSION RANGE

Length	ULS	Weight	OD
17.0m *	24kN	1016kg	457mm
18.0m *	24kN	1075kg	457mm
18.0m	32kN	1567kg	457mm
20.0m	32kN	1906kg	457mm
21.5m	40kN	2216kg	457mm
22.0m	32kN	2249kg	457mm
23.5m	36kN	2556kg	457mm
25.0m	32kN	2866kg	457mm

* Single length pole

6.4.5 Customer Steel Poles

Galvanized Steel 125x125x5.0 SHS Grade 350

LENGTH (m)	TIP STRENGTH (kN)			Sinking Depth (m)	Tip Height (m)	Nom. Windage Resolved to Tip (kN)
	Nominal Working Stress	ULS	Max. Wind Limit State			
8.0	2.0	4.0	3.60	1.4	6.6	0.62

Notes:

1. The limit state tip strength shown is inclusive of all loads: conductor forces, windage on the pole itself and all attachments.
2. For additional details, refer Overhead Construction Standard section 1.3.2.

6.5. POLE REINFORCEMENT (STAKING)

6.5.1 Application

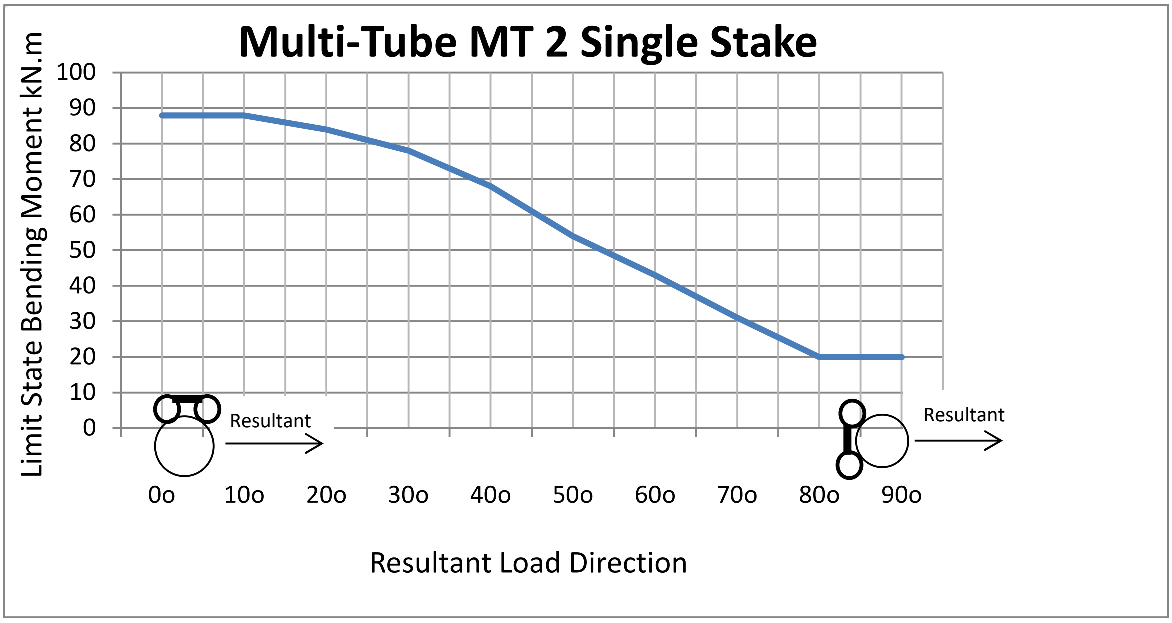
Where pole strength has been compromised near ground line by fungal decay, splitting or vehicular damage, it may be possible to reinstate the pole through application of one or more steel stakes. The site conditions and the extent of deterioration of the pole must be taken into account in determining if staking is feasible. The pole should be inspected and assessed as having at least another 15 years of life if it is to be staked. Poles carrying transformers with >100kVA capacity should be replaced rather than staked.

Designers should ensure that the tip load of the pole does not exceed either the capacity of the wood pole itself or the stake. For the stake capacity, only the max. wind condition need be checked. Tip Load Capacity is approximately equal to the Bending Moment Capacity of the stake divided by the height of the pole above ground[2].

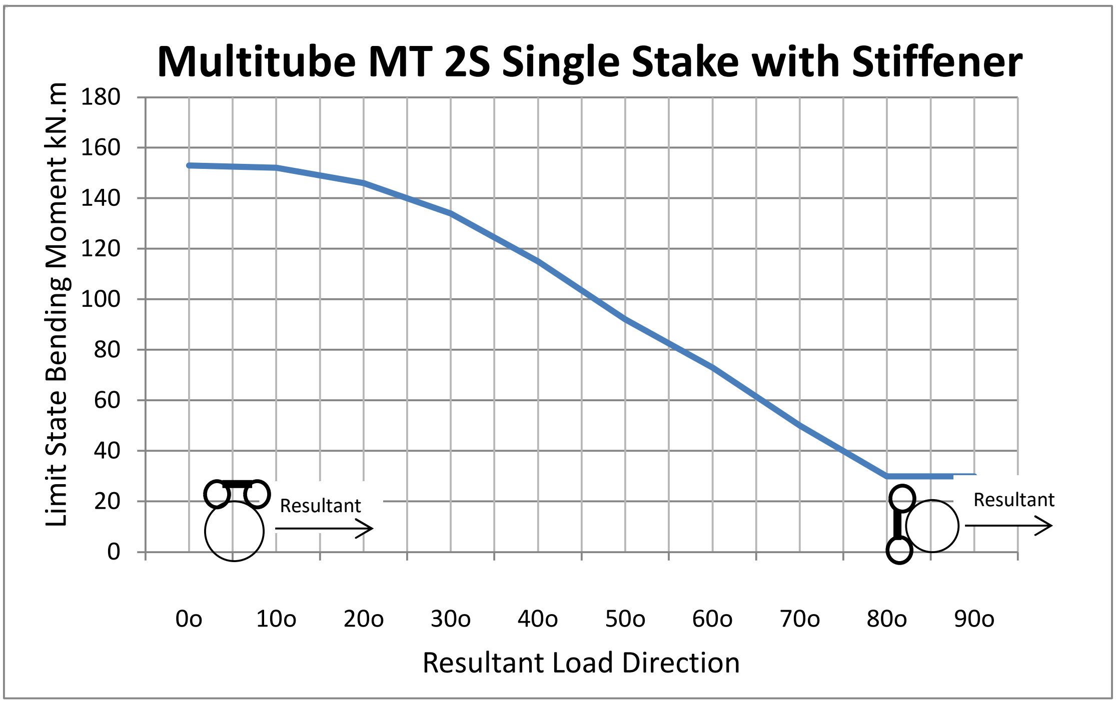
6.5.2 Multi-Tube MT2 Stakes

Type	DIMENSIONS (mm)			LS BENDING CAPACITY (kN.m)	
	Width	Length	Thickness	Longitudinal	Transverse
MT2 Single Stake	327	2700	6	18	88
MT2S Single Stake with Stiffener	327	2700	6	30	153
S Stiffener	76	1000	6	-----	------

For intermediate constructions, the stake should be positioned at right angles to the axis of the line to provide support for transverse forces. For termination or strain constructions, the stakes should be positioned parallel with the axis of the line to resist longitudinal forces. Where stakes are not aligned in this way, a derating needs to be applied to the strength as shown in the graphs below.



2 In reality, the pivot point for the bending moment is below ground line, typically at a point approximately 2/3 of the foundation depth, although this varies according to the type of soil.

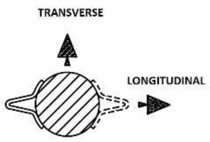


For double stakes, the net stake capacity is the sum of the individual stake capacities with respect to the direction of the applied load.

Suggested applications of pole nails for various pole strengths

Nom. Working Strength (kN)	Nom. Breaking Load (kN)	Pole Length (m)				
		8 / 9/9.5	10.5/11	12/12.5	13.5/14	15/15.5
4	17	1 x MT2	1 x MT2	1 x MT2	1 x MT2S	1 x MT2S
6	25	1 x MT2	1 x MT2S	1 x MT2S	1 x MT2S	1 x MT2S
8	33	1 x MT2S	1 x MT2S	1 x MT2S	2 x MT2S	2 x MT2S
10	42	1 x MT2S	2 x MT2S	2 x MT2S	2 x MT2S	2 x MT2S

ELTEK / RFD Type Stakes (Non-Current)



ID	DIMENSIONS (mm)			LS BENDING CAPACITY (kN.m)			
				Single Stake		Double Stake	
	Width	Length	Thickness	Longitudinal	Transverse	Longitudinal	Transverse
RFD600	275	3000	6	22	33	44	80
RFD680	300	3000	6	44	66	88	147
RFD880	300	3000	8	66	100	132	224

Where the resultant tip load is not exactly on-axis interpolate between longitudinal and transverse values.

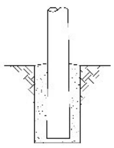
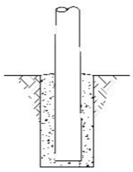
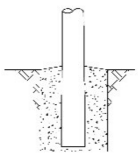
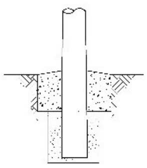
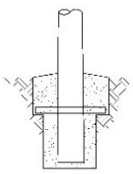
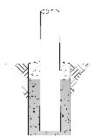
6.6 POLE FOUNDATIONS

6.6.1 Foundation Type Selection

The pole foundation design typically specifies:

- the sinking or embedment depth of the pole in the ground,
- the type of backfill used around the pole,
- whether a larger auger than usual is required,
- in poor soils, or for key poles (e.g. heavy plant poles), whether breast logs, piles, caissons, base pads or mass concrete is required.

In good soil, and where practicable, the designer should make the foundation strength match or exceed the pole strength.

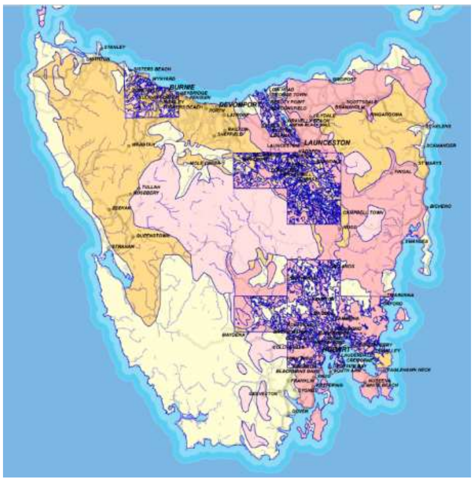
Section	Code	Description	Application
	NB	**Natural Backfill**	• Inexpensive • Generally adequate in good soils or for in-line poles • Requires greater sinking depth than other foundation types
	EB	**Enhanced Backfill** Imported backfill such as road base, fine crushed rock, decomposed granite or natural backfill that has had cement mixed with it to stabilise it. *Bore > Pole Dia + 150mm*	• More expensive than natural backfill requiring additional material to be brought to site and excess spoil removed • Effectively thickens pole base so that sinking depth can be reduced • Useful for strain or angle poles in poor or average soils • Stone-free backfill req'd for Titan Poles
	EBW	**Enhanced Backfill Wide Bore** As above, but where a larger auger has been used so that a larger plug of enhanced backfill may be installed. *Bore > Pole Dia + 300mm*	As above, but mainly for use in poorer soils.
	GC	**Gravel Collar** Wide gravel collar around pole to a depth of 800mm, natural backfill below. *Bore > Pole Dia + 600mm*	May be used as a remedial measure for improving foundation strength of existing poles in poorer soils
	BL	**Breast Log or Block** A crossmember (concrete log) is installed below ground to increase foundation reaction.	Use for poles carrying heavy plant such as transformers or regulators, except where soil is rock or hard clay. Backfill should be imported or cement-stabilised.
	CO	**Concrete**	Use with Stobie (Steel/Concrete) poles. *The top 400mm below ground line is to be natural backfill to allow for inspection.* May be used with wood poles in average or poor soil in lieu of EBW.
	SP	**Special** Custom design by civil engineer. May include caissons, piling, baulks, multiple logs, mass concrete, base pads.	Use in very poor soils such as swampy areas or very loose sand

6.6.2 Soil Types

The table below allows for 7 soil categories (other than rock, for which only minimum sinking and natural backfill is required). In determining soil type, the designer should take into account drainage of the area. Cohesive soils will be weakened significantly where drainage is poor.

Soil Type	Code	Classification	Characteristics	Unit Weight γ (kN/m^3)	Shear Strength / Cohesion c (kPa)	Friction Angle ϕ (º)
Weak/Weathered Rock 	**WR**		Shale class V and other types of fractured or broken rock where spacing between cracks and defects is <20mm.	18.0	250	0
Cohesive Granules stick together and form clods e.g. soils containing clay, blacksoil 	**CA**	**Hard**	Indented with difficulty by thumbnail.	21	200	0
	CB	**Stiff to Very Stiff**	Cannot be moulded by fingers. Able to indent with thumb but only able to penetrate with great effort.	21	100	0
	CC	**Firm**	Can be moulded by strong finger pressure. Moderate effort needed to penetrate 30mm with thumb.	19	37.5	0
	CD	**Soft**	Can be moulded by light finger pressure. Easily penetrated 40mm with thumb.	18	17.5	0
Particulated (Non-cohesive) Granules are loose and do not bind e.g. sand and gravel 	**PA**	**Dense**	When compacted in situ forms some clumps. Takes footprint less than 10mm deep.	20	0	35
	PB	**Loose**	Runs or crumbles very easily in hand. Takes footprint more than 10mm deep.	17	0	29

<u>Designers should not be overly conservative in assessing soil properties</u>. The sinking depths presented in the tables on the following pages allow for empirical assessment, i.e. using local knowledge and observation, not soil testing.



Designers may consult the 'Soil Classification' layer on the TasNetworks Webmap GIS system for general guidance regarding soil types in various areas. Note that there will be considerable variation in top soil thickness locally and drainage will also vary with topography, so the map cannot be relied upon entirely.

A comparison of strengths of the soil classifications above with the old Good/Medium/Poor classification system is presented in section 6.8.6. ('CC' and 'PA' roughly align with 'poor'; CB is between 'medium' and 'good').

In *very soft* cohesive soils, swampy areas or *very loose* particulated soils, special non-standard foundation designs may be required.

6.6.3 Sinking Depths to match Pole Strength – New Wood Pole Sizes

Wood Pole Length (m)	**Strength WS/NBL** (kN)	**Max. Wind Load** (kN)	**Min. Sink Depth** (m)	**Rock**	**Cohesive Soils** e.g. Clayey Soils									**Particulated (Non-Cohesive) Soils** e.g. Sand, Gravel			
				WR Weak / Weathered	**CA** Hard		**CB** Stiff to Very Stiff			**CC** Firm			**CD** Soft	**PA** Dense			**PB** Loose to Very Loose
				NB	**NB**	**EB**	**NB**	**EB**	**EBW**	**NB**	**EB**	**EBW**	**EBW**	**NB**	**EB**	**EBW**	**EBW**
9.5	**4/17**	10	1.55	1.55	1.55	1.55	1.70	1.55	1.55	2.55	2.20	2.00	2.80	2.45	2.25	2.15	2.60
	6/25	15		1.55	1.7	1.55	1.95	1.70	1.80	2.95	2.60	2.35	3.25	2.70	2.50	2.40	2.90
	8/33	20		1.55	1.90	1.70	2.10	1.90	2.00	3.25	2.85	2.60	3.60	2.90	2.70	2.55	3.10
11	**4/17**	10	1.70	1.70	1.70	1.70	1.75	1.70	1.70	2.70	2.35	2.15	2.95	2.55	2.35	2.25	2.70
	6/25	15		1.70	1.80	1.70	2.00	1.80	1.80	3.10	2.70	2.50	3.45	2.80	2.60	2.45	3.00
	8/33	20		1.80	2.00	1.70	2.20	2.00	1.80	3.35	3.00	2.75	3.80	3.00	2.80	2.65	3.25
12.5	**4/17**	10	1.85	1.85	1.85	1.85	1.85	1.85	1.85	2.85	2.45	2.25	3.10	2.65	2.45	2.30	2.80
	6/25	15		1.85	1.85	1.85	2.10	1.85	1.85	3.20	2.85	2.60	3.60	2.90	2.70	2.55	3.10
	8/33	20		1.85	1.85	1.85	2.30	2.05	1.90	3.50	3.15	2.90	4.00	3.10	2.90	2.75	3.35
14	**4/17**	10	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.95	2.60	2.35	3.25	2.70	2.50	2.35	2.90
	6/25	15		2.00	2.00	2.00	2.20	2.00	2.00	3.35	3.00	2.75	3.80	2.95	2.80	2.65	3.20
	8/33	20		2.00	2.00	2.00	2.40	2.15	2.00	3.65	3.30	3.05	4.20	3.15	3.00	2.85	3.45
15.5	**6/25**	15	2.15	2.15	2.15	2.15	2.25	2.15	2.15	3.45	3.10	2.85	3.95	3.05	2.85	2.70	3.30
	8/33	20		2.15	2.15	2.15	2.50	2.25	2.15	3.80	3.40	3.15	4.40	3.25	3.05	2.90	3.55
	10/42	25		2.15	2.15	2.15	2.65	2.45	2.25	4.10	3.70	3.45	4.75	3.40	3.25	3.10	3.75

Notes:

1. The setting depths are in metres.
2. Foundations deeper than 3.0m will require a large lifter/borer and should be avoided where possible. They are shown in the table above (shaded in grey) for reference only. In practice, it will be difficult to match foundation strength to pole strength for larger poles in CD or PB soils.
3. Calculated using Brinch Hansen method using ESAA *BHPile* software. Strength factor 0.8 used.
4. EB foundations are assumed to increase effective butt diameter by 150mm and EBW by 300mm. Pole diameter assumed to be that at 2m from butt for S3 poles + 10mm.

6.6.4 Foundation Strength for Minimum Sinking Depth – New Wood Pole Sizes

Wood Pole Length (m)	Strength WS/NBL (kN)	Max. Wind Load (kN)	Min. Sink Depth (m)	Rock	Cohesive Soils e.g. Clayey Soils														Particulated (Non-Cohesive) Soils e.g. Sand, Gravel							
				WR Weak / Weathered	CA Hard		CB Stiff to Very Stiff				CC Firm				CD Soft				PA Dense				PB Loose to Very Loose			
				NB	NB	EB	NB	EB	EBW	GC	NB	EB	EBW	GC	NB	EB	EBW	GC	NB	EB	EBW	GC	NB	EB	EBW	GC
9.5	**4/17**	10	1.55	>	>	>	8.45	11.78	15.84	13.30	3.17	4.42	5.57	4.93	1.47	2.05	2.59	2.30	2.13	2.86	3.58	3.50	1.10	1.50	1.90	1.81
	6/25	15		>	>	>	10.56	14.16	17.47	15.48	3.96	5.31	6.55	5.81	1.85	2.48	3.06	2.54	2.70	3.53	4.34	2.24	1.41	1.87	2.31	2.23
	8/33	20		>	>	>	11.31	14.84	18.11	16.29	4.24	5.57	6.79	6.11	1.98	2.60	3.17	2.67	2.87	3.70	4.50	2.37	1.50	1.95	2.39	2.29
11	**4/17**	10	1.70	>	>	>	9.38	12.86	16.06	14.13	3.52	4.83	6.02	5.30	1.65	2.26	2.82	2.48	2.59	3.46	4.10	4.02	1.34	1.81	2.26	2.10
	6/25	15		>	>	>	11.47	15.23	18.69	16.42	4.30	5.71	7.01	6.16	2.01	2.69	3.29	2.90	3.26	4.21	5.12	2.47	1.70	2.22	2.72	2.76
	8/33	20		>	>	>	12.38	16.06	19.47	17.42	4.64	6.02	7.30	6.53	2.17	2.81	3.41	3.05	3.45	4.39	5.31	2.60	1.81	2.32	2.82	2.86
12.5	**4/17**	10	1.85	>	>	>	10.34	14.02	17.38	15.30	3.87	5.26	6.51	5.74	1.81	2.45	3.04	2.67	3.14	4.10	5.04	4.61	1.63	2.16	2.66	2.40
	6/25	15		>	>	>	11.36	14.94	18.35	16.58	4.26	5.60	6.85	6.16	1.98	2.67	3.20	2.88	3.41	4.35	5.28	4.98	1.78	2.29	2.80	2.54
	8/33	20		>	>	>	12.22	15.73	19.09	17.54	4.59	5.90	7.12	6.53	2.14	2.75	3.33	3.04	3.63	4.58	5.49	5.14	1.89	2.42	2.91	2.67
14	**4/17**	10	2.00	>	>	>	11.50	15.36	18.75	16.56	4.32	5.76	7.09	6.29	2.02	2.69	3.31	2.93	3.78	4.88	5.92	5.25	1.95	2.56	3.14	2.75
	6/25	15		>	>	>	12.74	16.46	19.78	17.92	4.77	6.18	7.47	6.80	2.22	2.88	3.49	3.17	4.13	5.20	6.24	5.58	2.14	2.74	3.31	2.94
	8/33	20		>	>	>	13.50	17.18	20.56	18.90	5.07	6.45	7.73	7.10	2.37	3.01	3.62	3.31	4.35	5.41	6.45	5.84	2.27	2.85	3.42	3.07
15.5	**6/25**	15	2.15	>	>	>	13.79	17.73	21.30	19.25	5.17	6.66	8.03	7.26	2.42	3.10	3.74	3.39	4.83	6.05	7.22	6.32	2.51	3.18	3.82	3.33
	8/33	20		>	>	>	14.61	18.48	22.24	20.40	5.47	6.93	8.29	7.58	2.56	3.23	3.87	3.54	5.07	6.29	7.46	6.66	2.64	3.31	3.95	3.46
	10/42	25		>	>	>	15.33	19.15	22.94	21.10	5.74	7.18	8.53	7.87	2.69	3.36	3.98	3.68	5.30	6.50	7.62	6.86	2.77	3.42	4.06	3.58

Notes:

1. The foundation strengths are in kilonewtons and correspond to the maximum wind LS condition.
2. Calculated using Brinch Hansen method using ESAA *BHPile* software with 0.8 Strength Factor.
3. EB foundations are assumed to increase effective butt diameter by 150mm, EBW by 300mm and GC by 600mm to a depth of 800mm. Pole diameter assumed to be that at 2m from butt for S3 poles + 10mm.
4. Cells marked “>” have not been calculated as foundation strength for this depth exceeds pole strength.

6.6.5 Foundation Strengths for Minimum Sinking Depth + 300mm – New Wood Pole Sizes

Wood Pole Length (m)	Strength WS/NBL (kN)	Max. Wind Load (kN)	Min. Sink Depth +0.3 (m)	Rock	Cohesive Soils e.g. Clayey Soils																	Particulated (Non-Cohesive) Soils e.g. Sand, Gravel							
				WR Weak / Weathered	CA Hard		CB Stiff to Very Stiff				CC Firm				CD Soft				PA Dense				PB Loose to Very Loose						
				NB	NB	EB	NB	EB	EBW	GC	NB	EB	EBW	GC	NB	EB	EBW	GC	NB	EB	EBW	GC	NB	EB	EBW	GC			
9.5	**4/17**	10	1.85	>	>	>	12.64	17.70	22.48	19.55	4.74	6.64	8.37	7.25	2.21	3.10	3.90	3.38	3.86	5.17	6.42	5.89	1.98	2.70	3.39	3.04			
	6/25	15		>	>	>	16.21	21.80	26.94	23.21	6.08	8.18	10.10	8.70	2.84	3.82	4.72	4.06	5.03	6.55	8.00	3.53	2.61	3.44	4.23	4.47			
	8/33	20		>	>	>	17.24	22.86	27.92	24.51	6.52	8.57	10.47	9.19	3.04	4.00	4.89	4.29	5.34	6.84	8.32	3.74	2.78	3.60	4.39	4.62			
11	**4/17**	10	2.00	>	>	>	13.57	18.69	23.34	20.32	5.09	7.01	8.75	7.62	2.37	3.26	4.10	3.55	4.50	5.92	7.28	6.45	2.30	3.10	3.84	3.34			
	6/25	15		>	>	>	17.14	22.74	27.90	23.98	6.43	8.53	10.47	8.99	3.00	3.98	4.89	4.24	5.77	7.40	8.97	3.77	2.99	3.88	4.74	5.15			
	8/33	20		>	>	>	18.31	23.81	28.89	25.51	6.87	8.93	10.84	9.57	3.21	4.17	5.06	4.47	6.10	7.72	9.28	3.99	3.17	4.06	4.91	5.32			
12.5	**4/17**	10	2.15	>	>	>	14.56	19.78	24.54	21.47	5.46	7.41	9.22	8.05	2.54	3.46	4.30	3.76	5.20	6.77	8.26	7.14	2.67	3.54	4.35	3.70			
	6/25	15		>	>	>	16.00	21.07	25.92	23.25	6.00	7.90	9.66	8.66	2.80	3.70	4.51	4.03	5.63	7.17	8.66	7.62	2.91	3.76	4.58	3.94			
	8/33	20		>	>	>	17.23	22.21	27.42	24.56	6.46	8.34	10.06	9.15	3.02	3.89	4.70	4.27	6.00	7.52	8.99	7.98	4.75	3.95	4.75	4.10			
14	**4/17**	10	2.30	>	>	>	15.79	21.14	25.86	22.56	5.92	7.92	9.76	8.56	2.77	3.70	4.56	4.00	6.06	7.78	9.41	7.89	3.10	4.06	4.96	4.13			
	6/25	15		>	>	>	17.49	22.67	27.26	24.34	6.56	8.51	10.30	9.23	3.06	3.97	4.82	4.30	6.67	8.27	9.89	8.42	3.41	4.34	5.23	4.42			
	8/33	20		>	>	>	18.56	23.66	28.35	25.66	6.96	8.88	10.66	9.65	3.25	4.14	4.98	4.51	6.94	8.61	10.21	8.82	5.39	4.51	5.39	4.61			
15.5	**6/25**	15	2.45	>	>	>	18.54	23.90	28.74	25.50	6.96	8.96	10.83	9.63	3.25	4.19	5.06	4.50	7.44	9.33	11.10	9.33	3.87	4.88	5.86	4.86			
	8/33	20		>	>	>	19.62	24.93	29.22	27.04	7.38	9.34	11.18	10.06	3.44	4.37	5.23	4.69	7.87	9.70	11.46	9.82	4.08	5.09	6.05	5.07			
	10/42	25		>	>	>	20.64	25.82	30.80	27.97	7.74	9.70	11.50	10.43	3.62	4.53	5.38	4.86	8.21	10.02	11.78	10.13	4.26	5.26	6.22	5.26			

Notes:

1. The foundation strengths are in kilonewtons and correspond to the maximum wind LS condition.
2. Calculated using Brinch Hansen method using ESAA *BHPile* software with 0.8 Strength Factor.
3. EB foundations are assumed to increase effective butt diameter by 150mm, EBW by 300mm and GC by 600mm to a depth of 800mm. Pole diameter assumed to be that at 2m from butt for S3 poles + 10mm
4. Cells marked “>” have not been calculated as foundation strength for this depth exceeds pole strength.

6.6.6 Foundation Strength for Minimum Sinking Depth +600mm – New Wood Pole

Wood Pole Length (m)	Strength WS/NBL (kN)	Max. Wind Load (kN)	Min. Sink Depth +0.6 (m)	Rock	Cohesive Soils e.g. Clayey Soils															Particulated (Non-Cohesive) Soils e.g. Sand, Gravel							
				WR Weak / Weathered	CA Hard		CB Stiff to Very Stiff				CC Firm				CD Soft				PA Dense				PB Loose to Very Loose			
				NB	NB	EB	NB	EB	EBW	GC	NB	EB	EBW	GC	NB	EB	EBW	GC	NB	EB	EBW	GC	NB	EB	EBW	GC
9.5	**4/17**	10	2.1	>	>	>	>	>	>	>	6.69	9.41	11.87	10.24	3.12	4.38	5.54	4.78	6.42	8.54	10.56	9.10	3.28	4.42	5.57	4.66
	6/25	15		>	>	>	>	>	>	>	8.80	11.87	14.69	12.51	4.11	5.54	6.86	5.84	8.64	11.16	13.58	5.27	4.44	5.84	7.16	8.00
	8/33	20		>	>	>	>	>	>	>	9.44	12.45	15.23	13.22	4.41	5.81	7.11	6.17	9.16	11.65	14.05	5.59	4.73	6.11	7.42	8.25
11	**4/17**	10	2.3	>	>	>	>	>	>	>	7.01	9.66	12.10	10.45	3.26	4.51	5.65	4.88	7.22	9.46	11.58	9.70	3.68	4.93	6.10	5.01
	6/25	15		>	>	>	>	>	>	>	8.94	11.93	14.77	12.63	4.22	5.61	6.90	5.90	9.50	12.12	14.63	5.41	4.88	6.33	7.71	8.76
	8/33	20		>	>	>	>	>	>	>	9.66	12.59	15.30	13.32	4.51	5.88	7.14	6.22	10.04	12.63	15.12	5.72	5.18	6.61	7.98	9.03
12.5	**4/17**	10	2.45	>	>	>	>	>	>	>	7.34	10.02	12.45	10.72	3.42	4.67	5.81	5.01	8.10	10.50	12.75	10.48	4.13	5.46	6.70	5.41
	6/25	15		>	>	>	>	>	>	>	8.08	10.67	13.07	11.49	3.78	4.99	6.10	5.38	8.75	11.10	13.34	11.09	4.50	5.79	7.02	5.76
	8/33	20		>	>	>	>	>	>	>	8.72	11.25	13.60	12.14	4.06	5.25	6.35	5.66	9.31	11.63	13.86	11.78	4.82	6.08	7.31	6.08
14	**4/17**	10	2.60	>	>	>	>	>	>	>	7.82	10.50	12.96	11.14	3.66	4.90	6.05	5.20	9.17	11.71	14.13	11.38	4.69	6.10	7.42	5.90
	6/25	15		>	>	>	>	>	>	>	8.67	11.26	13.66	12.00	4.05	5.26	6.38	5.60	9.97	12.46	14.86	12.16	5.12	6.51	7.82	6.35
	8/33	20		>	>	>	>	>	>	>	9.22	11.76	14.13	12.56	4.30	5.49	6.59	5.86	10.48	12.96	15.33	12.75	5.36	6.77	8.08	6.64
15.5	**6/25**	15	2.75	>	>	>	>	>	>	>	9.04	11.68	14.13	12.30	4.22	5.46	6.59	5.74	11.06	13.73	16.29	11.49	5.68	7.15	8.56	6.86
	8/33	20		>	>	>	>	>	>	>	9.60	12.18	14.59	12.86	4.48	5.70	6.82	6.00	11.60	14.26	16.93	13.97	5.98	7.44	8.83	7.17
	10/42	25		>	>	>	>	>	>	>	10.08	12.62	15.01	13.34	4.70	5.90	7.01	6.22	12.10	14.72	17.25	14.42	6.26	7.70	9.09	7.44

Notes:

1. The foundation strengths are in kilonewtons and correspond to the maximum wind LS condition.
2. Calculated using Brinch Hansen method using ESAA *BHPile* software with 0.8 Strength Factor.
3. EB foundations are assumed to increase effective butt diameter by 150mm, EBW by 300mm and GC by 600mm to a depth of 800mm. Pole diameter assumed to be that at 2m from butt for S3 poles + 10mm.
4. Cells marked “>” have not been calculated as foundation strength for this depth exceeds pole strength.

6.6.7 Foundation Strength for Minimum Sinking Depth +900mm – New Wood Pole Sizes

Wood Pole Length (m)	Strength WS/NBL (kN)	Max. Wind Load (kN)	Min. Sink Depth +0.9 (m)	Rock	Cohesive Soils e.g. Clayey Soils															Particulated (Non-Cohesive) Soils e.g. Sand, Gravel							
				WR Weak / Weathered	CA Hard		CB Stiff to Very Stiff				CC Firm				CD Soft				PA Dense				PB Loose to Very Loose			
				NB	NB	EB	NB	EB	EBW	GC	NB	EB	EBW	GC	NB	EB	EBW	GC	NB	EB	EBW	GC	NB	EB	EBW	GC
9.5	**4/17**	10	2.45	>	>	>	>	>	>	>	9.04	12.74	16.10	13.71	4.22	5.95	7.52	6.40	10.02	13.30	16.35	12.93	5.07	6.90	8.58	6.80
	6/25	15		>	>	>	>	>	>	>	12.21	16.52	20.47	17.14	5.70	7.71	9.56	8.01	13.92	17.92	21.70	7.40	7.11	9.32	11.41	13.23
	8/33	20		>	>	>	>	>	>	>	13.11	17.33	21.23	18.11	6.12	8.09	9.91	8.46	14.75	18.69	22.45	7.84	7.57	9.75	11.81	13.63
11	**4/17**	10	2.6	>	>	>	>	>	>	>	9.28	12.83	13.87	14.13	4.34	6.00	7.52	6.37	10.94	14.30	17.46	13.58	5.55	7.41	9.15	7.15
	6/25	15		>	>	>	>	>	>	>	12.24	16.32	20.08	16.71	5.72	7.62	9.38	7.88	14.81	18.83	22.64	7.36	7.56	9.79	11.89	13.94
	8/33	20		>	>	>	>	>	>	>	13.09	17.10	20.81	17.76	6.11	7.98	9.72	8.29	15.64	19.61	23.39	7.77	8.02	10.22	12.30	14.33
12.5	**4/17**	10	2.75	>	>	>	>	>	>	>	9.57	13.06	16.27	13.73	4.46	6.10	7.60	6.42	12.00	15.49	18.77	14.42	6.08	8.02	9.82	7.58
	6/25	15		>	>	>	>	>	>	>	10.53	13.94	17.09	14.72	4.91	6.51	7.98	6.88	12.96	16.37	19.62	15.44	6.61	8.51	10.29	8.13
	8/33	20		>	>	>	>	>	>	>	11.36	14.69	17.79	15.57	5.30	6.86	8.30	7.26	13.78	17.14	20.35	16.29	7.07	8.93	10.70	8.58
14	**4/17**	10	2.90	>	>	>	>	>	>	>	10.03	13.49	16.67	14.03	4.69	6.30	7.78	6.54	13.30	16.93	20.35	15.54	6.74	8.77	10.66	8.18
	6/25	15		>	>	>	>	>	>	>	11.14	14.50	17.60	15.14	5.20	6.77	8.22	7.07	14.43	18.00	21.39	16.75	7.38	9.34	11.22	8.82
	8/33	20		>	>	>	>	>	>	>	11.82	15.14	18.19	15.84	5.52	7.15	8.50	7.39	15.17	18.69	22.02	17.54	7.79	9.73	11.58	9.23
15.5	**6/25**	15	3.05	>	>	>	>	>	>	>	11.46	14.82	17.94	15.31	5.34	6.91	8.37	7.15	14.85	19.46	23.02	17.87	8.02	10.10	12.06	9.41
	8/33	20		>	>	>	>	>	>	>	12.14	15.46	18.53	16.02	5.68	7.22	8.66	7.47	16.48	20.18	23.71	18.67	8.45	10.50	12.45	9.82
	10/42	25		>	>	>	>	>	>	>	12.77	16.02	19.07	16.62	5.97	7.49	8.90	7.76	17.15	20.83	24.34	19.39	8.82	10.85	12.78	10.21

Notes:

1. The foundation strengths are in kilonewtons and correspond to the maximum wind LS condition.
2. Calculated using Brinch Hansen method using ESAA *BHPile* software with 0.8 Strength Factor.
3. EB foundations are assumed to increase effective butt diameter by 150mm, EBW by 300mm and GC by 600mm to a depth of 800mm. Pole diameter assumed to be that at 2m from butt for S3 poles + 10mm.
4. Cells marked “>” have not been calculated as foundation strength for this depth exceeds pole strength.

6.6.8 Foundation Strength for Minimum Sinking Depth +1200mm – New Wood Pole Sizes

Wood Pole Length (m)	Strength WS/NBL (kN)	Max. Wind Load (kN)	Min. Sink Depth +1.2 (m)	Rock	Cohesive Soils e.g. Clayey Soils																Particulated (Non-Cohesive) Soils e.g. Sand, Gravel							
				WR Weak / Weathered	CA Hard		CB Stiff to Very Stiff				CC Firm				CD Soft				PA Dense				PB Loose to Very Loose			
				NB	NB	EB	NB	EB	EBW	GC	NB	EB	EBW	GC	NB	EB	EBW	GC	NB	EB	EBW	GC	NB	EB	EBW	GC
9.5	**4/17**	10	2.75	>	>	>	>	>	>	>	11.81	16.69	21.12	17.66	5.52	7.79	9.86	8.24	14.88	19.68	24.13	18.50	7.49	10.14	12.61	9.54
	6/25	15		>	>	>	>	>	>	>	16.40	22.25	27.61	22.66	7.66	10.39	12.89	10.58	21.40	27.45	33.14	9.94	10.85	14.21	17.35	20.67
	8/33	20		>	>	>	>	>	>	>	17.62	23.35	28.64	23.94	8.23	10.90	13.37	11.18	22.65	28.61	34.25	10.53	11.55	14.85	17.96	21.26
11	**4/17**	10	2.90	>	>	>	>	>	>	>	11.92	16.54	20.77	17.26	5.57	7.73	9.70	8.06	15.90	20.72	25.14	19.18	8.00	10.69	13.17	9.89
	6/25	15		>	>	>	>	>	>	>	16.11	21.53	26.52	21.62	7.43	10.05	12.39	10.19	22.13	28.06	33.63	9.65	11.22	14.51	17.59	21.08
	8/33	20		>	>	>	>	>	>	>	17.23	22.56	27.49	22.98	8.05	10.53	12.83	10.73	23.36	29.19	34.72	10.19	11.91	15.14	18.19	21.54
12.5	**4/17**	10	3.05	>	>	>	>	>	>	>	12.13	16.59	20.69	17.10	5.66	7.74	9.66	7.98	17.07	22.00	26.58	20.08	8.59	11.33	13.86	10.35
	6/25	15		>	>	>	>	>	>	>	13.36	17.71	21.73	18.35	6.24	8.27	10.14	8.58	18.43	23.23	27.76	21.54	9.36	12.02	14.51	11.10
	8/33	20		>	>	>	>	>	>	>	14.42	18.69	22.64	19.41	6.74	8.72	10.58	9.07	19.60	24.32	28.80	22.78	10.00	12.64	15.09	11.74
14	**4/17**	10	3.20	>	>	>	>	>	>	>	12.58	16.93	20.93	17.26	5.87	7.90	9.78	8.06	18.59	23.63	28.34	21.39	9.36	12.16	14.77	11.02
	6/25	15		>	>	>	>	>	>	>	13.95	18.19	22.11	18.66	6.51	8.50	10.32	8.70	20.18	25.10	29.74	22.82	10.26	12.98	15.55	11.76
	8/33	20		>	>	>	>	>	>	>	14.83	18.99	22.86	19.54	6.93	8.86	10.67	9.12	21.20	26.05	30.66	24.21	10.82	13.50	16.05	12.48
15.5	**6/25**	15	3.45	>	>	>	>	>	>	>	14.19	18.38	22.27	18.66	6.61	8.59	10.40	8.72	21.60	26.70	31.52	24.34	10.96	13.79	16.46	12.54
	8/33	20		>	>	>	>	>	>	>	15.06	19.18	23.02	19.52	7.02	8.96	10.75	9.12	22.66	27.68	32.46	25.49	11.55	14.34	16.98	13.14
	10/42	25		>	>	>	>	>	>	>	15.82	19.89	23.70	20.29	7.39	9.28	11.06	9.47	23.58	28.56	33.31	26.48	12.06	14.82	17.44	13.65

Notes:

1. The foundation strengths are in kilonewtons and correspond to the maximum wind LS condition.
2. Foundations deeper than 3.0m will require a large lifter/borer and should be avoided where possible. They are shown in the table above for reference purposes only.
3. Calculated using Brinch Hansen method using ESAA *BHPile* software with 0.8 Strength Factor.
4. EB foundations are assumed to increase effective butt diameter by 150mm, EBW by 300mm and GC by 600mm to a depth of 800mm. Pole diameter assumed to be that at 2m from butt for S3 poles + 10mm.
5. Cells marked “>” have not been calculated as foundation strength for this depth exceeds pole strength.

6.6.9 Foundation Strength for Minimum Sinking Depth – Old Wood Pole Sizes

Wood Pole Length (m)	Nom. Working Strength (kN)	Max. Wind Load (kN)	Min. Sink Depth (m)	Rock	Cohesive Soils e.g. Clayey Soils																Particulated (Non-Cohesive) Soils e.g. Sand, Gravel							
				WR Weak / Weathered	CA Hard		CB Stiff to Very Stiff				CC Firm				CD Soft				PA Dense				PB Loose to Very Loose			
				NB	NB	EB	NB	EB	EBW	GC	NB	EB	EBW	GC	NB	EB	EBW	GC	NB	EB	EBW	GC	NB	EB	EBW	GC
8	**6**	11.46	LINE 1.5	>	>	>	9.74	13.44	16.83	15.22	3.65	5.04	6.30	5.70	1.71	2.35	2.94	2.66	2.34	3.14	3.92	3.82	1.22	1.66	2.08	2.02
			STAY 1.8	>	>	>	14.83	20.50	25.71	22.69	5.57	7.70	9.63	8.50	2.59	3.58	4.50	3.97	4.34	5.76	7.14	6.54	2.24	3.02	3.78	3.44
	8	16.72	1.80	>	>	>	16.37	21.89	26.99	24.43	6.14	8.21	10.11	9.15	2.86	3.84	4.72	4.27	4.72	6.13	7.49	6.96	2.45	3.31	4.11	3.66
	10	22.19	1.80	>	>	>	17.58	23.01	28.06	25.81	6.59	8.62	10.51	9.66	3.09	4.14	4.91	4.51	5.02	6.42	7.78	7.26	2.62	3.53	4.40	3.82
9	**4**	8.46	1.55	>	>	>	8.94	12.48	13.15	13.97	3.36	4.69	4.93	5.23	1.57	2.19	2.75	2.45	2.24	3.04	3.79	3.65	1.17	1.60	2.02	1.92
	6	12.27	1.65	>	>	>	11.34	15.34	19.06	17.14	4.26	5.76	7.14	6.42	1.98	2.69	3.33	2.99	3.01	3.95	4.88	4.66	1.57	2.01	2.59	2.45
	8	16.68	1.80	>	>	>	15.02	19.81	24.27	22.08	5.63	7.42	9.09	8.27	2.62	3.47	4.24	3.86	4.32	5.57	6.75	6.29	2.26	2.93	3.58	3.31
10.5	**4**	8.63	1.70	>	>	>	9.86	13.52	16.91	14.91	3.70	5.07	6.34	5.58	1.73	2.37	2.96	2.59	2.72	3.62	4.48	4.19	1.41	1.90	2.37	2.21
	6	12.41	1.80	>	>	>	11.47	16.42	20.21	18.16	4.62	6.16	7.57	6.80	2.16	2.88	3.54	3.17	3.58	4.64	5.66	5.23	1.86	2.44	2.99	2.75
	8	16.71	1.80	>	>	>	13.33	17.33	21.06	19.26	5.14	6.50	7.89	7.22	2.34	3.04	3.68	3.38	3.78	4.88	5.89	5.50	2.00	2.57	3.12	2.90
12	**4**	8.78	1.85	>	>	>	10.80	14.64	18.19	16.02	4.05	5.49	6.82	6.00	1.89	2.56	3.18	2.80	3.26	4.29	5.25	4.77	1.70	2.25	2.78	2.51
	6	12.54		>	>	>	11.87	15.60	19.09	17.22	4.45	5.86	7.15	6.45	2.08	2.74	3.34	3.01	3.55	4.54	5.50	5.04	1.84	2.39	2.91	2.66
	8	16.63		>	>	>	12.77	16.43	19.87	18.24	6.16	6.16	7.44	6.83	2.24	2.88	3.47	3.18	3.79	4.77	5.73	5.33	1.98	2.51	3.04	2.80
13.5	**4**	9.29	2.00	>	>	>	11.97	15.97	19.70	17.47	4.48	5.98	7.38	6.54	2.10	2.80	3.44	3.06	3.94	5.07	6.16	5.44	2.03	2.65	3.25	2.86
	6	13.70		>	>	>	13.23	17.12	20.77	18.88	4.96	6.42	7.78	7.07	2.32	2.99	3.63	3.30	4.29	5.41	6.48	5.81	2.22	2.84	3.44	3.06
	8	17.24		>	>	>	14.03	17.86	21.44	19.74	5.26	6.70	8.03	7.39	2.46	3.12	3.74	3.46	4.51	5.62	6.70	6.05	2.35	2.96	3.55	3.18
15	**6**	13.25	2.15	>	>	>	14.29	18.37	22.18	18.42	5.36	6.90	8.30	7.66	2.50	3.22	3.89	3.52	4.99	6.26	7.47	6.54	2.59	3.28	3.95	3.44
	8	16.58		>	>	>	15.12	19.15	22.94	19.18	5.68	7.18	8.59	8.12	2.66	3.36	4.02	3.66	5.25	6.50	7.63	6.82	2.74	3.42	4.08	3.58
	10	20.00		>	>	>	15.87	19.84	23.58	19.87	5.95	7.44	8.83	8.50	2.78	3.47	4.13	3.81	5.49	6.72	7.92	7.04	2.86	3.47	4.19	3.70

Notes:

1. The foundation strengths are in kilonewtons and correspond to the maximum wind LS condition.
2. Calculated using Brinch Hansen method using ESAA *BHPile* software with 0.8 Strength Factor.
3. EB foundations are assumed to increase effective butt diameter by 150mm, EBW by 300mm and GC by 600mm to a depth of 800mm. Pole diameter assumed to be that at 2m from butt + 10mm.
4. Cells marked “>” have not been calculated as foundation strength for this depth exceeds pole strength.

6.6.10 Foundation Strength for Minimum Sinking Depth +300mm – Old Wood Pole Sizes

Wood Pole Length (m)	Nom. Working Strength (kN)	Max. Wind Load (kN)	Min. Sink Depth +0.3 (m)	Rock	Cohesive Soils e.g. Clayey Soils														Particulated (Non-Cohesive) Soils e.g. Sand, Gravel							
				WR Weak / Weathered	CA Hard		CB Stiff to Very Stiff				CC Firm				CD Soft				PA Dense				PB Loose to Very Loose			
				NB	NB	EB	NB	EB	EBW	GC	NB	EB	EBW	GC	NB	EB	EBW	GC	NB	EB	EBW	GC	NB	EB	EBW	GC
8	6	11.46	LINE 1.8	>	>	>	>	>	>	>	5.57	7.70	9.63	8.50	2.59	3.58	4.50	3.97	4.34	5.76	7.14	6.54	2.24	3.02	3.78	3.44
			STAY 2.1	>	>	>	>	>	>	>	7.95	11.02	13.82	12.18	3.71	5.15	6.45	5.68	7.31	9.68	11.90	10.19	3.74	5.06	6.29	5.36
	8	16.72	2.10	>	>	>	>	>	>	>	8.78	11.78	14.51	13.12	4.10	5.49	6.78	6.13	7.95	10.26	12.48	10.85	4.10	5.38	6.59	5.71
	10	22.19	2.10	>	>	>	>	>	>	>	9.44	12.37	15.07	13.84	4.42	5.78	7.04	6.46	8.45	10.74	12.94	11.38	4.38	5.64	6.84	5.98
9	4	8.46	1.85	>	>	>	>	>	>	>	5.02	7.04	8.88	7.70	2.35	3.30	4.14	3.60	2.34	5.47	6.78	6.11	2.10	2.87	3.58	3.22
	6	12.27	1.95	>	>	>	>	>	>	>	6.26	8.48	10.51	9.34	2.91	3.95	4.91	4.37	3.12	6.90	8.45	7.54	2.74	3.49	4.46	3.97
	8	16.68	2.10	>	>	>	>	>	>	>	8.05	10.62	13.02	11.81	3.76	4.96	6.08	5.50	4.48	9.30	11.25	9.82	3.76	4.88	5.95	5.17
10.5	4	8.63	2.00	>	>	>	>	>	>	>	5.36	7.38	9.22	8.03	2.50	3.44	4.30	3.74	4.72	6.22	7.65	6.69	2.43	3.25	4.03	3.52
	6	12.41	2.10	>	>	>	>	>	>	>	6.58	8.78	10.82	9.66	3.07	4.10	5.06	4.51	6.02	7.74	9.41	8.18	3.10	4.06	4.98	4.30
	8	16.71	2.10	>	>	>	>	>	>	>	7.12	9.28	11.26	10.26	3.33	4.34	5.26	4.78	6.43	8.14	9.79	8.61	3.30	4.28	5.18	4.53
12	4	8.78	2.15	>	>	>	>	>	>	>	5.71	7.74	9.62	8.43	2.66	3.62	4.50	3.94	5.42	7.07	8.62	7.33	2.78	3.69	4.54	3.86
	6	12.54		>	>	>	>	>	>	>	6.27	8.27	10.10	9.06	2.93	3.86	4.72	4.22	5.87	7.49	9.02	7.81	3.04	3.92	4.77	4.11
	8	16.63		>	>	>	>	>	>	>	6.75	8.70	10.51	9.57	3.15	4.06	4.91	4.46	6.26	7.86	9.39	8.21	3.25	4.12	4.96	4.32
13.5	4	9.29	2.30	>	>	>	>	>	>	>	6.16	8.24	10.16	8.91	2.88	3.86	4.74	4.16	6.29	8.06	9.76	8.14	3.23	4.21	5.15	4.29
	6	13.70		>	>	>	>	>	>	>	6.83	8.56	10.72	9.62	3.18	4.13	5.01	4.48	6.85	8.59	10.27	8.72	3.54	4.50	5.42	4.59
	8	17.24		>	>	>	>	>	>	>	7.25	9.23	11.09	10.05	3.38	4.30	5.17	4.69	7.20	8.94	10.61	9.12	3.74	4.69	5.60	4.80
15	6	13.25	2.45	>	>	>	>	>	>	>	7.19	9.28	11.22	9.98	3.36	4.34	5.23	4.66	7.74	9.66	11.49	9.58	4.00	5.05	6.06	5.04
	8	16.58		>	>	>	>	>	>	>	7.63	9.68	11.58	10.43	3.57	4.53	5.41	4.86	8.14	10.03	11.86	9.97	4.22	5.25	6.26	5.25
	10	20.00		>	>	>	>	>	>	>	8.01	10.03	11.92	10.82	3.74	4.69	5.57	5.06	8.48	10.37	12.18	10.34	4.42	5.44	6.43	5.44

Notes:

4. The foundation strengths are in kilonewtons and correspond to the maximum wind LS condition.
5. Calculated using Brinch Hansen method using ESAA *BHPile* software with 0.8 Strength Factor.
6. EB foundations are assumed to increase effective butt diameter by 150mm, EBW by 300mm and GC by 600mm to a depth of 800mm. Pole diameter assumed to be that at 2m from butt + 10mm.
7. Cells marked “>” have not been calculated as foundation strength for this depth exceeds pole strength.

6.6.11 Foundation Strength for Minimum Sinking Depth +600mm – Old Wood Poles Sizes

Wood Pole Length (m)	Nom. Working Strength (kN)	Max. Wind Load (kN)	Min. Sink Depth +0.6 (m)	Rock	Cohesive Soils e.g. Clayey Soils															Particulated (Non-Cohesive) Soils e.g. Sand, Gravel							
				WR Weak / Weathered	CA Hard		CB Stiff to Very Stiff				CC Firm				CD Soft					PA Dense				PB Loose to Very Loose			
				NB	NB	EB	NB	EB	EBW	GC	NB	EB	EBW	GC	NB	EB	EBW	GC		NB	EB	EBW	GC	NB	EB	EBW	GC
8	**6**	11.46	LINE 2.1	>	>	>	>	>	>	>	7.95	11.02	13.82	12.18	3.71	5.15	6.45	5.68		7.31	9.68	11.90	10.19	3.74	5.05	6.28	5.36
			STAY 2.4	>	>	>	>	>	>	>	10.85	15.07	18.94	16.51	5.07	7.04	8.85	7.71		11.54	15.20	18.64	14.99	5.87	7.90	9.79	7.89
	8	16.72	2.40	>	>	>	>	>	>	>	11.98	16.11	19.89	17.71	5.60	7.52	9.30	8.27		12.53	16.10	19.50	16.02	6.42	8.40	10.28	8.43
	10	22.19	2.40	>	>	>	>	>	>	>	12.91	16.94	20.67	18.67	6.03	7.90	9.65	8.72		13.31	16.83	20.22	16.85	6.86	8.80	10.66	8.86
9	**4**	8.46	2.15	>	>	>	>	>	>	>	7.10	9.98	12.59	10.91	3.31	4.66	5.89	7.47		6.80	9.06	11.18	9.39	3.47	4.72	5.89	4.94
	6	12.27	2.25	>	>	>	>	>	>	>	8.70	11.82	14.67	12.99	4.06	5.52	6.85	8.88		8.59	11.15	13.60	11.38	4.40	5.82	7.17	5.98
	8	16.68	2.40	>	>	>	>	>	>	>	10.96	14.51	17.81	15.89	5.12	6.78	8.32	10.93		11.44	14.56	17.55	14.53	5.84	7.62	9.25	7.65
10.5	**4**	8.63	2.30	>	>	>	>	>	>	>	7.38	10.18	12.74	11.98	3.44	4.75	5.95	5.15		7.58	9.94	12.18	9.97	3.87	5.18	6.40	5.25
	6	12.41	2.40	>	>	>	>	>	>	>	8.94	11.97	14.75	13.57	4.18	5.58	6.90	6.06		9.55	12.13	14.67	12.03	4.86	6.34	7.73	6.34
	8	16.71	2.40	>	>	>	>	>	>	>	9.68	12.64	15.38	13.74	4.51	5.90	7.18	6.42		10.11	12.74	15.25	12.70	5.22	6.66	8.03	6.69
12	**4**	8.78	2.45	>	>	>	>	>	>	>	7.68	11.10	13.01	11.23	3.58	4.88	6.08	5.25		8.45	10.94	13.31	10.74	4.32	5.70	6.99	5.65
	6	12.54		>	>	>	>	>	>	>	8.45	11.17	13.66	12.03	3.95	5.22	6.38	5.62		9.14	11.58	13.94	11.42	4.69	6.05	7.33	6.02
	8	16.63		>	>	>	>	>	>	>	9.12	11.76	14.22	12.72	4.26	5.54	6.64	5.94		9.73	12.00	14.46	12.03	5.02	6.35	7.63	6.34
13.5	**4**	9.29	2.60	>	>	>	>	>	>	>	8.14	10.93	13.47	11.60	3.81	5.10	6.29	5.41		9.52	12.18	14.69	11.68	4.86	6.34	7.71	6.14
	6	13.70		>	>	>	>	>	>	>	9.02	11.73	14.22	12.51	4.21	5.47	6.64	5.84		10.37	12.96	15.50	12.56	5.33	6.77	8.13	6.61
	8	17.24		>	>	>	>	>	>	>	9.58	12.24	14.70	13.07	4.48	5.71	6.86	6.11		10.90	13.46	15.92	13.10	5.62	7.04	8.38	6.90
15	**6**	13.25	2.75	>	>	>	>	>	>	>	9.38	12.10	14.64	12.75	4.38	5.65	6.83	5.95		11.44	14.21	16.86	13.54	5.87	7.41	8.86	7.12
	8	16.58		>	>	>	>	>	>	>	9.94	12.62	15.12	13.33	4.64	5.89	7.06	6.22		12.02	14.75	17.39	14.11	6.19	7.71	9.15	7.42
	10	20.00		>	>	>	>	>	>	>	10.43	13.09	15.55	13.84	4.88	6.11	7.26	6.46		12.51	15.23	17.86	14.66	6.46	7.97	9.41	7.71

Notes:

1. The foundation strengths are in kilonewtons and correspond to the maximum wind LS condition.
2. Calculated using Brinch Hansen method using ESAA *BHPile* software with 0.8 Strength Factor.
3. EB foundations are assumed to increase effective butt diameter by 150mm, EBW by 300mm and GC by 600mm to a depth of 800mm. Pole diameter assumed to be that at 2m from butt + 10mm.
4. Cells marked “>” have not been calculated as foundation strength for this depth exceeds pole strength.

6.6.12 Foundation Strength for Minimum Sinking Depth +900mm – Old Wood Poles Sizes

Wood Pole Length (m)	**Nom. Working Strength** (kN)	**Max. Wind Load** (kN)	**Min. Sink Depth +0.9** (m)	**Rock**	**Cohesive Soils** e.g. Clayey Soils														**Particulated (Non-Cohesive) Soils** e.g. Sand, Gravel							
				WR Weak / Weathered	**CA** Hard		**CB** Stiff to Very Stiff				**CC** Firm				**CD** Soft				**PA** Dense				**PB** Loose to Very Loose			
				NB	**NB**	**EB**	**NB**	**EB**	**EBW**	**GC**	**NB**	**EB**	**EBW**	**GC**	**NB**	**EB**	**EBW**	**GC**	**NB**	**EB**	**EBW**	**GC**	**NB**	**EB**	**EBW**	**GC**
8	**6**	11.46	LINE 2.4	>	>	>	>	>	>	>	10.85	15.07	18.94	16.51	5.07	7.04	8.85	7.71	11.39	15.20	18.64	14.99	5.87	7.90	9.79	7.89
			STAY 2.7	>	>	>	>	>	>	>	14.29	19.92	25.06	21.44	6.67	9.30	11.70	10.02	17.07	22.69	27.73	21.22	8.74	11.74	14.51	11.17
	8	16.72	2.70	>	>	>	>	>	>	>	15.82	21.30	26.34	22.99	7.39	9.94	12.29	10.74	18.75	24.03	29.01	22.77	9.55	12.48	15.22	11.98
	10	22.19	2.70	>	>	>	>	>	>	>	17.04	22.40	27.36	24.22	7.95	10.46	12.78	11.31	19.92	25.10	30.05	23.98	10.19	13.07	15.79	12.62
9	**4**	8.46	2.45	>	>	>	>	>	>	>	9.62	13.54	17.10	14.64	4.48	6.32	7.98	6.83	10.62	14.08	17.33	13.68	5.38	7.31	9.09	7.20
	6	12.27	2.55	>	>	>	>	>	>	>	11.63	15.95	19.70	17.12	5.42	7.39	9.20	8.00	13.17	17.04	20.69	16.42	6.70	8.85	10.86	8.64
	8	16.68	2.70	>	>	>	>	>	>	>	14.43	19.15	23.50	20.56	6.74	8.94	10.98	9.60	17.10	21.70	26.06	20.64	8.74	11.28	13.68	10.86
10.5	**4**	8.63	2.60	>	>	>	>	>	>	>	9.78	13.52	16.94	14.42	4.56	6.32	7.92	6.74	11.50	15.04	18.35	14.29	5.82	7.79	9.62	7.52
	6	12.41	2.70	>	>	>	>	>	>	>	11.74	15.74	19.42	16.77	5.49	7.34	9.07	7.82	14.14	18.05	21.76	17.09	7.20	9.38	11.41	8.99
	8	16.71	2.70	>	>	>	>	>	>	>	12.70	16.62	20.24	17.76	5.94	7.76	9.46	8.29	15.09	18.93	22.61	18.06	7.73	9.86	11.87	9.50
12	**4**	8.78	2.75	>	>	>	>	>	>	>	10.02	13.66	17.02	14.38	4.67	6.38	7.95	6.72	12.53	16.18	19.60	15.07	6.35	8.37	10.26	7.94
	6	12.54		>	>	>	>	>	>	>	11.02	14.59	17.87	15.42	5.15	6.82	8.35	7.20	13.54	17.10	20.48	16.11	6.91	8.88	10.75	8.48
	8	16.63		>	>	>	>	>	>	>	11.89	15.38	18.61	16.30	5.55	7.18	8.69	7.62	14.38	17.90	21.26	17.02	7.38	9.33	11.17	8.96
13.5	**4**	9.29	2.90	>	>	>	>	>	>	>	10.45	14.05	17.34	14.62	4.88	6.56	8.10	6.88	13.81	17.60	21.15	16.18	7.01	9.10	11.07	8.51
	6	13.70		>	>	>	>	>	>	>	11.58	15.09	18.32	15.78	5.41	7.04	8.56	7.36	15.01	18.70	22.22	17.42	7.66	9.71	11.65	9.17
	8	17.24		>	>	>	>	>	>	>	12.04	15.74	18.94	16.25	5.74	7.36	8.85	7.71	15.76	19.42	22.91	18.21	8.10	10.11	12.03	9.58
15	**6**	13.25	3.05	>	>	>	>	>	>	>	11.86	15.36	18.59	16.01	5.54	7.17	8.67	7.42	16.26	20.14	23.82	18.48	8.30	10.45	12.48	9.73
	8	16.58		>	>	>	>	>	>	>	12.59	16.02	19.20	16.99	5.89	7.49	8.98	7.76	17.06	20.88	24.54	19.33	8.74	10.86	12.88	10.18
	10	20.00		>	>	>	>	>	>	>	13.23	16.61	19.76	17.86	6.18	7.76	9.23	8.05	16.85	21.55	25.20	20.10	9.14	11.23	13.23	10.58

Notes:

1. The foundation strengths are in kilonewtons and correspond to the maximum wind LS condition.
2. Calculated using Brinch Hansen method using ESAA *BHPile* software with 0.8 Strength Factor.
3. EB foundations are assumed to increase effective butt diameter by 150mm, EBW by 300mm and GC by 600mm to a depth of 800mm. Pole diameter assumed to be that at 2m from butt + 10mm.
4. Cells marked “>” have not been calculated as foundation strength for this depth exceeds pole strength.

6.6.13 Foundation Strength for Minimum Sinking Depth +1200mm – Old Wood Poles Sizes

Wood Pole Length (m)	Nom. Working Strength (kN)	Max. Wind Load (kN)	Min. Sink Depth +1.2 (m)	Rock	Cohesive Soils e.g. Clayey Soils															Particulated (Non-Cohesive) Soils e.g. Sand, Gravel							
				WR Weak / Weathered	CA Hard		CB Stiff to Very Stiff				CC Firm				CD Soft				PA Dense				PB Loose to Very Loose			
				NB	NB	EB	NB	EB	EBW	GC	NB	EB	EBW	GC	NB	EB	EBW	GC	NB	EB	EBW	GC	NB	EB	EBW	GC
8	**6**	11.46	LINE 2.7	>	>	>	>	>	>	>	14.29	19.92	25.06	21.44	6.67	9.30	11.70	10.02	>	>	>	>	8.74	11.74	14.51	11.17
			STAY 3.0	>	>	>	>	>	>	>	18.34	25.62	32.26	27.06	8.56	11.95	15.06	12.64	>	>	>	>	12.50	16.75	20.69	15.34
	8	16.72	3.00	>	>	>	>	>	>	>	20.30	27.39	33.90	29.02	9.49	12.78	15.82	13.55	>	>	>	>	13.65	17.81	21.68	16.50
	10	22.19	3.00	>	>	>	>	>	>	>	21.87	28.82	35.23	30.59	10.22	13.46	16.45	14.27	>	>	>	>	14.56	18.66	22.50	17.41
9	**4**	8.46	2.75	>	>	>	>	>	>	>	12.58	17.74	22.46	18.86	5.87	9.22	10.50	8.80	>	>	>	>	7.94	10.77	13.38	10.13
	6	12.27	2.85	>	>	>	>	>	>	>	15.07	20.58	25.63	21.82	7.04	9.62	11.97	10.19	>	>	>	>	9.76	12.86	15.76	12.06
	8	16.68	3.00	>	>	>	>	>	>	>	18.48	24.58	30.19	25.89	8.62	11.47	14.10	12.10	>	>	>	>	12.46	16.08	19.47	14.94
10.5	**4**	8.63	2.90	>	>	>	>	>	>	>	12.58	17.44	21.89	18.24	5.87	8.14	10.22	8.51	>	>	>	>	8.42	11.23	13.84	10.40
	6	12.41	3.00	>	>	>	>	>	>	>	14.99	20.14	24.88	21.02	6.99	9.41	11.62	9.82	>	>	>	>	10.26	13.34	16.21	12.35
	8	16.71	3.00	>	>	>	>	>	>	>	16.24	21.28	25.94	22.29	7.58	9.94	12.11	10.40	>	>	>	>	11.01	14.03	16.86	13.09
12	**4**	8.78	3.05	>	>	>	>	>	>	>	12.70	17.38	21.66	17.94	5.94	8.11	10.11	8.37	>	>	>	>	8.98	11.84	14.48	10.82
	6	12.54		>	>	>	>	>	>	>	13.98	18.54	22.75	19.25	6.53	8.66	10.62	8.98	>	>	>	>	9.78	12.56	15.17	11.62
	8	16.63		>	>	>	>	>	>	>	15.09	19.55	23.70	20.35	7.04	9.14	11.07	9.50	>	>	>	>	10.45	13.18	15.76	12.27
13.5	**4**	9.29	3.20	>	>	>	>	>	>	>	13.09	17.62	21.79	18.00	6.11	8.22	10.18	8.40	>	>	>	>	9.73	12.64	15.36	11.47
	6	13.70		>	>	>	>	>	>	>	14.53	18.93	23.02	19.44	6.78	8.85	10.75	9.07	>	>	>	>	10.66	13.49	16.69	12.38
	8	17.24		>	>	>	>	>	>	>	15.44	19.78	23.81	20.35	7.22	9.23	11.12	9.50	>	>	>	>	11.25	14.03	19.20	12.96
15	**6**	13.25	3.35	>	>	>	>	>	>	>	13.81	19.06	23.09	19.36	6.86	8.90	10.78	9.04	>	>	>	>	11.34	14.29	17.04	12.99
	8	16.58		>	>	>	>	>	>	>	14.67	19.89	23.87	20.26	7.30	9.28	11.15	9.46	>	>	>	>	11.95	14.85	17.58	13.60
	10	20.00		>	>	>	>	>	>	>	15.42	20.62	24.56	21.06	7.66	9.63	11.47	9.82	>	>	>	>	12.50	15.34	18.06	14.13

Notes:

1. The foundation strengths are in kilonewtons and correspond to the maximum wind LS condition.
2. Calculated using Brinch Hansen method using ESAA *BHPile* software with 0.8 Strength Factor.
3. EB foundations are assumed to increase effective butt diameter by 150mm, EBW by 300mm and GC by 600mm to a depth of 800mm. Pole diameter assumed to be that at 2m from butt + 10mm.
4. Cells marked “>” have not been calculated as foundation strength for this depth exceeds pole strength.

6.6.14 Foundation Strengths for Titan Poles

MINIMUM SINKING DEPTH

Pole Length (m)	**Strength** (kN)			**Sinking Depth** (m)	**Rock**	**Cohesive Soils** e.g. Clayey Soils						**Particulated (Non-Cohesive) Soils** e.g. Sand, Gravel		
	WS	Ult	Max. Wind LS		**WR** Weak / Weathered	**CA** Hard	**CB** Stiff to Very Stiff		**CC** Firm		**CD** Soft	**PA** Dense		**PB** Loose to Very Loose
					CO / EB	**CO / EB**	**CO / EB**	**EBW**	**CO / EB**	**EBW**	**EBW**	**CO / EB**	**EBW**	**EBW**
12.5	8	16	14.4	1.85	>	>	16.94	20.13	6.35	7.54	3.52	4.91	5.81	3.09
	12	24	21.6		>	>	17.26	20.43	6.48	7.66	3.58	4.99	5.90	3.14
14	8	16	14.4	2.00	>	>	17.36	20.78	6.51	7.79	3.63	5.46	6.72	3.44
	12	24	21.6		>	>	17.01	20.45	6.38	7.66	3.57	5.36	6.40	3.39
15.5	12	24	21.6	2.15	>	>	18.75	22.37	7.04	8.38	3.92	6.37	7.54	3.98

MINIMUM SINKING DEPTH +450mm

Pole Length (m)	**Strength** (kN)			**Sinking Depth** (m)	**Rock**	**Cohesive Soils** e.g. Clayey Soils						**Particulated (Non-Cohesive) Soils** e.g. Sand, Gravel		
	WS	Ult	Max. Wind LS		**WR** Weak / Weathered	**CA** Hard	**CB** Stiff to Very Stiff		**CC** Firm		**CD** Soft	**PA** Dense		**PB** Loose to Very Loose
					CO / EB	**CO / EB**	**CO / EB**	**EBW**	**CO / EB**	**EBW**	**EBW**	**CO / EB**	**EBW**	**EBW**
12.5	8	16	14.4	2.30	>	>	>	>	10.48	12.46	5.82	10.10	11.89	6.29
	12	24	21.6		>	>	>	>	10.69	12.66	5.90	10.27	12.08	6.38
14	8	16	14.4	2.45	>	>	>	>	10.37	12.43	5.81	10.72	12.69	6.70
	12	24	21.6		>	>	>	>	10.16	12.22	5.71	10.53	12.50	6.59
15.5	12	24	21.6	2.60	>	>	>	>	10.86	12.98	6.06	11.97	14.10	7.42

Notes:

1. The foundation strengths are in kilonewtons and correspond to the maximum wind LS condition.
2. Calculated using Brinch Hansen method using ESAA *BHPile* software with 0.8 strength factor.
3. EB foundations are assumed to increase effective butt diameter by 150mm, EBW by 300mm, CO by 150mm.
4. Cells marked “>” have not been calculated as foundation strength for this depth significantly exceeds pole strength.
5. Foundation material should be free of rocks.

6.6.15 Foundation Strengths for Stobie Poles

MINIMUM SINKING DEPTH

Mark No.	**Pole Length** (m)	**Section (mm)**	**Max. Wind Load Long Axis** (kN)	**Min. Sink Depth** (m)	**Rock**	**Cohesive Soils** e.g. Clayey Soils				**Particulated (Non-Cohesive) Soils** e.g. Sand, Gravel	
					WR Weak / Weathered	**CA** Hard	**CB** Stiff to Very Stiff	**CC** Firm	**CD** Soft	**PA** Dense	**PB** Loose to Very Loose
1	**9**	102 x 51	5.97	1.6	>	>	>	3.92	1.82	3.28	1.73
3		127 x 64	8.26	1.7	>	>	>	4.70	2.19	4.10	2.16
7	**10.5**	127 x 64	7.93	1.7	>	>	>	4.00	1.87	3.49	1.84
11		152 x 76	9.64	1.8	>	>	>	4.72	2.21	4.27	2.26
16	**12**	152 x 76	8.74	2.0	>	>	>	5.38	2.51	5.38	2.82
20	**13**	152 x 76	8.25	2.0	>	>	>	4.94	2.30	4.94	2.59

MINIMUM SINKING DEPTH +300mm

Mark No.	**Pole Length** (m)	**Section (mm)**	**Max. Wind Load Long Axis** (kN)	**Sink Depth** (m)	**Rock**	**Cohesive Soils** e.g. Clayey Soils				**Particulated (Non-Cohesive) Soils** e.g. Sand, Gravel	
					WR Weak / Weathered	**CA** Hard	**CB** Stiff to Very Stiff	**CC** Firm	**CD** Soft	**PA** Dense	**PB** Loose to Very Loose
1	**9**	102 x 51	5.97	1.6	>	>	>	6.24	2.91	6.05	3.17
3		127 x 64	8.26	1.7	>	>	>	7.26	3.39	7.26	3.81
7	**10.5**	127 x 64	7.93	1.7	>	>	>	6.14	2.86	6.18	3.23
11		152 x 76	9.64	1.8	>	>	>	7.06	3.30	7.33	3.84
16	**12**	152 x 76	8.74	2.0	>	>	>	7.71	3.60	8.74	4.56
20	**13**	152 x 76	8.25	2.0	>	>	>	7.07	3.30	8.03	4.19

MINIMUM SINKING DEPTH +600mm

Mark No.	**Pole Length** (m)	**Section (mm)**	**Max. Wind Load Long Axis** (kN)	**Sink Depth** (m)	**Rock**	**Cohesive Soils** e.g. Clayey Soils				**Particulated (Non-Cohesive) Soils** e.g. Sand, Gravel	
					WR Weak / Weathered	**CA** Hard	**CB** Stiff to Very Stiff	**CC** Firm	**CD** Soft	**PA** Dense	**PB** Loose to Very Loose
1	**9**	102 x 51	5.97	1.6	>	>	>	>	4.30	>	5.28
3		127 x 64	8.26	1.7	>	>	>	>	4.88	>	6.18
7	**10.5**	127 x 64	7.93	1.7	>	>	>	>	4.11	>	5.25
11		152 x 76	9.64	1.8	>	>	>	>	4.64	>	6.08
16	**12**	152 x 76	8.74	2.0	>	>	>	>	4.91	>	6.94
20	**13**	152 x 76	8.25	2.0	>	>	>	>	4.50	>	6.38

Notes:

1. The foundation strengths are in kilonewtons and correspond to the maximum wind LS condition.
2. Calculated using Brinch Hansen method using ESAA *BHPile* software with 0.8 strength factor.
3. Assumes a 500mm diameter auger is used with CO (concrete) foundation starting 400mm below ground level.
4. Cells marked “>” have not been calculated as foundation strength for this depth significantly exceeds pole strength.

6.7 POLE ALIGNMENTS

6.7.1 General Practice

Poles located within road reserves shall be installed on an alignment approved by the authority controlling the roadway – usually the local authority (council) or the Department of Transport on main roads, highways and freeways.

Standard alignments may vary according to:

- the individual authority standards and particular locality
- the era in which the area was developed
- whether the area is urban or rural
- the width of the footpath
- whether there are kerbs at the edges of the carriageway
- the position of concrete footpaths
- terrain – slope of the verge, embankments
- the speed limit of the road
- proximity to intersections and bends in the road.

Designers will need to use judgment as to whether to follow standard alignments or to match the alignment of existing poles within a street.

Designers should avoid having conductors overhanging private property or violating required clearances from structures within property, including under blowout conditions. Where this is unavoidable, a wayleave may be sought from property owners to address the incursion.

Restrictions concerning streetlight pole placement are also found in *AS/NZS1158 - Road Lighting*. As a general guideline, ensure that there is at least 0.7m between the outside of the pole and the kerb to minimise risk of damage from/to vehicles, or 1.0m near corners.

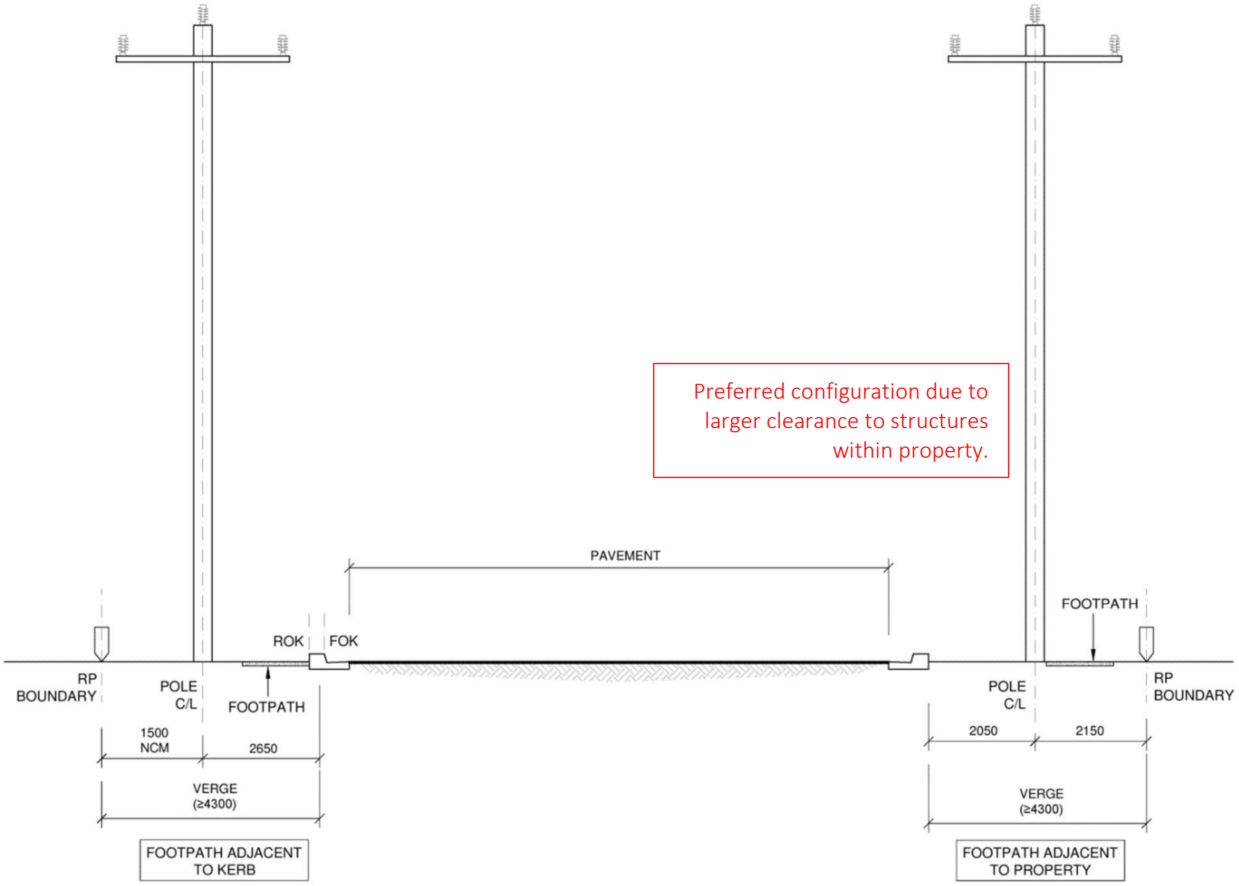
On high-speed roads (≥ 80km/hr) where there is no physical obstruction to the path of vehicles (such as drains or embankments), increased separation from the road pavement should be considered to adequately safeguard the pole and reduce the probability of a vehicle impact – refer section 6.6.4 for main roads.

Note that local authorities may have additional restrictions on pole placement, e.g. clearances from walking paths and bike paths.

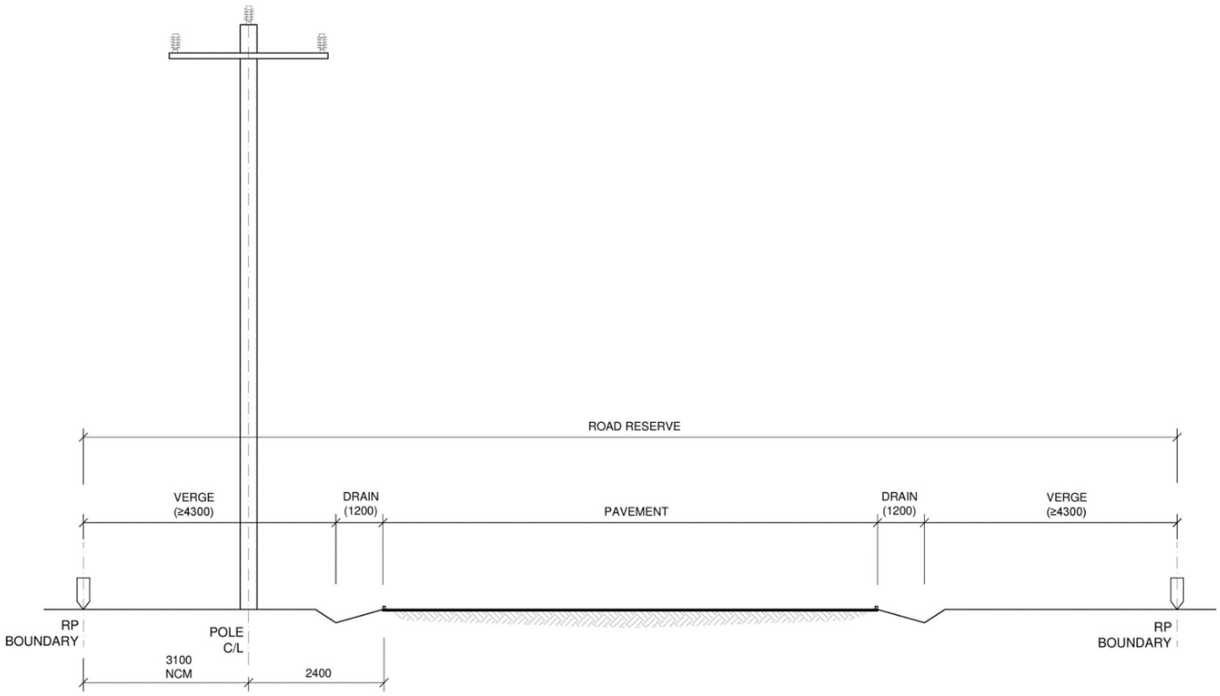
6.7.2 Urban areas

The alignments shown below are typical. They apply to various council areas, including Brighton, Clarence, Glenorchy, Hobart, and Kingborough.

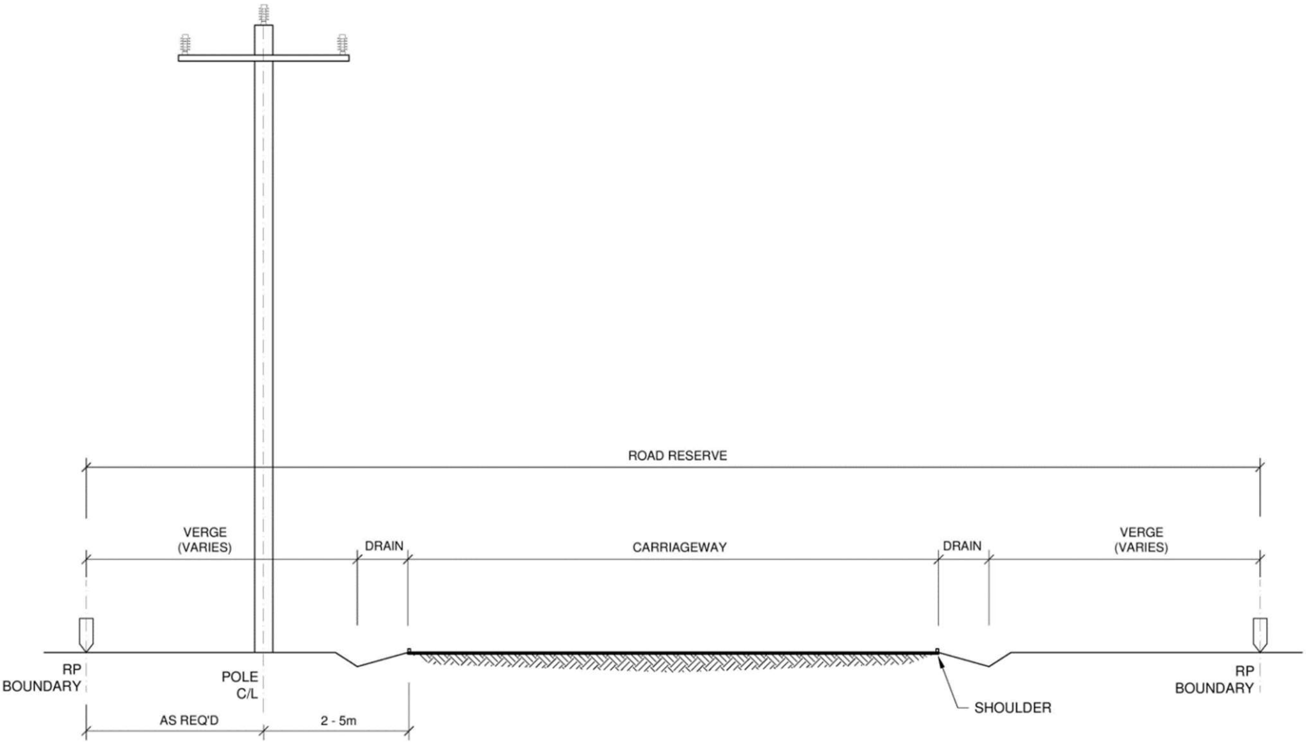
Kerbed Roads



Unkerbed Roads



6.7.3 Rural areas



It is desirable to have the pole set back 5m from the edge of bitumen if possible, and at least 2.0m from the centre of the drain. Where this latter distance cannot be achieved, road authorities should be requested to consider the provision of warning or protective measures.

6.7.4 Main Roads

The Department of Main Roads require poles to be installed in accordance with Austroads *Guide to Road Design* Part 6 and VicRoads *Road Design Note 06-03A*. These recognize that poles in proximity to the carriageway greatly increase the risk to motorists that lose control of their vehicles and leave the road. Clear zones free of poles are to be maintained adjacent to the carriageway. The width of the zone varies according to the speed, traffic volume and curve radius, as shown in the diagrams overleaf.

If the clearance zone cannot be achieved for some reason, then the following options may be considered:

- Use of an alternative line route, possibly even inside private property
- Acquisition of additional land to widen the road reserve
- Undergrounding of mains
- Installation of safety barriers.

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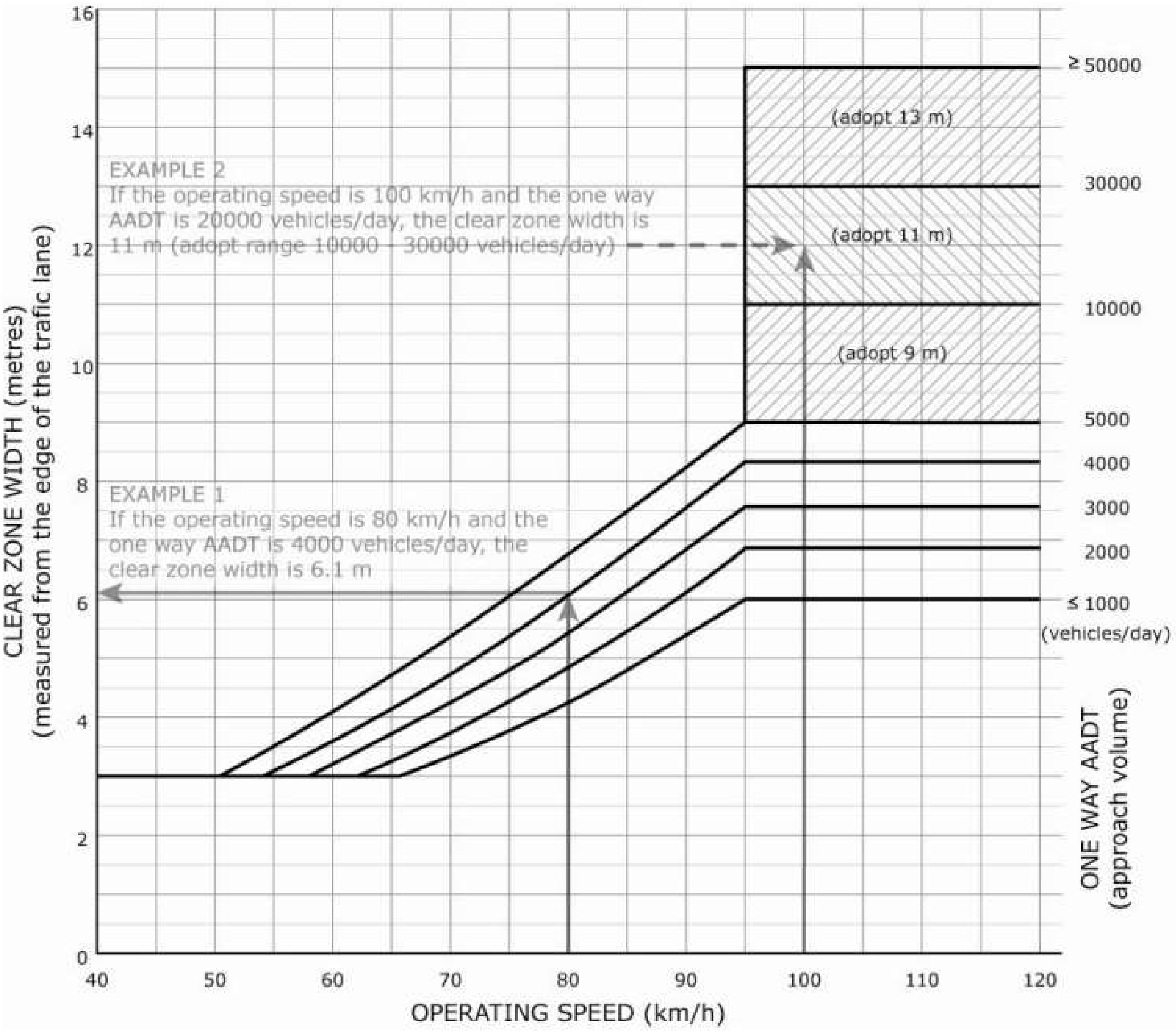
Appendix A: VicRoads Supplement to AGRD Part 6 - Clear Zone Guidelines

Clear zone widths on straights (VicRoads Supplement Figure V4.1)



Adjustment factors for clear zones on curves (Austroads table 4.2)						
Radius (m)	Design speed (km/h)					
	60	70	80	90	100	110
900	1.1	1.1	1.1	1.2	1.2	1.2
700	1.1	1.1	1.2	1.2	1.2	1.3
600	1.1	1.2	1.2	1.2	1.3	1.4
500	1.1	1.2	1.2	1.3	1.3	1.4
450	1.2	1.2	1.3	1.3	1.4	1.5
400	1.2	1.2	1.3	1.3	1.4	-
350	1.2	1.2	1.3	1.4	1.5	-
300	1.2	1.3	1.4	1.5	1.5	-
250	1.3	1.3	1.4	1.5	-	-
200	1.3	1.4	1.5	-	-	-
150	1.4	1.5	-	-	-	-
100	1.5	-	-	-	-	-

6.8 POLE POSITIONING

In general, designers start by positioning poles at the ends and bend points of a line, then position intermediate poles with regard to spanning capability and other considerations such as those in the table below.

CORRECT	WRONG / AVOID
In urban areas, position poles on the footway in line with alternate lot boundaries so that all lots can be serviced and so that there is minimal impact to house frontages. (On large lots, it is not so critical to align poles with lot boundaries.)	Avoid locations that will cause mains or services to cross private property. Also, minimise the number of spans of mains or services crossing roadways.
	Avoid locations that will obstruct views from houses. This is especially important where there is pole-mounted plant.
Straight lines are preferable, both for minimising forces on structures and aesthetically.	Minimise deviation angles.
	Avoid placing poles within 2.0m from existing driveways or so as to block gateways or access tracks on rural properties.
	Avoid switching sides of the road more often than is necessary, particularly if phase transpositions are required,
Keep span lengths reasonably similar if practicable; otherwise strain points will be needed. (Remember 2:1 rule.)	
Coordinate positions with road lighting requirements.	
Position poles so as to minimise vegetation clearing.	
	Avoid locations where they are likely to impede the vision of motorists or where they are likely to be struck by errant vehicles, e.g. on a sharp corner, or the outside radius of a tight curve. Consider installation of barriers or reflectors on poles where unavoidable.
On undulating ground, poles are best placed on the tops of ridges, or on the 'shoulders' either side of a gully.	Avoid placing poles at the bottom of a gully. Not only is this inefficient, it also creates problems with uplift. Also, after heavy rain the gully may become a watercourse and foundation may be jeopardised.
	Avoid placing poles in swampy ground or loose sand where the foundation will be poor.
	Avoid locations close to the top of an embankment where foundation strength may be compromised.
	Avoid placing poles within 2.0m of drains or culverts.
	Avoid locations where excavation is difficult, e.g. on rocky ridges.
Where poles are earthed, ensure adequate clearances from telecommunications earths.	Avoid locations where there are numerous or sensitive underground services, e.g. a congested footpath with a major optical fibre cable.
Ensure good access to poles, especially for poles with switches and other plant.	Avoid locations where access is difficult, e.g. steep embankments, poor quality access tracks, crops, heavy vehicular traffic, median strips, behind locked gates.

6.9 Engineering Notes

6.9.1 Wood Pole Strength

For line design, we are primarily concerned with the tip load capacity of the pole, i.e. its capacity to withstand an overturning bending moment[3]. However, combined bending moment and compressive strength can be a limitation for wood poles supporting very heavy plant items.

The ultimate tip strength or nominal breaking load (kN) of a solid, round wood pole can be taken to be:

$$F_T = \frac{f'_b \, \pi \, D^3 \times 1000}{32\,h}$$

where:

f'_b = characteristic strength in bending – dependent on *AS2209* strength class (MPa) – see table below

D = ground line diameter (m)

h = tip height above ground (m)

AS2209 Strength Groups

STRENGTH GROUP	Nominal Breaking Load (MPa)	
	Bending (Rupture Stress)	Compression
S1	100	75
S2	80	60
S3	65	50
S4	50	40

Hardwood Species Sourced in Tasmania

SPECIES		STRENGTH GROUP		STRESS GRADE		DURABILITY RATING
Brand	Description	Green	Dry	Green	Dry	
MS	Browntop Stringybark *Eucalyptus Obliqua*	S3	SD3	F17	F27	3
AA	Alpine Ash *Eucalyptus delegatensis*	S4	SD4	F14	F22	4
WP	White Peppermint *Eucalyptus pulchella Linearis*	S4	SD4	F14	F22	3
MA	Mountain Ash *Eucalyptus regnans*	S4	SD3	F14	F27	4
BG	Southern Blue Gum *Eucalyptus globulus*	S3	SD2	F17	F27	3
MN	White Gum *Eucalyptus viminalis*	S4	SD4	F14	F22	4
ST	Tasmanian Ironbark *Eucalyptus sieberi*	S3	SD3	F17	F27	3

[3] Bending moment is the product of load and height above the pivot point, which for simplicity can be assumed to be ground line, but in reality is a point at approximately 2/3 of the embedment depth below ground.

TasNetworks applies strength factors of 0.6 and 0.34 to the ultimate strength to determine the maximum wind and sustained load limit states respectively (refer section 2.3.10).

6.9.2 In-Service Wood Poles

Where circuits are altered on existing wood poles causing the tip load to increase by more than, say, 1.0kN sustained or 2.0kN under maximum wind, it is recommended that the pole be inspected above and below ground if it is more than 10 years old.

If significant decay is found internally or externally, then the pole diameter should be measured on an axis aligned with the proposed new resultant tip load direction. Any external decay should be subtracted from the diameter measurement. The ultimate tip load can be calculated using the formula above.

Where an internal hollow is detected of diameter *d*, then the nominal breaking load (kN) may be calculated as follows:

$$F_T = \frac{f'_b \, \pi \, (D^4 - d^4) \times 1000}{32 \, h \, D}$$

Again, strength factors need to be applied to the nominal breaking load to determine the limit state strengths.

A central hollow in a wood pole is not uncommon, particularly as the pole dries out over time and timber shrinkage occurs. However, if only of moderate size, such a hollow has very little effect on pole strength. Conversely, decay of the outer fibres on the timber in the pole results in a significant loss of strength.

6.9.3 Stobie Pole Strength

Limit State strengths for Stobie poles have been derived by scaling up the previous Working Stress strengths by a factor of 2.17. The WS strengths are given in TasNetworks drawing D-OH1-3.1/17, as well as in the HECT *Overhead Line Design & Construction Manual* drawing M0291. According to drawing M0291, these poles were designed for a maximum working stress of 103.5MPa. The rolled steel, being an imperial size, is likely to be 250MPa grade. For limit state design, the maximum allowable stress has been increased to 225MPa, i.e. 90% of 250MPa, in accordance with *AS/NZS7000:2016* section K2.

Pole tip strengths (for resisting overturning moment) can be calculated from first principles using the formulas below. This method relies entirely on the steel elements and ignores any contribution from the concrete in-fill.

$$F_S = f_y \, A \, d \, / \, h$$

$$F_W = 2 \, Z_x \, F_S \, / \, h$$

where:

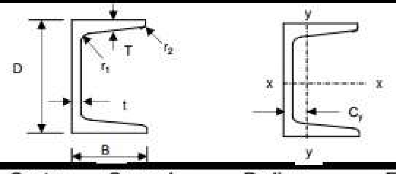
F_S = tip strength in strong direction (N)
F_W = tip strength in weak direction (N)
f_y = allowable stress (MPa)
A = cross-sectional area of steel member (mm^2)

d = distance between centre-lines of steel members at ground line (m)
h = tip height (m)
Z_x = section modulus of steel member (mm^3)

Steel section details and pole properties are shown in the tables below.

CHANNELS

Tapered Flange



Imperial

Designation Size	Mass Per Metre	Thickness Web	Thickness Flange	Root Radius	Toe Radius	Area Of Section	Centre Of Gravity	Second moment Of Area		Radius Of Gyration		Elastic Modulus	
DxB		t	T	r_1	r_2	A	C_y	I_x	I_y	r_x	r_y	Z_x	Z_y
mm	kg/m	mm	mm	mm	mm	cm^2	cm	cm^4	cm^4	cm	cm	cm^3	cm^4
102x51(4 x 2)	10.42	6.1	7.6	9.1	2.4	13.3	1.51	207	29.0	3.95	1.48	40.8	8.14
127x64 (5 x 21/2)	14.90	6.4	9.2	10.7	2.4	19.0	1.94	483	67.2	5.04	1.88	76.0	15.3
152x76 (6 x 3)	17.88	6.4	9.0	12.2	2.4	22.8	2.21	852	114	6.12	2.24	112	21.1

MARK No.	POLE LENGTH (m)	STEEL SECTION (mm)	Sunk (m)	Tip Height (m)	Width at Bend 1.525m from butt (mm)	GL Width (mm)	Approx. Steel CL spacing 'd' (mm)	'A' (mm^2)
1	9	102x51	1.60	7.4	370	368	338	1330
3	9	127x64	1.70	7.3	370	366	327	1900
7	10.5	127x64	1.70	8.8	405	401	362	1900
11	10.5	152x76	1.80	8.7	405	399	349	2280
16	12	152x76	2.00	10.0	440	429	385	2280
20	13	152x76	2.00	11.0	460	449	405	2280

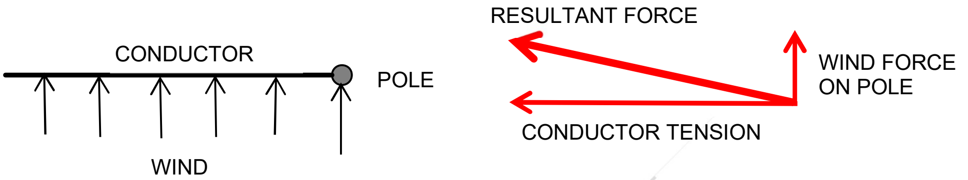
6.9.4 Sizing of Poles that are Stayed

The question frequently arises as to what strength to select for a pole that is stayed. Where practicable, it is recommended that new poles be sized to be able to carry at least one half of the applied load. This will not always be achievable but provides a useful guide. A ground stay exerts significant compressive load on a pole, so the pole should not be of a size that could readily buckle.

6.9.5 Wind Loading on Poles

The tip load contribution due to wind force on the pole itself, along with crossarms and insulators, can be obtained from the pole tables in sections 6.2 and 6.3 for wood poles. These values are calculated by multiplying the wind pressure on the pole (1.2kPa for round wood poles) by the projected area of the pole and then applying a factor of 0.5 since, the centre of pressure is halfway up the pole, not at the tip. The area is taken to be the product of tip height (assuming min. sinking) and ground-line diameter for an S4 grade wood pole. No account of the pole taper is made, assuming this reduction in width is offset by the area of the crossarms and insulators.

The load factor for the self-windage of the pole is 1.0 and can therefore be ignored. Once again, the force due to pole windage needs to be added vectorially to the forces applied by the conductors to determine the total load on the pole, as illustrated below for a dead end (termination) pole.



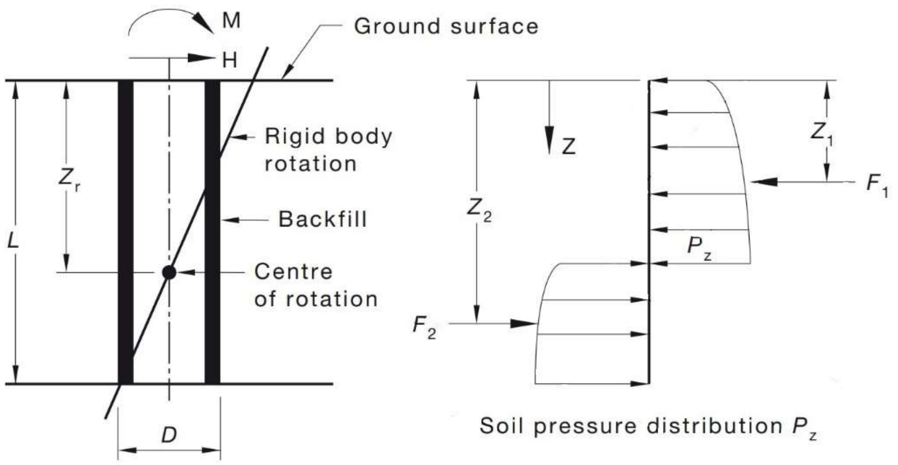
For Stobie poles, with flat surfaces, a wind pressure of 1.5kPa has been used to calculate wind forces on the pole. On the wide face, the pole tapers from approximately 400mm at the base (depending upon the Mark No.) to 203mm at the tip. A multiplier of 1.1 has been applied to allow for wind forces on crossarms and insulators.

6.9.6 Plant Loads

Plant loads are primarily downloads on poles; they usually only make a small contribution to overturning moment or tip load since the plant is close to the pole and the 'lever arm' is very short. Also, the centre of pressure for any wind loading is somewhat below the tip. In TasNetworks, the heaviest pole size available for the length should be selected where there are transformers of 100kV.A or above, regulators or reclosers, which addresses the applied download. Therefore, In TasNetworks, calculation of the contribution of pole-mounted plant to pole tip loading is not mandatory. Section 2.2.2 gives the wind pressure to be used where such calculations are undertaken: 1.5kPa.

6.9.7 Foundations

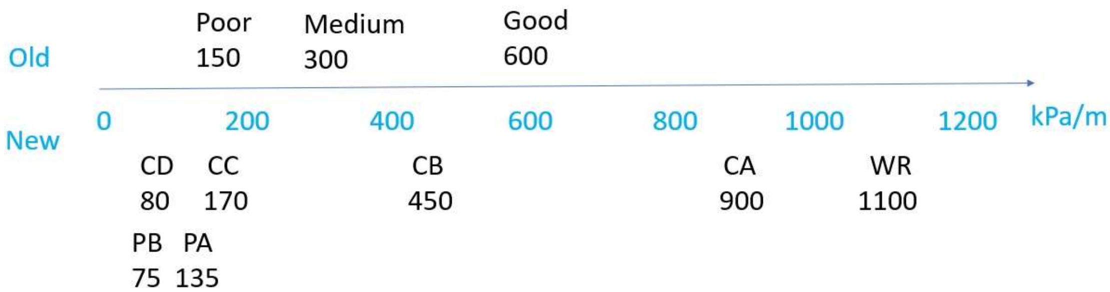
Most distribution pole foundations are a bored pier type. The diagram below shows the overturning moment, M, any shear force applied, H, and the soil passive reactions and pressure distribution with depth. The bearing forces of the soil on the pole butt need to be strong enough to resist the overturning moment.



The larger the projected area of the butt, the greater the footing strength. Use of imported materials to enhance the foundation strength such as road base or concrete increase the effective width of the butt.

Details of foundation strength calculation methods may be found in *AS/NZS7000:2016* Appendix L and *HB331:2020* section 10. The Brinch Hansen method has been used by TasNetworks, but with a comparatively high soil strength factor of 0.8, even for empirical assessment of soil (i.e. without geotechnical testing). This is higher than the 0.5 value normally used for natural, untested materials so that results are not unduly onerous and are comparable with other calculation methods widely used in distribution network design.

For a rough comparison with the previous bearing pressure method described in ESAA document C(b)1 1991 and used in the legacy manual, the *approximate* bearing pressures in kPa/m corresponding with the soil types given in section 6.5.2 are as shown below.



6.10 WORKED EXAMPLES

Example 1 Urban LV Termination (Dead End) Pole in Hard Clay Ground

A 50m span of 4C 95mm^2 LVABC strung at 6%NBL (urban) terminates on a pole, applying the following mechanical load:

3.51kN Sustained Load (with application of 1.1 load factor)
9.96kN Max. Wind Load (with application of 1.25 load factor)

The ground may be classified as hard clay.

Select a suitable pole and foundation and determine if a stay is required.

From section 6.1.2 we note that an 11m pole is normally used for LV mains.

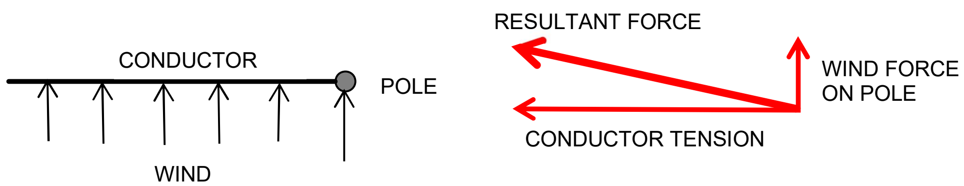
We are hopeful that we can avoid a stay. We now refer to the wood pole table in section 6.2.1. Let us select a 6kN Working Strength / 25kN Nominal Breaking Load pole and see if it is adequate. This is one size up from the 4kN/17kN size that we would use for an intermediate pole.

LENGTH (m)	TIP STRENGTH (kN)				S3 Grade Timber		S4 Grade Timber		Approx. Dry Mass (kg)	Nom. Windage Resolved to Tip (kN)
	Nominal Working Stress	Nominal Breaking Load	No Wind (Sustained) Limit State	Max. Wind Limit State	Min. Dia. Tip (mm)	Min. Dia. 2m from butt (mm)	Min. Dia. Tip (mm)	Min. Dia. 2m from butt (mm)		
9.5	4	17	6	10	209	280	234	305	554	1.45
	6	25	9	15	249	320	279	350	746	1.62
	8	33	12	20	279	350	314	385	916	1.78
	4	17	6	10	208	293	236	320	681	1.79
11.0	6	25	9	15	251	335	286	370	937	2.04
	8	33	12	20	286	370	321	405	1142	2.24

We note that this 11/6/25 pole has a No Wind LS strength of 9kN, well above the applied load of 3.19kN.

It has a Max. Wind LS strength of 15kN. Now the applied Max. Wind. Conductor load is 9.96kN, and there is also the tip load contribution of 2.04kN due to wind on the pole itself. If we were to simply add these two loads arithmetically, we would have a total tip load of 12.00kN, which is less than the 15kN capacity, so this pole is able to take the applied load without the need for a stay.

Since the worst-case wind direction is perpendicular to the conductor span, the force on the pole will be perpendicular to the force applied by the conductor, as shown below. Adding the two vectorially, we have a Total Max. Wind. Tip Load of 10.17kN. This is well within the 15kN capacity of the pole.



Since we are well within the capacity of the selected pole, the question arises as to whether we could drop down a size, i.e. to a 11m/4kN/17kN pole. This smaller pole has a Max. Wind LS strength of 10.0kN, which is less than the applied tip load of 10.11kN (the pole windage reduces slightly with the thinner pole), so it could not be used (without staying). Also, given it is a dead end or termination pole, it is better to stay with the heavier size.

We will now consider the foundation. The soil is good and can be classified as "CA". We note that we can match the foundation strength to the pole strength if we use a sinking depth of 1.85m, just a little more than the minimum sinking depth of 1.80m, even using natural backfill – see section 6.6.3 – so we will take this option as one that minimises costs of materials, has adequate strength and does not require an extra deep or extra wide bore.

6.6.3 Sinking Depths to match Pole Strength –

Wood Pole Length (m)	Strength WS/NBL (kN)	Max. Wind Load (kN)	Min. Sink Depth (m)	Rock		
				WR Weak / Weathered	CA Hard	
				NB	NB	EB
9.5	4/17	10	1.55	1.55	1.55	1.55
	6/25	15	1.65	1.65	1.75	1.65
	8/33	20	1.80	1.80	1.90	1.80
11	4/17	10	1.70	1.70	1.70	1.70
	6/25	15	1.80	1.80	1.85	1.80
	8/33	20	1.80	1.80	2.00	1.80

Example 2 Rural 11kV Intermediate Angle Pole in Dense Sand

An 11kV pole is to be installed in a rural area on a 10° bend in the road. The 3-phase mains are MERCURY conductor strung at medium tension (18% NBL) and the spans are 120m long, applying the following mechanical load:

1.94kN Sustained Load (with application of 1.1 load factor)
10.69kN Max. Wind Load (with application of 1.25 load factor)

There are no immediate prospects for installing LV mains under the 11kV mains in this location.

The soil may be classified as loose, coarse, dry sand, not cohesive.

Select a suitable pole and foundation and determine if a stay is required.

From section 6.1.2 we note that a 12.5m pole is normally used for 11kV mains.

We are hopeful that we can avoid a stay. We now refer to the wood pole table in section 6.2.1. Let us first try a 4kN/17kN size.

LENGTH (m)	TIP STRENGTH (kN)				S3 Grade Timber		S4 Grade Timber		Approx. Dry Mass (kg)	Nom. Windage Resolved to Tip (kN)
	Nominal Working Stress	Nominal Breaking Load	No Wind (Sustained) Limit State	Max. Wind Limit State	Min. Dia. Tip (mm)	Min. Dia. 2m from butt (mm)	Min. Dia. Tip (mm)	Min. Dia. 2m from butt (mm)		
9.5	4	17	6	10	209	280	234	305	554	1.45
	6	25	9	15	249	320	279	350	746	1.62
	8	33	12	20	279	350	314	385	916	1.78
11.0	4	17	6	10	208	293	236	320	681	1.79
	6	25	9	15	251	335	286	370	937	2.04
	8	33	12	20	286	370	321	405	1142	2.24
12.5	4	17	6	10	215	310	245	340	853	2.17
	6	25	9	15	260	355	280	385	1094	2.46
	8	33	12	20	295	390	330	425	1400	2.72

We note that this pole has a maximum wind LS strength of 10.0kN. This will be insufficient. The conductor loading alone is 10.69kN, and then we have the wind load of the pole itself. Therefore, we jump up one size, to a 6kN/25kN rating.

LENGTH (m)	TIP STRENGTH (kN)				S3 Grade Timber		S4 Grade Timber		Approx. Dry Mass (kg)	Nom. Windage Resolved to Tip (kN)
	Nominal Working Stress	Nominal Breaking Load	No Wind (Sustained) Limit State	Max. Wind Limit State	Min. Dia. Tip (mm)	Min. Dia. 2m from butt (mm)	Min. Dia. Tip (mm)	Min. Dia. 2m from butt (mm)		
9.5	4	17	6	10	209	280	234	305	554	1.45
	6	25	9	15	249	320	279	350	746	1.62
	8	33	12	20	279	350	314	385	916	1.78
11.0	4	17	6	10	208	293	236	320	681	1.79
	6	25	9	15	251	335	286	370	937	2.04
	8	33	12	20	286	370	321	405	1142	2.24
12.5	4	17	6	10	215	310	245	340	853	2.17
	6	25	9	15	260	355	280	385	1094	2.46
	8	33	12	20	295	390	330	425	1400	2.72

This pole has a maximum wind LS strength of 15.0kN. Now the applied tip load will be 10.69kN from the conductors plus 2.46kN tip load due to wind force on the pole. Since these two elements are in the same direction for this pole configuration, we can add them arithmetically, i.e. a total of 13.15kN, which falls within the capacity of the pole. We also check that the 1.94kN sustained load is within the 9kN No Wind LS capacity of the pole.

The dense sand soil may be classified as 'PB'. Firstly, we refer to section 6.6.3 to see if it is possible and practicable to match our foundation depth to the full strength of the pole.

6.6.3 Sinking Depths to match Pole Strength – New Wood Pole Sizes

Wood Pole Length (m)	Strength WS/NBL (kN)	Max. Wind Load (kN)	Min. Sink Depth (m)	Rock	Cohesive Soils e.g. Clayey Soils										Particulated (Non-Cohesive) Soils e.g. Sand, Gravel			
				WR Weak / Weathered	CA Hard		CB Stiff to Very Stiff			CC Firm			CD Soft	PA Dense			PB Loose to Very Loose
				NB	NB	EB	NB	EB	EBW	NB	EB	EBW	EBW	NB	EB	EBW	EBW
9.5	4/17	10	1.55	1.55	1.55	1.55	1.70	1.55	1.55	2.55	2.20	2.00	2.80	2.45	2.25	2.15	2.60
	6/25	15	1.65	1.65	1.75	1.65	1.95	1.70	1.65	2.95	2.60	2.35	3.25	2.70	2.50	2.40	2.90
	8/33	20	1.80	1.80	1.90	1.80	2.10	1.90	1.80	3.25	2.85	2.60	3.60	2.90	2.70	2.55	3.10
11	4/17	10	1.70	1.70	1.70	1.70	1.75	1.70	1.70	2.70	2.35	2.15	2.95	2.55	2.35	2.25	2.70
	6/25	15	1.80	1.80	1.85	1.80	2.00	1.80	1.80	3.10	2.70	2.50	3.45	2.80	2.60	2.45	3.00
	8/33	20	1.80	1.80	2.00	1.80	2.20	2.00	1.80	3.35	3.00	2.75	3.80	3.00	2.80	2.65	3.25
12.5	4/17	10	1.85	1.85	1.85	1.85	1.85	1.85	1.85	2.85	2.45	2.25	3.10	2.65	2.45	2.30	2.80
	6/25	15		1.85	1.85	1.85	2.10	1.85	1.85	3.20	2.85	2.60	3.60	2.90	2.70	2.55	3.10
	8/33	20		1.85	1.85	1.85	2.30	2.05	1.90	3.50	3.15	2.90	4.00	3.10	2.90	2.75	3.35
14	4/17	10	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.95	2.60	2.35	3.25	2.70	2.50	2.35	2.90

We see that we need a depth of 3.10m with an 'EBW' foundation (imported backfill, extra wide bore), which depth may well be excessive and impractical.

For comparison, we check table 6.6.7, which gives foundation strengths for a sinking depth of 2.75m (min. sink + 900mm). This slightly shallower 'EBW' foundation has a strength of just 10.29kN, which is insufficient to cater for the applied load on the pole.

Should we wish to avoid a foundation of 3.1m depth, our options are to:

- fit a stay to the pole
- reduce stringing tension on the line and shorten the span lengths
- have a special foundation designed.

SECTION 7 – STAYS

Version: 3.3

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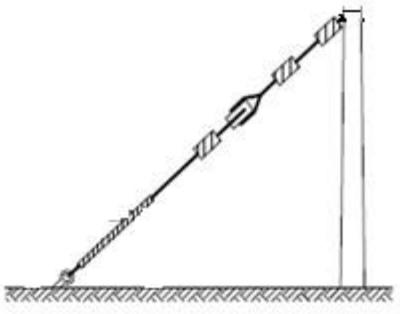
SECTION 7 -STAYS

7.1 STAY TYPE SELECTION

Do not install stays unnecessarily. For example, it is usually better to specify a heavy, unstayed pole than a light, stayed pole. Stays can be a hazard in areas of high pedestrian traffic, areas where trucks are reversing, in corridors where motor bikes ride, in flood-prone areas, in land used to grow crops or holding yards for cattle or horses.



Ground stay

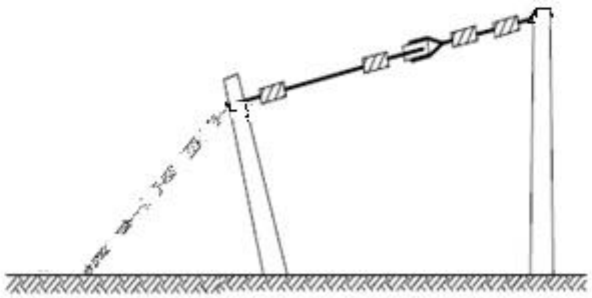
Used for most applications.

Fit guard for stays where likely to cause injuries to pedestrians, cattle, horses or other large animals.

Vertical (sidewalk) stay

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

Not suitable for poles with operating platforms or transformers.



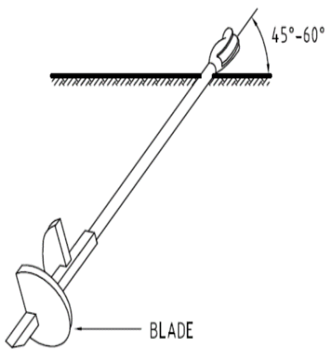
Aerial (pole) stay

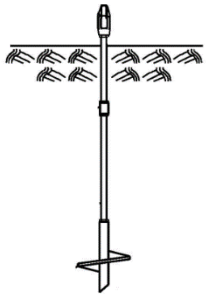
Used where a ground stay is unsuitable e.g. crossing a roadway. In most cases, the stay pole will need to be supported with a ground stay.

7.2 GROUND ANCHOR SELECTION

SCREW ANCHORS

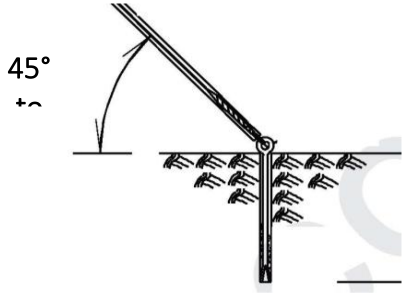
Used for most soil types

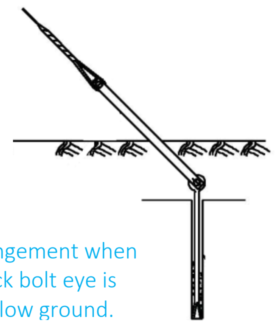




ROCK ANCHORS

Used in bedrock / where anchors cannot be driven to the required depth

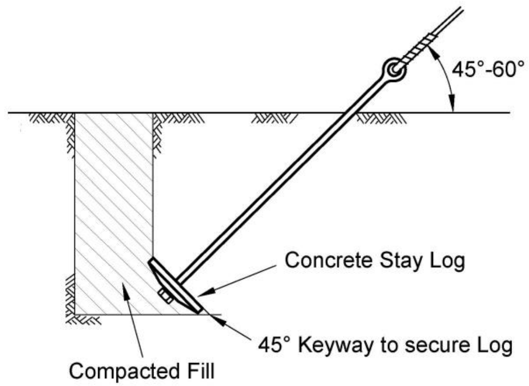


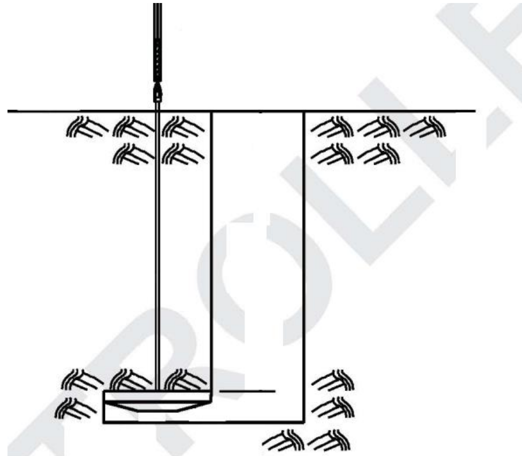


Arrangement when rock bolt eye is below ground.

BLOCK ANCHORS

Used for very loose or swampy ground





7.3 STAY FORCES

7.3.1 Stay Force Calculation

Stays should be designed to take the *full tip load* applied to the pole that needs support, not just the amount of force by which the pole strength is exceeded. This is because load is not shared effectively between the pole and the stay – the pole can flex but the stay is fixed and must immediately pick up the full load. Capacity checks for stay components need only be undertaken for the maximum limit state load, not the sustained load condition.

7.3.2 Aerial Stay Wire Tension

For an aerial stay that is reasonably level and attached near the tip of a pole, the maximum tension in the stay wire is approximately equal to the maximum tip load of the pole.

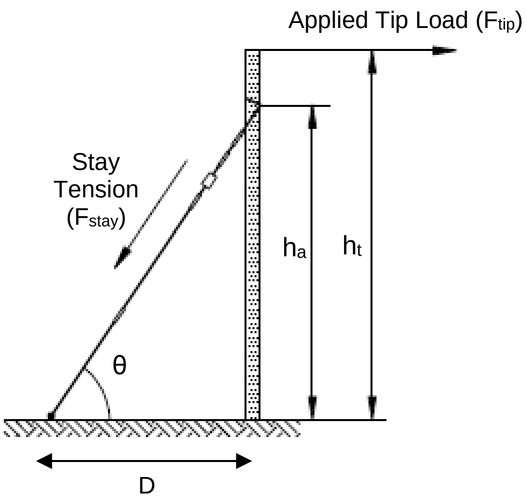
Where the stay is attached significantly below the tip, then the stay load may be calculated as follows:

$$F_{stay} = F_{tip} \quad h_t / h_a$$

where:

F_{stay} = Stay wire tension (kN)
F_{tip} = Applied tip load (kN)
h_a = Stay attachment height above ground (m)
h_t = Pole tip height above ground (m)

7.3.3 Ground Stay Wire Tension



Stay wire load is affected by:

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

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

where:

F_{stay}	=	Stay wire tension (kN)
F_{tip}	=	Applied tip load (kN)
θ	=	Angle of stay to the ground
h_a	=	Stay attachment height above ground (m)
h_t	=	Pole tip height above ground (m)
D	=	Distance between stay anchor and pole (m)

$D = h_a \tan\theta$

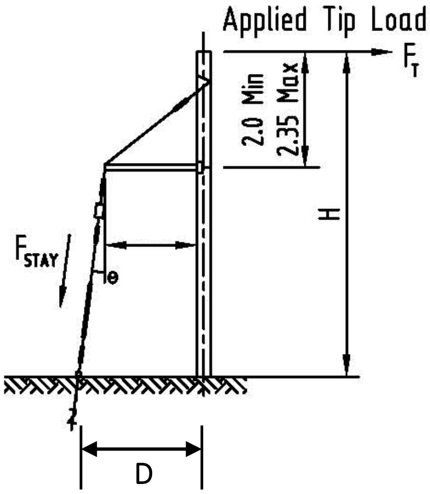
θ		45°	50°	55°	60°
F_{stay} / F_{tip}	stay attached near tip	1.41	1.56	1.74	2.00
	stay attached at 90% of tip height	1.57	1.73	1.94	2.22
	stay attached at 80% of tip height	1.77	1.94	2.18	2.50

	h_a	**θ**			
	Stay Attachment Height	45°	50°	55°	60°
D Distance Stay to Pole centre	13.0	13.0	10.9	9.1	7.5
	12.0	12.0	10.1	8.4	6.9
	11.0	11.0	9.23	7.7	6.4
	10.0	10.0	8.4	7.0	5.8
	9.0	9.0	7.6	6.3	5.2
	8.0	8.0	6.7	5.6	4.6
	7.0	7.0	5.9	4.9	4.0
	6.0	6.0	5.0	4.2	3.5

7.3.4 Vertical Stay Wire Tension

The following assumes an outrigger arm length of approximately 2.15m. The larger the distance between the stay anchor and the pole, the more effective is the stay. The force carried by the stay wire is several times that of the tip load as given by the following equation:

$$F_{STAY} = \frac{F_T \cdot H}{D \cdot \cos \theta}$$



where:

- F_{stay} = Stay wire tension (kN)
- F_t = Applied tip load (kN)
- θ = Angle of stay from vertical
- H = Pole tip height above ground (m)
- D = Distance from stay anchor to pole (m) is approx. equal to:

$$(H - 2.15) \tan \theta + 2.3$$

POLE LENGTH (m)	NOM. TIP HEIGHT (m)	θ	0°	5°	10°	15°	20°
9.5	7.7	D (m)	2.30	2.79	3.28	3.79	4.32
		F_{stay} / F_t	3.35	2.77	2.38	2.10	1.90
11	9.2	D (m)	2.30	2.92	3.54	4.19	4.87
		F_{stay} / F_t	4.00	3.17	2.64	2.27	2.01
12.5	10.65	D (m)	2.30	3.04	3.80	4.58	5.39
		F_{stay} / F_t	4.63	3.51	2.85	2.41	2.10
14	12.0	D (m)	2.30	3.16	4.04	4.94	5.89
		F_{stay} / F_t	5.22	3.81	3.02	2.52	2.17
15.5	13.35	D (m)	2.30	3.28	4.27	5.30	6.38
		F_{stay} / F_t	5.80	4.09	3.17	2.61	2.23

7.4 STAY COMPONENT STRENGTHS

The limit state strength of a stay is determined by the least value of the strength of the individual components:

- Stay wire
- Stay insulator
- Bolt/s through pole
- Anchor rod
- Anchor + foundation

Note that the force on a ground stay or vertical stay is greater than the tip load applied to the pole and depends upon the angle of the stay wire to the ground – refer previous section.

STAY WIRE

Steel Stay wire	Minimum breaking Load (kN)	Strength Factor	Maximum Design Tension (kN)
7/2.75[A]	51.8	0.8	41.4
19/2.00	74.4	0.8	59.5
19/2.75[B]	140.6	0.8	112.4

A: Obsolete wire size shown for reference purposes only – not for use on new installations.
B: Wire size not a current stock item—shown for reference purposes only – not for use on new installations.

STAY INSULATOR

Insulator Type	Minimum Failing Load (kN)	Strength Factor	Limit State Strength (kN)
Disc	70	0.8	56
Guy GY2[A]	70	0.8	56
Guy GY3	220	0.8	176
Fibreglass Long Rod [B]	220	0.8	176

A: Obsolete insulator size shown for reference purposes only – not for use on new installations.
B: Insulator type not a current stock item—shown for reference purposes only – not for use on new installations.

BOLT / ANCHOR ROD

Bolt/Rod Type	Bolt Diameter	Ultimate Strength (kN)	Strength Factor	Limit State Strength (kN)
Eyebolt through wood pole	M20	98 (UTS)	0.8	78.4
Stay Rod for block anchors or screw anchors	M20	98 (UTS)	0.8	78.4
Stay Rod on rock anchors	M24	141 (UTS)	0.8	112.8
Attachment to Stobie poles via two crossarm straps	M16	72 (Shear strength, threaded section, x 2)	0.8	57.6

Refer also Section 7.6 for bolts subject to combined shear and tension.

SCREW ANCHOR + FOUNDATION STRENGTH

Where practicable, select an anchor type with a strength equal to or better than the stay wire strength.
Information shown below is taken from a Dulmison catalogue.
Designers should nominate screw anchor size and installation torque on the works plan.

No. OF BLADES	BLADE DIAMETER	TYP. USE	ELEMENT	GOOD SOIL		MEDIUM SOIL		POOR SOIL	
				2	3	4	5	6	7
1 SINGLE	200mm	GOOD SOIL	LS Strength (kN)	115	95	80	60	45	25
			Install Torque (N.m)	7600	5600	3700	2300	1300	400
	300mm	POOR SOIL	LS Strength (kN)	-	115	95	80	60	40
			Install Torque (N.m)	-	6800	4400	3100	1750	800

Soil classification

<table>
<tr><th>Soil Category</th><th>Soil Class</th><th>Description</th><th colspan="3">Soil Class as per pole foundations</th><th>Anchor Type to be used</th></tr>
<tr><td rowspan="3">Good</td><td>1</td><td>Solid bedrock</td><td></td><td></td><td></td><td>ROCK ANCHOR</td></tr>
<tr><td>2</td><td>Hardpan; dense fine sand; compact gravel; laminated rock; slate schist; sandstone</td><td>WR</td><td>CA</td><td rowspan="4">PA</td><td rowspan="6">SCREW ANCHOR</td></tr>
<tr><td>3</td><td>Hard clay; dense sand; shale; broken bedrock; compact clay-gravel mixtures</td><td rowspan="5"></td><td rowspan="3">CB</td></tr>
<tr><td rowspan="2">Medium</td><td>4</td><td>Medium dense sand gravel mix; very stiff to hard clays and silts</td></tr>
<tr><td>5</td><td>Medium dense coarse sand or sandy gravel; stiff to very stiff silts and clays</td></tr>
<tr><td rowspan="3">Poor</td><td>6</td><td>Loose to medium dense sand; firm to stiff clays and silts</td><td rowspan="2">CC</td><td rowspan="3">PB</td></tr>
<tr><td>7</td><td>Medium stiff clay; loose sand; fill; silt</td></tr>
<tr><td>8</td><td>Soft clay; very loose sand; swampy ground; humus; saturated silt</td><td></td><td>CD</td><td>BLOCK ANCHOR</td></tr>
</table>

Note: When the sustained load on the screw anchor exceeds 50% of the maximum wind load, there is a possibility that the anchor may creep. Even though there is no failure of the anchor in the ground, this may lead to relaxation of the guy and necessitate periodic retensioning. To avoid this, apply a strength derating factor to the anchor strengths listed in the table above, as shown below.

No Wind Load / Max. Wind Load	Screw Anchor Strength De-Rating Factor
≤0.5	1.0
0.5 – 0.6	0.87
0.6 – 0.7	0.77
0.7 – 0.8	0.65
0.8 – 0.9	0.63
0.9 – 1.0	0.57

BLOCK ANCHOR + FOUNDATION STRENGTH

The strengths shown below apply to 1200mm x 350mm polymeric composite anchor blocks. For 700mm x 350mm concrete block anchors, the strength is 7/12 of that for polymeric composite blocks shown below.

ANCHOR ROD	DEPTH (mm)	LIMIT STATE CAPACITY (kN)		
		POOR SOIL	AVERAGE SOIL	GOOD SOIL
M20 x 2100	1400	22	36	42
M24 x 3000[A]	1800	26	50	70
M24 x 4000[A]	2400	30	70	114*

A: Not a current stock item—shown for reference purposes only – not for use on new installations.

*Anchor rod limitation governs.

ROCK ANCHOR + FOUNDATION STRENGTH

ANCHOR ROD	LIMIT STATE CAPACITY (kN)	
	VERTICAL	INCLINED
M24 x 600	76	76
M24 x 1200[A]	114*	114*
M24 x 1800[A]	114*	114*

A: Not a current stock item—shown for reference purposes only – not for use on new installations.

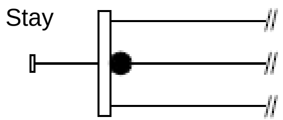
*Anchor rod limitation governs.

STAY CAPACITY

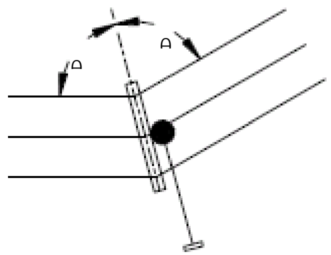
POLE TYPE	BOLT SIZE	STAY ANGLE TO THE HORIZONTAL			
		45°	50°	55°	60°
		kN	kN	kN	kN
Hardwood	M16	23.6	21.8	20.4	19.3
	M20	36.9	34.1	31.9	30.1
Softwood	M16	19.1	17.6	16.5	15.6
	M20	29.7	27.4	25.6	24.2
TITAN 24kN ULS Substation / equipment pole	M16	25.8	25.3	25.0	24.9
	M20	31.9	29.5	27.6	26.1
TITAN STD 24kN ULS	M16	25.8	25.3	23.8	22.5
	M20	27.6	25.5	23.8	22.5
TITAN STD 16kN ULS	M16	16.0	14.8	13.8	13.0
	M20	16.0	14.8	13.8	13.0

7.5 STAY POSITIONING

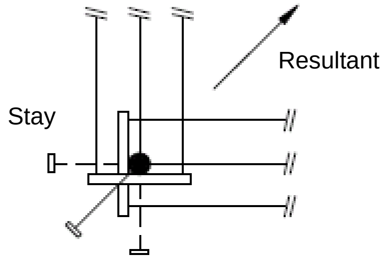
SINGLE STAY



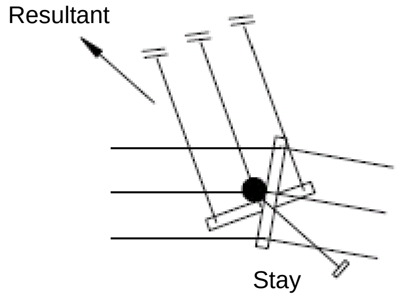
TERMINATION POLE
Stay opposite attached circuit.



LINE DEVIATION POLE
Stay opposite bisector of deviation angle.

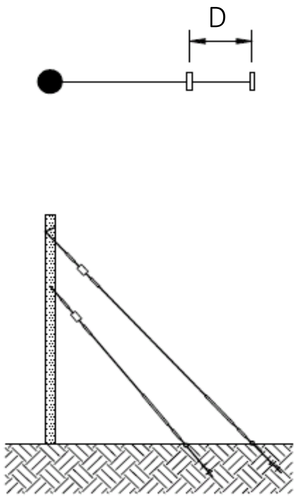


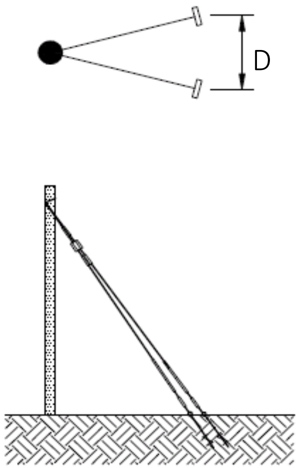
CORNER OR HEAVY DEVIATION ANGLE
Use either a single stay opposite resultant force direction or two stays – one opposite each circuit (advantages for construction).

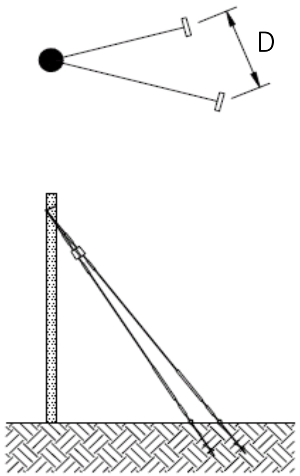


COMPLEX POLE
Stay opposite resultant

DUAL STAY



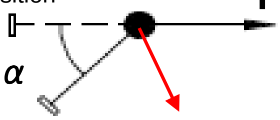




Dual stays are used where required stay tension exceeds the capacity of a single stay. As a general rule, ‘D’ should be greater than 2.0m for screw anchors.

Ensure that any guard rails are not positioned close to a fence in a way that could cause stock to become entrapped or injured.

STAY POSITIONING – OFFSET FROM IDEAL POSITION



At times it is necessary to offset a stay from the ideal orientation to get clear an obstacle such as a tree, drain or underground utility. An angle of up to 35°, say, may be used provided the pole has sufficient strength. The combined effect of the forces applied by conductors, F_C, and the passive reaction of the stay, F_{SC}, can be calculated as follows:

$$F_{SC} = F_C \sin \alpha$$

α	5°	10°	15°	20°	25°	30°	35°
sin α	0.087	0.174	0.259	0.342	0.423	0.500	0.574

where α is the offset angle of the stay from the ideal position opposite F_C

The total resultant force on the pole is then:

$$\overline{F_{TOTAL}} = \overline{F_{SC}} + \overline{F_{WP}}$$

where F_{WP} is the wind force on the pole resolved to the tip.

The total resultant force should not exceed the capacity of the pole - refer section 6.2.

7.6 ENGINEERING BACKGROUND

Stays apply a passive resistance that is equal in magnitude and opposite in direction to any force applied to the pole in the line of the stay.

Designers may find it necessary to alert construction crews to the need for temporary stays on strain poles while construction is in progress, prior to all conductors being erected and correctly tensioned.

Hex Bolt Strengths

These are unlikely to be the limiting factor in a stay assembly, but details are provided for completeness.

BOLT DIAMETER	GRADE	RATED STRENGTH (kN) Prior to application of strength factor		
		N_{TF} Ultimate Tensile Strength	V_{SF} (shank) Shear Strength	V_{SF} (thread) Shear Strength
M16	4.6 (std)	62.8	50	36
	8.8 (high)	125.6	101	72
M20	4.6 (std)	98	79	56
	8.8 (high)	203	163	117
M24	4.6 (std)	141	113	81
	8.8 (high)	293	235	168

Grade 4.6 bolts are standard bolts with 400N/mm^2 tensile strength and a proof strength (the point where inelastic deformation may occur) that is 0.6 of the ultimate strength. Grade 8.8 bolts are tempered bolts with 800N/mm^2 tensile strength and a proof strength that is 0.8 of the ultimate strength.

For bolts subject to combined tensile (N^*_{TF}) and shear (V^*_{SF}) forces, the following relationship must be satisfied:

$(V^*_{SF} / \Phi V_{SF}) + (N^*_{TF} / \Phi N_{TF}) \leq 1$ where Φ (Strength factor or Capacity factor) = 0.8 as per section 2.3.10.

7.7 WORKED EXAMPLES

Example 1 Ground Stay for a LV Termination (Dead-End) Pole in Firm Clay Soil

A 100m span of 4C 95mm^2 LVABC terminates on a Pole. The stringing tension is to be Limited, i.e. 10% NBL. The soil can be described as firm clay/sand mix, and as the surrounding terrain is flat, drainage is average. Select pole size, foundation and ground stay as required. There are no constraints affecting the location of the stay anchor.

Firstly, we need to determine the tip load on the pole. From section 5.9.9, we find that the LVABC mains apply a tip load of 5.85kN No Wind LS and 16.71kN Max. Wind LS. The wind force on the pole will be at right angles to the conductor tension force, so the effect on Max. Wind LS load will be very slight and we will ignore it for now.

Since it is a LV pole, we would normally select a length of 11m. However, according to section 5.9.6, the sag in the span at 75°C is 3.95m and we can see that we will need additional height once we allow for embedment in the ground and maintaining minimum ground clearance. Therefore, we select a 12.5m pole. Since it is a termination on a long span of fairly heavy cable, we try the heaviest pole size, 8kN Working Stress or 33kN Nom. Breaking Load. According to section 6.2, this size pole has a No Wind capacity of 12kN and a Max. Wind capacity of 20kN.

Since the capacity of the pole is greater than the applied load for both No Wind and Max. Wind conditions, it seems that we have selected a pole that does not need staying, which is ideal. However, we have yet to consider the pole foundation strength. The soil can be classified as "CC" according to the table in section 6.5.2.

If we were to match foundation strength to pole strength, which we do where practicable, we would need a sinking depth of at least 3.55m according to section 6.5.3. This is impractical. If we used 3.05m embedment (min. sink of 1.85m + 1.2m), we could only achieve a Max. Wind strength of 14.15kN at best, which is insufficient for the applied load. Therefore, we will need to fit a stay to the pole after all.

We will try an EBW foundation and sinking depth of 1.85m + 0.6m = 2.45m, with a strength of 8.50kN according to section 6.5.6. This just complies with the rule-of-thumb suggested in section 6.8.3 that the unstayed pole be able to withstand 50% of the applied load where practicable. The height of the pole tip is 10.05m. We again check that we have adequate ground clearance on the LVABC mains.

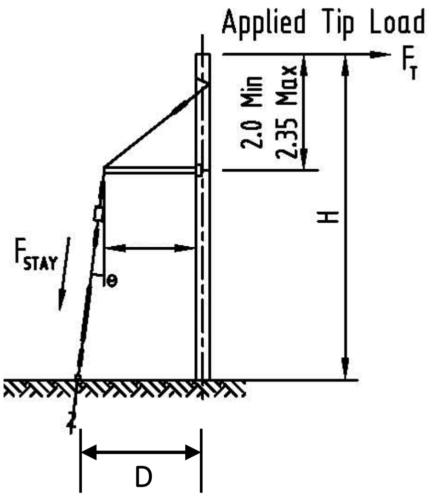
We nominate a regular ground stay with an angle to the ground of 45°. The Max. Wind force on the stay will be the tip load, 16.71kN, divided by the cosine of 45°, i.e. 23.63kN. This does not exceed the capacity of the 19/2.00 steel stay wire, insulators, eye bolt or stay rod.

We will use a screw anchor, a single blade type of 300mm diameter. If we take the soil to be soil class 6 as per section 7.3, then this anchor will have a capacity of 60kN – there is no need to apply a derating factor to this as the No Wind Load is less than 50% of the Max. Wind Load. We nominate an installation torque of 1750N.m.

If we assume the stay attaches at a point 300mm below the tip, then the anchor should be installed at a distance of 9.75m from the pole base.

Example 2 Vertical Stay for a LV Termination (Dead-End) Pole in Firm Clay Soil

As per Example 1, but this time the pole is located 4.5m away from the property boundary and a vertical stay must be used instead of a ground stay.



We have a space of only 4.5m from the property boundary to the pole, and so we will assume we only have 4.2m from the pole centre to the screw anchor centre, leaving a margin of 0.15m from the outside of the anchor blade to the boundary. Looking at the table from section 7.3.4, we will assume the stay wire is 10° off the vertical, for which D is approximately 3.80m, which is less than the 4.2m available.

POLE LENGTH (m)	NOM. TIP HEIGHT (m)	**θ**	0°	5°	10°	15°	20°
9.5	7.7	D (m)	2.30	2.79	3.28	3.79	4.32
		F_{stay} / F_t	3.35	2.77	2.38	2.10	1.90
11	9.2	D (m)	2.30	2.92	3.54	4.19	4.87
		F_{stay} / F_t	4.00	3.17	2.64	2.27	2.01
12.5	10.65	D (m)	2.30	3.04	3.80	4.58	5.39
		F_{stay} / F_t	4.63	3.51	2.85	2.41	2.10
14	12.0	D (m)	2.30	3.16	4.04	4.94	5.89
		F_{stay} / F_t	5.22	3.81	3.02	2.52	2.17
15.5	13.35	D (m)	2.30	3.28	4.27	5.30	6.38
		F_{stay} / F_t	5.80	4.09	3.17	2.61	2.23

The force on the stay wire and anchor is 2.85 times the tip load, i.e. 47.6kN. This does not exceed the capacity of the 19/2.00 steel stay wire, insulators, eye bolt or stay rod.

The 300mm single helix screw anchor has a capacity of 60kN, which is more than adequate for this applied load. Again, there is no need to apply a derating factor to this strength as the No Wind Load is less than 50% of the Max. Wind Load. We nominate an installation torque of 1750N.m.

SECTION 8 – POLETOP CONSTRUCTIONS

Version: 3.8

TasNetworks | Powering a Bright Future

SECTION 8 – POLETOP CONSTRUCTIONS

8.1 POLETOP CONSTRUCTION SELECTION

8.1.1 Factors Influencing Selection

Poletop constructions should be selected according to:

- Voltage
- No. of phases
- Conductor type
- Spanning and angular capacity
- Terrain
- Local environment – pollution (may affect choice of insulator), wildlife
- Matching with existing adjacent constructions where appropriate, e.g. for isolated pole replacements.

Designers should specify preferred constructions wherever practicable; non-standard constructions should only be used for repairs or minor modifications to existing sections of overhead line.

8.1.2 Preferred Constructions for Low Voltage Mains

LVABC – preferred style of LV overhead reticulation

CONSTRUCTION	USAGE
Intermediate Single Suspension	For in-line and small deviation angle intermediate poles
Intermediate Double Suspension (Angle)	For larger deviation angles typically in the range 25 - 50°, may be used for smaller angles for long spans of heavy cable
Strain	Where required for electrical or mechanical isolation of spans, typically with angular range 0 - 30°
Dead End	Where LVABC segment terminates, or on heavy angles

Open-wire Mains – for use on long spans or other areas where LVABC isn't suitable

CONSTRUCTION	USAGE
Intermediate Pin	For straight line and modest deviation angle (up to 25° where conductors are light or slack-strung) intermediate poles.
Intermediate Offset Pin	For in-line and small deviation angle intermediate poles where the crossarm is offset to one side, typically over the carriageway to increase clearance from private property, e.g. where verge is narrow, buildings are close to front boundary or on corners.
Strain	Where required for electrical or mechanical isolation of spans, typically with angular range 0 - 50°.
Dead End	Where segment of mains terminates, or on heavy angles.

Mk1 crossarms are standard, but Mk3 crossarms are used with transformers. Strain and Dead End constructions use double crossarms. All new crossarms being installed are fibre-reinforced polymer (FRP) types; older types are timber.

8.1.3 Preferred Constructions for HV Mains

Open-Wire Mains – preferred style of HV overhead reticulation

CONSTRUCTION	USAGE
Intermediate Delta Pin	For straight line and modest deviation angle intermediate poles where spans are long. Large delta spacing (with FRP crossarm and raiser) is the preferred pole-top construction for poles in rural areas as it is intrinsically safer for wildlife and increased conductor spacing makes firestarts from clashing less likely.
Intermediate Pin	For straight line and modest deviation angle (up to 25° where conductors are light or slack-strung) intermediate poles. Where the middle phase is offset from centre, it should stagger from one side to the other on alternate poles to increase interphase spacing and reduce the incidence of mid-span conductor clashing.
Intermediate Offset Pin	For in-line and modest deviation angle intermediate poles where the crossarm is offset to one side, typically over the carriageway to increase clearance from private property, e.g. where verge is narrow, buildings are close to front boundary or on corners.
Intermediate Vertical Pin	For in-line and small deviation angle intermediate poles in double-circuit applications, with three phases of one circuit on one side of the pole and three phases of the other circuit on the opposite side of the pole.
Strain	Where required for electrical or mechanical isolation of spans, typically with angular range 0 - 50°. Conductor loops should be underslung where practical.
Strain Delta (Large and small options)	As above, but with middle phase raised for increased spanning capability and which reduces the likelihood of electrocution during in-span raptor collision and firestart from conductor clashing. Conductor loops should be underslung where practical.
Strain Vertical	As for Strain, but for double-circuit applications, one circuit on each side of the centreline.
Dead End	Where segment of mains terminates, or on heavy angles.
Dead End Delta (Large and small options)	As above, but with middle phase raised for increased spanning capability and which reduces the likelihood of electrocution during in-span raptor collision.
Dead End Vertical	As for Dead End, but for double-circuit applications, one circuit on each side of the centreline.

Fibre-reinforced polymer (FRP) crossarms are being introduced and are preferred over steel crossarms where available. These are 2840mm long. Intermediate constructions use 100mm x 100mm section with 5.2mm wall thickness. Strain constructions use 125mm x 125mm section with 6.5mm wall thickness. Intermediate delta constructions make use of a FRP riser on which a pin insulator is mounted.

SWER – for use in outlying rural areas only

CONSTRUCTION	USAGE
Intermediate Pin	For straight line and modest deviation angle (up to 25°) intermediate poles.
Intermediate Flying Angle	For intermediate poles with deviation angles in the range 25 - 90°
Strain	Where required for electrical or mechanical isolation of spans, with angular range 0 - 60°.
Dead End	Where segment of line terminates, or on heavy angles.

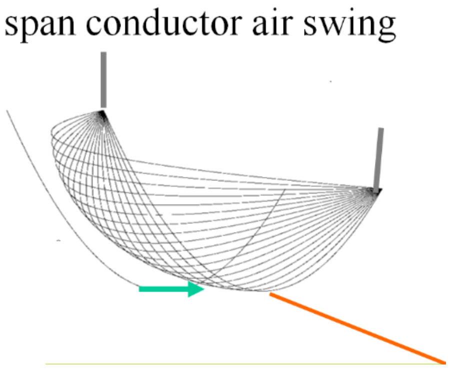
HVABC – for use in areas with heavy vegetation, wildlife and other special circumstances

CONSTRUCTION	USAGE
Intermediate Suspension Single Hook	For in-line and deviation angle intermediate poles up to 45°
Intermediate Suspension Double Hook	For larger deviation angles up to 45°, may be used for smaller angles for long spans of heavy cable
Strain	Where required for electrical or mechanical isolation of spans, typically with angular range 0 - 30°
Dead End	Where HVABC segment terminates, or on heavy angles

Note that Metallic Screened (MS) HVABC should be used. Some older non-metallic screened (NMS) HVABC exists within the network.

8.2 CONDUCTOR SPACING AND PREVENTING MID-SPAN CLASHING

Conductors can swing and clash due to factors such as electromagnetic forces under fault current, turbulent winds, birds taking off.



In general, to avoid clashing between conductors, the following condition must be met:

$$\sqrt{(X^2 + (1.2\,Y)^2)} \geq U/150 + k\sqrt{(D + li)}$$

where:

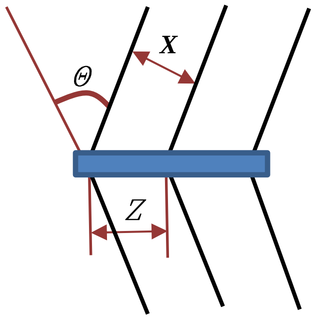
X	is the horizontal distance between the conductors at mid-span (m)
Y	is the vertical distance between the conductors at mid-span (m)
U	is the rms difference in potential between the two conductors (kV)
D	is the greater of the two conductor sags (m) – No Wind, 30°C
li	is the length of any freely swinging suspension insulator with either conductor (m)
k	is an empirical factor which in TasNetworks is taken to be 0.5 for HV lines and 0.45 for LV lines

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

The probability of mid-span clashing also increases as conductor sag increases. Sag increases with span length, but decreases with increased stringing tension, so tighter stringing enables greater distances to be spanned.

Also, as deviation angle increases, there is a reduction of spacing between phase conductors, as illustrated.

$$X = Z\cos(\Theta/2)$$



Where a span has different types of construction at each end, say flat horizontal at one end and vertical at the other end, or where phases are being ‘rolled’ in a transposition, the maximum allowable span lengths should be the average of that for the two individual construction types, then reduced by, say, 25%.

Mid-span clashing is not of concern with SWER lines, ABC, pilot cables, ADSS or open-wire lines fitted with conductor spreaders.

LV CONSTRUCTIONS

Construction	No. Phases	Interphase Spacing (mm)	Max. Allowable Sag @ 30°C (m)	Remarks
Intermediate, Offset, Strain or Dead End w. Mk1 X-arm	3	535	1.40	
	1	1680	13.09	
Intermediate, Strain or Dead End w. Mk3 X-arm	3	460, 535	1.21	Assumes Mk3 one end of span only, Mk1 at other end
	1	2600, 1680	22.56	

HV CONSTRUCTIONS

Construction		No. Phases	Interphase Spacing (mm)		Max. Allowable Sag @ 30°C (m)			Remarks
			Hor	Vert	11kV	22kV	33kV	
Intermediate Flat Pin w. FRP X-arm	Mid phase not centred or staggered	3	850	0	2.39	1.96	1.57	
	Mid phase staggered or centred		1355 or 850/1860	0	6.57	5.84	5.15	
	Mid phase offset one end, centred other end		850/1355	0	4.24	3.65	3.12	
	Outside phases only	1	2710	0	27.81	26.28	-	
Offset Intermediate Flat Pin w. FRP Xarm		3	1090	0	4.13	3.56	3.03	
Delta Intermediate Pin w. FRP X-arm and FRP Pin Riser		3	1355	1223	14.81	13.70	12.64	
Double-circuit Vertical Intermediate Pin w. FRP Xarm (or Mk4 steel X-arm)	Small	3	0	920	4.25	3.67	-	
	Large	3	0	1150	-	-	5.38	
Strain or Dead End w. FRP Xarm		3	1355	230	6.86	6.11	5.41	
Delta Strain or Dead End w. FRP X-arm	Small	3	1355	460	7.73	6.93	6.18	
	Large		1355	920	11.22	10.25	9.34	
Double-circuit Vertical Strain or Dead-End w. FRP Xarm (or Mk5 steel X-arm)	Small	3	0	920	4.25	3.67	-	
	Large	3	0	1150	-	-	5.38	
Intermediate Flat Pin w. Mk4 steel X-arm	Mid phase not centred or staggered	3	675	0	1.45	1.12		
	Mid phase staggered or centred		1055 or 675/1435	0	3.85	3.30		
	One end offset, other centred		675 1005	0 0	2.35	1.92		
	Outside phases only	1	2110	0	16.59	15.42		
Delta Intermediate Flat Pin w. Steel Mk4 X-arm	Small	3	1055	610	5.86	5.17		
	Large			1070	10.09	9.18		
Offset Intermediate Flat Pin w. steel X-arm		3	865	0	2.51	2.06		
Strain or Dead End w. Steel Mk5 X-arm		3	1005	0	3.47	2.95		
		1	2010	0	15.00	13.89		
Delta Strain or Dead End w. Steel Mk5 X-arm	Small	3	1005	610	5.48	4.81		
	Large			1070	9.70	8.81		
Trident (Obsolete)		3 or 1	1020	0	3.58	3.05		Critical spacing is between lower, outside phases

8.3 COMPONENT STRENGTHS AND LIMITATIONS

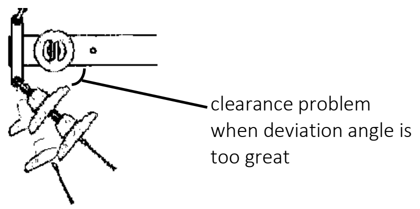
8.3.1 Insulators

Voltage	Type	Min. Failing Load (kN)	Limit State Strength 900Pa Wind (kN)
LV	Pin LVLP 91mm high	7	**5.6**
	Strain Reel SHLV1 (obsolete) 54mm high	9	**7.2**
	Strain Reel SHLV2 76mm high	20	**16**
11/22kV	Pin 22kV aerodynamic style ALP22/450	11	**8.8**
	Older style line pin insulators (obsolete)	7	**5.6**
33kV	Pin 33kV aerodynamic style ALP33/920	7	**5.6**
11/22/33kV	Strain – glass or porcelain disk	70	**56**

For ergonomic reasons, and to avoid 'birdcaging' of conductors, TasNetworks has decided to limit the load on intermediate pin constructions (excluding SWER lines), as follows:

- Maximum 25° deviation angle
- Maximum actual sustained transverse force per wire of 0.80kN, equivalent to 81.5kg. This equates to a 0.88kN limit after application of a load factor of 1.1.

Angles on open-wire strain constructions have been limited to 50° to maintain adequate clearance from the crossarm. For SWER lines with insulators attached directly to the pole, a 60° limit has been applied.



8.3.2 Crossarms

TasNetworks requires strain crossarms to be able to act as dead ends if necessary, i.e. to carry the full load when conductors are attached on one side only.

LV Crossarms

These have a 100mm x 100mm section. The lengths are as follows:

- Mk1: 1830mm
- Mk3: 2750mm (used with transformers).

X-arm Type	No. Phases	No Wind[1]	900Pa Wind[2]
Timber 2 x Mk 1	3	5.57kN	8.35kN
	1	6.84kN	11.40kN
Timber 2 x Mk 3	3	2.67kN	4.45kN
	1	4.41kN	7.36kN

Maximum Conductor Load per Wire on Dual TIMBER Crossarm Strain and Dead End Constructions

The newer FRP Crossarms have greater capacity than timber crossarms, as shown below[3]. However, at present time, TasNetworks are not loading these more than for timber crossarms.

X-arm Type	No. Phases	No Wind	900Pa Wind
FRP 2 x Mk 1	3	9.26kN	23.16kN
	1	12.63kN	31.58kN
FRP 2 x Mk 3	3	6.49kN	16.24kN
	1	9.03kN	22.58kN

Maximum Conductor Load per Wire (sum of horizontal & vertical components)
on Dual FRP Crossarm LV Strain and Dead End Constructions

A nominal 6kN limit has been set for transverse load per wire for strain angle constructions.

[1] 0.3 x Nominal Breaking Load
[2] 0.5 x Nominal Breaking Load
[3] The Wagners 100mm x100mm section with 5.2mm wall thickness crossarms have an ultimate moment rating of 17.7kN.m. Strength factors of 0.3 and 0.75 are applied for No Wind and Max. Wind limit state ratings respectively.

HV Crossarms

FRP X-Arm Type	Length	Section	Ultimate BM Capacity	Lever Arm	No Wind Ø=0.3	900Pa Wind Ø=0.75
Intermediate Flat Pin	2840mm	100mm x 100mm x 5.2mm wall thickness	17.7kNm	1.355m + 0.505m	2.85kN	7.14kN
Intermediate: 1 ph. Flat Pin, Offset Pin Delta Pin, 2-cct vertical Pin	2840mm	100mm x 100mm x 5.2mm wall thickness	17.7kNm	0.397m + 1.09m	3.57kN	8.93kN
Strain / Dead End	2840mm	125mm x 125mm x 6.5mm wall thickness	33.8kNm	1.355m	7.48kN	18.71kN

Maximum Conductor Load per Wire (sum of horizontal & vertical components) on FRP Crossarms

Inserts are provided at hole positions to prevent crushing or tearing at these points. Their capacity is in excess of the shear or tensile strengths of the bolts through the holes.

Steel Mk 4 Intermediate: 75mm x 75mm x 8mm angle section, 2210mm long
(Offset construction is similar but with different hole positions.)

Steel Mk 5 Strain & Dead End: (Dual) 100mm x 100mm x 8mm angle section, 2210mm long

Steel X-arm Type	Max. Cond. Load per Wire @900Pa Wind[4]	Nom. Max. Transverse Load per Wire @900Pa Wind
Mk 4	5.04kN	5kN
Dual Mk 5	11.34kN	8kN

Maximum Conductor Load per Wire on Dual Steel Crossarm Strain and Dead End Constructions (Obsolete)

FRP PIN RAISER FOR DELTA INTERMEDIATE CONSTRUCTION

The FRP riser used in Delta Intermediate constructions is 1830mm long with 100mm x 100mm section and 5.2mm wall thickness, with an ultimate bending moment capacity of 17.7kN.m. The lever arm is approximately 1.25m. Thus, with application of strength factors, the maximum loads that can be applied are:

4.25kN sustained
10.62kN 900Pa Wind Limit State

The strength of the metallic insert into which the insulator pin is screwed has a higher capacity than the FRP riser. Therefore, the limiting factor for the whole assembly is the strength of the insulator attached.

[4] 90% of Nominal Failing Load

8.3.3 King Bolts through Timber Poles

Timber poles are assumed to have the following strengths where crossarms are attached with king bolts with suitable bracing and large washers:

- 45kN Nom. Breaking Load
- 27kN 900Pa Wind Limit State
- 15.3kN Sustained

8.3.4 Steel Bolts

BOLT DIAMETER	GRADE	RATED STRENGTH (kN) Prior to application of strength factor of 0.8		
		N_{TF} Ultimate Tensile Strength	V_{SF} (shank) Shear Strength	V_{SF} (thread) Shear Strength
M12	4.6 (std)	33.7	28	19
	8.8 (high)	67.4	57	38
M16	4.6 (std)	62.8	50	36
	8.8 (high)	125.6	101	72
M20	4.6 (std)	98	79	56
	8.8 (high)	203	163	117
M24	4.6 (std)	141	113	81
	8.8 (high)	293	235	168

Grade 4.6 bolts are standard bolts with 400N/mm^2 tensile strength and a proof strength (the point where inelastic deformation may occur) that is 0.6 of the ultimate strength. King bolts and other bolts associated with crossarms are grade 4.6. Grade 8.8 bolts are tempered bolts with 800N/mm^2 tensile strength and a proof strength that is 0.8 of the ultimate strength.

Thus, applying the 0.8 strength factor, for the M16 grade 4.6 bolts used as king bolts and for attaching insulators on strain constructions, the 900Pa Wind Limit State strength is 50.2kN in tension and 28.8kN for shear.

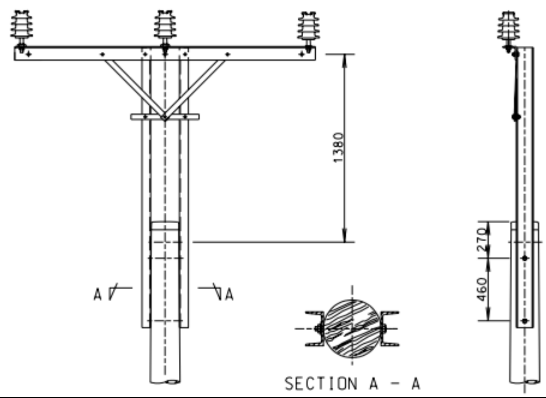
For bolts subject to combined tensile (N^*_{TF}) and shear (V^*_{SF}) forces, the following relationship must be satisfied:

$(V^*_{SF} / \Phi V_{SF}) + (N^*_{TF} / \Phi N_{TF}) \leq 1$ where Φ (Strength factor or Capacity factor) = 0.8 as per section 2.3.10.

8.3.5 Raisers

STEEL HV POLE EXTENDERS (OBSOLETE)

These were used to increase pole height, especially for retrofitting HV to an existing LV pole. They are used in conjunction with a steel Mk4 crossarm for an intermediate 11kV or 22kV construction.



TFC (Tapered Flange Channel) Size	Maximum LS Transverse Load on Construction
100 x 50	6.514kN
125 x 65	11.822Kn

8.3.6 Conductors and Cables

Conductor span lengths are not only limited by mid-span clashing. Other limitations include:

- conductor load under 900Pa wind not to exceed 90% of NBL
- vertical load for lifting conductors. This can be relevant for heavy ABC cables. There may be lifting capacity limits on EWP jibs, e.g. 150kg or 1.45kN, otherwise other lifting methods may need to be employed. HVABC is typically installed using tension stringing, so a vertical load limit of 4.5kN or 460kg has been adopted.

For MSHVABC with a 19/2.00 SC/GZ catenary, the conductor load should not exceed 17.6kN (25% NBL) sustained or 35.3kN (50% NBL) under 500Pa wind conditions.

8.3.7 LVABC Components

Single suspension clamps are taken to have a 6kN limit. These are limited to a 25° deviation angle.

Double suspension angle constructions are ideally used for angles of exceeding 15° but can be used for lesser angles if necessary. Where a M16 hook bolt is used, double suspension angle constructions are taken to have a 10.8kN limitation, the limiting factor being the opening of the hook bolt. This applies to both vertical and transverse loads. Where used with a closed eyebolt, the limit is 12.0kN.

With a maximum stringing tension of only 10% NBL for LVABC, the capacity of strain clamps and related fittings is not of concern when closed eyebolts and eyenuts are used. However, where open M16 hookbolts are used, a 10.8kN limitation applies.

8.3.8 HVABC Components

Suspension constructions may be used for deviation angles up to 45°. Strain constructions may be used for deviation angles up to 30°. For larger deviation angles, a ‘right-angle’ strain construction (two dead end constructions) should be used.

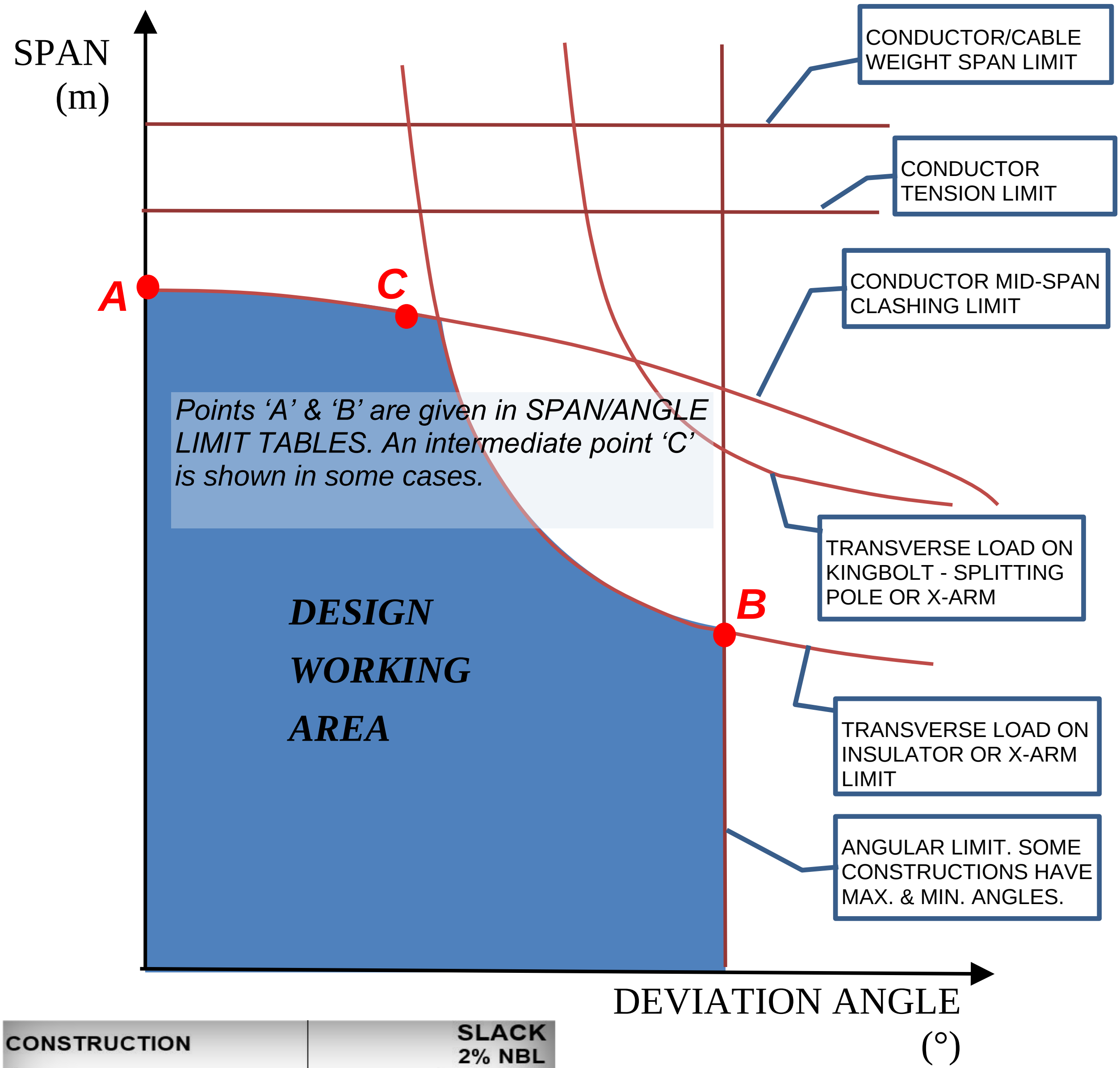
On suspension constructions, one or two M16 hook bolts may be used, depending upon the loading. The M16 hook bolts are rated at 10.8kN (i.e. 12kN failing load).

On strain constructions, M20 hook bolts and hook nuts are used, these having a rating of 21.6kN (i.e. 24kN failing load).

8.4 SPAN / DEVIATION ANGLE LIMITS

8.4.1 Interpreting Tables

The tables on the following pages show the range of span lengths and deviation angles for which various constructions may be used. The factors limiting span and angle are illustrated below. Note that the relative positions of these limits on the plot vary from one construction to the next and with conductor type and tension. Thus, the shape of the 'design working area' varies. One, two or three points (A, B, C) are given. Designers can interpolate between the points to make sure they are working within the corrrect range for the construction/conductor/tension combination.



CONSTRUCTION	SLACK 2% NBL	
Description	MERCURY	NEPTUNE
Strain 3ph w. Double Mk1 x-arm	0-50°	0-50°
	34m/0°	34m/0°
	30m/50°	30m/50°

Angular Range
A
B

Worked Example

A segment of 4C 95mm^2 LVABC mains in an urban area strung at 6%NBL is to follow a road with a 16° bend. What is the maximum span length that can be used either on the spans adjacent the bend point?

Looking at the Span/Angle Limits table in section 8.4.2, we notice that a single suspension angle on this cable at this tension can handle an angle of up to 20°.

'RUCTION	URBAN 6% NBL				
Description	2C 50mm^2	4C 50mm^2	2C 95mm^2	4C 95mm^2	4C 150mm^2
Intermediate Single Suspension	0-25°	0-25°	0-25°	0-20°	0-15°
	224m/0°	185m/0°	167m/0°	138m/0°	116m/0°
	183m/10°	144m/10°	127m/10°	96m/10°	70m/10°
	133m/25°	90m/25°	76m/25°	58m/20°	49m/15°
Angle Double Suspension See Note 2	0-50°	0-50°	0-50°	0-50°	0-40°
	300m/15°	211m/15°	167m/15°	188m/15°	142m/15°
				139m/30°	85m/30°
	300m/50°	211m/50°	167m/50°	91m/50°	50m/40°
Strain					

The maximum span length for a 10° bend is 96m, and for a 20° bend, 58m. So, interpolating, we for a 16° bend, we will be a little less than halfway between these. We could calculate as follows:

96 – [(16 – 10) / (20 – 10) x (96 – 58)] = 73m

Or, we could have said that we have a 38m reduction for 10°, i.e. 3.8m/1°, so for 6° beyond 10°, we need to subtract 6 x 3.8m from 96m, taking us to 73m.

Now, if our proposed span is less than 73m, we can use the single suspension construction. However, if we need a longer span, then we may need to consider the Angle (double suspension) construction. It will allow up to 188m on an 15° bend and 139m on a 30° bend, so interpolating for a 16° bend, the maximum span length would be 185m.

8.4.2 LVABC

CONSTRUCTION		SLACK 2% NBL					URBAN 6% NBL					LIMITED 10% NBL				
APL	**Description**	2C 50mm²	4C 50mm²	2C 95mm²	4C 95mm²	4C 150mm²	2C 50mm²	4C 50mm²	2C 95mm²	4C 95mm²	4C 150mm²	2C 50mm²	4C 50mm²	2C 95mm²	4C 95mm²	4C 150mm²
I/LVABC-*aln*	Intermediate Single Suspension	0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-20°	0-15°	0-25°	0-20°	0-20°	0-10°	0-10°
		224m/0°	185m/0°	167m/0°	138m/0°	116m/0°	224m/0°	185m/0°	167m/0°	138m/0°	116m/0°	224m/0°	185m/0°	167m/0°	138m/0°	116m/0°
							183m/10°	144m/10°	127m/10°	96m/10°	70m/10°	160m/10°	119m/10°	105m/10°	104m/5°	81m/5°
		205m/25°	165m/25°	150m/25°	110m/25°	83m/25°	133m/25°	90m/25°	76m/25°	58m/20°	49m/15°	89m/25°	69m/20°	61m/20°	73m/10°	49m/10°
D/LVABC-*aln*	Angle Double Suspension See Note 2	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-35°	0-25°
		300m/15°	300m/15°	300m/15°	300m/15°	210m/15°	300m/15°	300m/15°	279m/15°	210m/15°	165m/15°	300m/15°	271m/15°	239m/15°	175m/15°	123m/15°
										170m/30°	109m/30°	280m/30°	194m/30°	165m/30°	98m/30°	94m/20°
		300m/50°	300m/50°	300m/50°	295m/50°	210m/50°	300m/50°	260m/50°	220m/50°	128m/50°	58m/50°	230m/50°	118m/50°	106m/50°	80m/35°	71m/25°
S/LVABC-*aln*	Strain	0-30°	0-30°	0-30°	0-30°	0-30°	0-30°	0-30°	0-30°	0-30°	0-30°	0-30°	0-30°	0-30°	0-30°	0-30°
		300m/30°	300m/30°	300m/30°	300m/30°	300m/30°	300m/30°	300m/30°	300m/30°	300m/30°	300m/30°	300m/30°	300m/30°	300m/30°	300m/30°	300m/30°
DE/LVABC-*aln*	Dead End	300m	300m	300m	300m	300m	300m	300m	300m	300m	300m	300m	300m	300m	300m	300m

Notes:

1. Span and angle limitations reflect strength limitations of components and clearance limitations. Designers still need to allow for other limitations such as ground clearance, intercircuit clearance and tip loads on poles.
2. It is preferred that the Angle construction be used for deviation angles of 15° or more.
3. Do not string LVABC cables tighter than 10% NBL. This would exceed the capacity of the strain clamp. Also, spreading the phase cores is very difficult, even at 10%NBL.
4. An arbitrary limit of 300m has been set for span lengths in the table above. However, spans exceeding this length may be possible.
5. Ice loading case not considered in above limits.
6. Note that long spans of heavier cables such as 4C 95mm² and 150mm² may not be able to be lifted using the jib on a EWP which typically has a 150kg (1.45kN) lifting capacity. Other methods of raising the cable may be required.
7. This table assumes that closed eyebolts or eyenuts are used for all strain, dead end and angle constructions. However, if open M16 hook bolts or hooknuts are used, the span/angle capacity will be reduced (10.8kN limit).

8.4.3 Bare LV Mains – Intermediate Constructions

CONSTRUCTION		SLACK 2% NBL			URBAN 6% NBL			LIMITED 10% NBL			MEDIUM 18% NBL			FULL 22% NBL
APL	**Description**	MERCURY	NEPTUNE	FLUORINE	MERCURY	NEPTUNE	FLUORINE	MERCURY	NEPTUNE	FLUORINE	MERCURY	NEPTUNE	FLUORINE	FLUORINE
I1/LV/3	Intermediate Single Pin 3ph	0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-18°	0-25°	0-15°	0-10°	0-21°	0-17°
	w. Mk1 x-arm,	34m/0°	34m/0°	42m/0°	55m/0°	55m/0°	67m/0°	68m/0°	68m/0°	81m/0°	86m/0°	86m/0°	106m/0°	118m/0°
O1/LV/3	Offset Single Pin 3ph	33m/25°	33m/25°	41m/25°	53m/25°	53m/25°	65m/25°	65m/25°	67m/18°	79m/25°	83m/15°	85m/10°	104m/21°	116m/17°
I3/LV/3	Intermediate Single Pin 3ph	0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-18°	0-25°	0-15°	0-10°	0-21°	0-17°
	w. Mk3 x-arm	31m/0°	31m/0°	39m/0°	51m/0°	51m/0°	61m/0°	61m/0°	61m/0°	74m/0°	78m/0°	78m/0°	96m/0°	108m/0°
	(Mk1 at adjacent poles)	30m/25°	30m/25°	38m/25°	49m/25°	49m/25°	59m/25°	59m/25°	60m/18°	72m/25°	77m/15°	77m/10°	95m/21°	106m/17°
I1/LV/1	Intermediate Single Pin 1ph	0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-18°	0-25°	0-15°	0-10°	0-21°	0-17°
	w. Mk1 x-arm,	107m/0°	107m/0°	135m/0°	185m/0°	185m/0°	232m/0°	238m/0°	238m/0°	297m/0°	315m/0°	315m/0°	391m/0°	429m/0°
O1/LV/1	Offset Single Pin 1ph							236m/12	210m/9°	295m/10°	250m/8°	230m/5°	360m/10°	380m/8°
		104m/25°	104m/25°	131m/25°	180m/25°	170m/25°	226m/25°	160m/25°	145m/18°	260m/25°	175m/15°	170m/10°	240m/21°	260m/17°
I3/LV/1	Intermediate Single Pin 1ph	0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-18°	0-25°	0-15°	0-10°	0-21°	0-17°
	w. Mk3 x-arm	140m/0°	140m/0°	177m/0°	244m/0°	244m/0°	306m/0°	314m/0°	314m/0°	394m/0°	418m/0°	340m/0°	523m/0°	450m/0°
						235m/12°		255m/12°	210m/9°	392m/10°	250m/8°	230m/5°	360m/10°	380m/8°
		136m/25°	136m/25°	172m/25°	238m/25°	170m/25°	298m/25°	160m/25°	145m/18°	260m/25°	175m/15°	170m/10°	240m/21°	260m/17°

Notes:

1. Span and angle limitations reflect strength limitations of components, clearance limitations and avoidance of mid-span clashing. Designers still need to allow for other limitations such as ground clearance, intercircuit clearance and tip loads on poles.
2. Standard crossarm sizes and geometry is assumed. Assumes vibration protection installed on tight-strung lines or other locations susceptible to aeolian vibration.
3. Ice loading case not considered in above limits.

8.4.4 Bare LV Mains – Strain Constructions

CONSTRUCTION		SLACK 2% NBL			URBAN 6% NBL			LIMITED 10% NBL			MEDIUM 18% NBL			FULL 22% NBL
APL	**Description**	MERCURY	NEPTUNE	FLUORINE	MERCURY	NEPTUNE	FLUORINE	MERCURY	NEPTUNE	FLUORINE	MERCURY	NEPTUNE	FLUORINE	FLUORINE
S1/LV/3	Strain 3ph w. Double Mk1 x-arm	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-40°	0-30°	0-50°	0-50°
		34m/0°	34m/0°	42m/0°	55m/0°	55m/0°	67m/0°	68m/0°	68m/0°	81m/0°	85m/0°	50m/0°	106m/0°	118m/0°
											81m/35°			
		30m/50°	30m/50°	38m/50°	49m/50°	49m/50°	60m/50°	63m/50°	57m/50°	73m/50°	77m/40°	50m/30°	96m/50°	106m/50°
S1/LV/1	Strain 1ph w. Double Mk1 x-arm	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-40°	0-30°	0-50°	0-50°
		107m/0°	107m/0°	135m/0°	185m/0°	185m/0°	232m/0°	238m/0°	238m/0°	297m/0°	170m/0°	97m/0°	391m/0°	326m/0°
						180m/25°		185m/25°	123m/25°	289m/25°	156m/20°	97m/15°	234m/25°	222m/25°
		96m/50°	96m/50°	122m/50°	167m/50°	114m/50°	210m/50°	93m/50°	57m/50°	175m/50°	77m/40°	70m/30°	130m/50°	119m/50°
S3/LV/3	Strain 3ph w. Double Mk3 x-arm	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	NA	NA	0-50°	NA	NA	0-50°	NA
		31m/0°	31m/0°	39m/0°	51m/0°	51m/0°	61m/0°	NA	NA	74m/0°	NA	NA	60m/0°	NA
		28m/50°	28m/50°	35m/50°	46m/50°	46m/50°	55m/50°			67m/50°			60m/50°	
S3/LV/1	Strain 1ph w. Double Mk3 x-arm	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-40°	NA	0-50°	0-50°
		140m/0°	140m/0°	177m/0°	244m/0°	244m/0°	306m/0°	118m/0°	314m/0°	258m/0°	66m/0°	NA	156m/0°	140m/0°
						190m/25°		118m/25°	123m/25°	258m/25°	66m/20°			140m/25°
		126m/50°	126m/50°	160m/50°	205m/50°	114m/50°	277m/50°	93m/50°	57m/50°	175m/50°	66m/40°		156m/50°	119m/50°
DE1/LV/3	Dead End 3ph w. Double Mk1 x-arm	34m	34m	42m	55m	55m	67m	68m	68m	81m	85m	50m	106m	118m
DE1/LV/1	Dead End 1ph w. Double Mk1 x-arm	107m	107m	135m	185m	185m	232m	238m	238m	297m	170m	97m	391m	326m
DE3/LV/3	Dead End 3ph w. Double Mk3 x-arm	31m	31m	39m	51m	51m	61m	NA	NA	74m	NA	NA	60m	NA
DE3/LV/1	Dead End 1ph w. Double Mk3 x-arm	140m	140m	177m	244m	244m	277m	118m	122m	258m	66m	NA	156m	140m

Notes:

1. Span and angle limitations reflect strength limitations of components, clearance limitations and avoidance of mid-span clashing. Designers still need to allow for other limitations such as ground clearance, intercircuit clearance and tip loads on poles.
2. Standard crossarm sizes and geometry is assumed. Assumes vibration protection installed on tight-strung lines or other locations susceptible to aeolian vibration.
3. Ice loading case not considered in above limits.

8.4.5 Bare 11kV Mains – Intermediate Constructions

CONSTRUCTION			SLACK 2% NBL			URBAN 6% NBL			LIMITED 10% NBL				MEDIUM 18% NBL				FULL 22% NBL	
APL	Description		MERCURY	NEPTUNE	FLUORINE	MERCURY	NEPTUNE	FLUORINE	MERCURY	NEPTUNE	FLUORINE	3/2.75 SC/GZ	MERCURY	NEPTUNE	FLUORINE	3/2.75 SC/GZ	FLUORINE	3/2.75 SC/GZ
I/11/3/ FRP	Intermediate Flat Pin 3ph FRP Xarm See Note 4	Mid phase centred or staggered	0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-18°	0-25°	0-20°	0-15°	0-10°	0-20°	0-11°	0-17°	0-9°
			77m/0°	77m/0°	95m/0°	132m/0°	132m/0°	161m/0°	168m/0°	168m/0°	200m/0°	278m/0°	220m/0°	220m/0°	266m/0°	369m/0°	290m/0°	408m/0°
			73m/25°	73m/25°	90m/25°	126m/25°	126m/25°	154m/25°	160m/25°	160m/18°	193m/25°	235m/20°	215m/15°	215m/10°	257m/20°	364m/11°	280m/17°	400m/9°
		Mid phase not staggered or centred	0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-18°	0-25°	0-20°	0-15°	0-10°	0-20°	0-11°	0-17°	0-9°
			46m/0°	46m/0°	56m/0°	76m/0°	76m/0°	92m/0°	95m/0°	95m/0°	114m/0°	160/0°	120m/0°	120m/0°	147m/0°	216m/0°	162m/0°	240m/0°
			44m/25°	44m/25°	53m/25°	71m/25°	71m/25°	87m/25°	90m/25°	90m/18°	100m/25°	155m/20°	117m/15°	118m/10°	142m/20°	213m/11°	157m/17°	237m/9°
		Mid phase offset one end, centred other end	0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-18°	0-25°	0-20°	0-15°	0-10°	0-20°	0-11°	0-17°	0-9°
			61m/0°	61m/0°	75m/0°	104m/0°	104m/0°	127m/0°	132m/0°	132m/0°	159m/0°	220m/0°	171m/0°	171m/0°	206m/0°	292m/0°	225m/0°	324m/0°
			57m/25°	57m/25°	71m/25°	99m/25°	99m/25°	121m/25°	125m/25°	125m/18°	152m/25°	211m/20°	166m/15°	166m/10°	198m/20°	288m/11°	216m/17°	320m/9°
I/11/1/ FRP	Intermediate Flat Pin 1ph FRP Xarm		0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-18°	0-25°	0-20°	0-15°	0-10°	0-20°	0-11°	0-17°	0-9°
			154m/0°	154m/0°	196m/0°	275m/0°	275m/0°	340m/0°	355m/0°	270m/0°	437m/0°	590m/0°	380m/0°	270m/0°	520m/0°	695m/0°	420m/0°	800m/0°
			148m/25°	148m/25°	188m/25°	264m/25°	264m/25°	325m/25°	340m/25°	240m/18°	418m/25°	564m/20°	340m/15°	240m/10°	400m/20°	688m/11°	400m/17°	750m/9°
Delta I/11/3/ FRP	Intermediate Delta Pin 3ph FRP Xarm & Riser		0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-18°	0-25°	0-20°	0-15°	0-10°	0-20°	0-11°	0-17°	0-9°
			115m/0°	115m/0°	144m/0°	200m/0°	200m/0°	247m/0°	257m/0°	257m/0°	316m/0°	427m/0°	341m/0°	270m/0°	418m/0°	568m/0°	420m/0°	626m/0°
			109m/25°	109m/25°	137m/25°	181m/25°	181m/25°	223m/25°	232m/25°	232m/18°	286m/25°	401m/20°	229m/15°	240m/10°	392m/20°	557m/11°	400m/17°	618m/9°
OFFSET /11/3/ FRP	Offset Pin 3ph FRP Xarm		0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-18°	0-25°	0-20°	0-15°	0-10°	0-20°	0-11°	0-17°	0-9°
			60m/0°	60m/0°	74m/0°	103m/0°	103m/0°	125m/0°	130m/0°	130m/0°	157m/0°	217m/0°	168m/0°	168m/0°	243m/0°	288m/0°	222m/0°	320m/0°
			56m/25°	56m/25°	70m/25°	98m/25°	98m/25°	119m/25°	123m/25°	123m/18°	150m/25°	210m/20°	163m/15°	163m/10°	195m/20°	282m/11°	214m/17°	315m/9°
IV/11/3/ FRP	Vertical Double Cct 2 x 3ph FRP Xarms		0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-18°	0-25°	0-20°	0-15°	0-10°	0-20°	0-11°	0-17°	0-9°
			61m/0°	61m/0°	76m/0°	103m/0°	103m/0°	128m/0°	131m/0°	131m/0°	160m/0°	221m/0°	170m/0°	170m/0°	208m/0°	294m/0°	228m/0°	326m/0°
			61m/25°	61m/25°	76m/25°	103m/25°	103m/25°	128m/25°	131m/25°	131m/18°	160m/25°	221m/20°	170m/15°	146m/10°	208m/20°	294m/11°	228m/17°	326m/9°

Notes:

1. Span and angle limitations reflect strength limitations of components, clearance limitations and avoidance of mid-span clashing. Designers still need to allow for other limitations such as ground clearance, intercircuit clearance and tip loads on poles.
2. Standard crossarm sizes and geometry is assumed. Assumes vibration protection installed on tight-strung lines or other locations susceptible to aeolian vibration.
3. Ice loading case not considered in above limits.
4. Where the middle phase is offset from centre, it should be staggered from one side to the other on alternate poles; otherwise spanning capability is greatly reduced. However, for the span adjoining the strain position, which has the middle phase centred on the pole, the average separation between phases is reduced.

Bare 11kV Mains – Intermediate Constructions…

CONSTRUCTION		SLACK 2% NBL			URBAN 6% NBL			LIMITED 10% NBL				MEDIUM 18% NBL				FULL 22% NBL	
APL	**Description**	MERCURY	NEPTUNE	FLUORINE	MERCURY	NEPTUNE	FLUORINE	MERCURY	NEPTUNE	FLUORINE	3/2.75 SC/GZ	MERCURY	NEPTUNE	FLUORINE	3/2.75 SC/GZ	FLUORINE	3/2.75 SC/GZ
I/11/3	Intermediate Flat Single Pin 3ph	0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-18°	0-25°	0-20°	0-15°	0-10°	0-20°	0-11°	0-17°	0-9°
IB/11/3	Mid phase centred or staggered	59m/0°	59m/0°	73m/0°	100m/0°	100m/0°	123m/0°	126m/0°	126m/0°	154m/0°	213m/0°	163m/0°	163m/0°	200m/0°	284m/0°	219m/0°	315m/0°
	Mk4 Xarm	57m/25°	57m/25°	71m/25°	97m/25°	97m/25°	120m/25°	123m/25°	122m/18°	150m/25°	209m/20°	161m/15°	162m/10°	196m/20°	282m/11°	216m/17°	314m/9°
	Intermediate Flat Single Pin 3ph	0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-18°	0-25°	0-20°	0-15°	0-10°	0-20°	0-11°	0-17°	0-9°
	mid phase offset one end, centred	45m/0°	45m/0°	56m/0°	75m/0°	75m/0°	91m/0°	93m/0°	93m/0°	113m/0°	159m/0°	119m/0°	119m/0°	146m/0°	214m/0°	160m/0°	239m/0°
	other end – see Note 4	43m/25°	43m/25°	54m/25°	73m/25°	73m/25°	88m/25°	90m/25°	91m/18°	110m/25°	156m/20°	118m/15°	118m/10°	143m/20°	212m/11°	158m/17°	238m/9°
	Mk4 Xarm																
I/11/1	Intermediate Flat Single Pin 1ph	0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-18°	0-25°	0-20°	0-15°	0-10°	0-20°	0-11°	0-17°	0-9°
	Mk4 Xarm	120m/0°	120m/0°	161m/0°	209m/0°	209m/0°	261m/0°	269m/0°	269m/0°	336m/0°	455m/0°	357m/0°	357m/0°	444m/0°	605m/0°	470m/0°	667m/0°
								237m/10°	179m/10°			218m/8°	200m/5°	318m/10°		309m/10°	
		117m/25°	117m/25°	157m/25°	204m/25°	194m/25°	254m/25°	133m/25°	122m/18°	328m/25°	448m/20°	150m/15°	146m/10°	205m/20°	420m/11°	229m/17°	450m/9°
IDS/11/3	Intermediate Delta Single Pin 3ph	0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-18°	0-25°	0-20°	0-15°	0-10°	0-20°	0-11°	0-17°	0-9°
	Small (460mm mid-phase raise)	71m/0°	71m/0°	90m/0°	122m/0°	122m/0°	152m/0°	155m/0°	155m/0°	192m/0°	263m/0°	203m/0°	203m/0°	250m/0°	349m/0°	274m/0°	385m/0°
	Mk4 Xarm							152m/20°	153m/15°			202m/8°	200m/5°	249 m/10°		272m/10°	
		69m/25°	69m/25°	87m/25°	119m/25°	119m/25°	148m/25°	133m/25°	122m/25°	187m/25°	256m/20°	150m/15°	146m/10°	205m/20°	347m/11°	229m/17°	383m/9°
IDL/11/3	Intermediate Delta Single Pin 3ph	0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-18°	0-25°	0-20°	0-15°	0-10°	0-20°	0-11°	0-17°	0-9°
	Large (920mm mid-phase raise)	94m/0°	94m/0°	118m/0°	162m/0°	162m/0°	203m/0°	208m/0°	208m/0°	258m/0°	351m/0°	274m/0°	274m/0°	339m/0°	466m/0°	372m/0°	514m/0°
	Mk4 Xarm							207m/10°	179m/10°			218m/8°	200m/5°	318m/10°		309m/10°	
		91m/25°	91m/25°	115m/25°	158m/25°	158m/25°	198m/25°	133m/25°	122m/18°	251m/25°	345m/20°	150m/15°	146m/10°	205m/20°	420m/11°	229m/17°	450m/9°
O/11/3	Offset Single Pin 3ph	0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-18°	0-25°	0-20°	0-15°	0-10°	0-20°	0-11°	0-17°	0-9°
	Mk4 Xarm	46m/0°	46m/0°	57m/0°	78m/0°	78m/0°	95m/0°	97m/0°	97m/0°	118m/0°	165m/0°	124m/0°	124m/0°	152m/0°	222m/0°	167m/0°	247m/0°
		44m/25°	44m/25°	55m/25°	76m/25°	76m/25°	92m/25°	94m/25°	95m/18°	115m/25°	162m/20°	123m/15°	123m/10°	149m/20°	220m/11°	165m/17°	246m/9°
TRI/11/3	Trident 3ph or 1ph	0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-18°	0-25°	0-20°	0-15°	0-10°	0-20°	0-11°	0-17°	0-9°
	(Obsolete Construction)	56m/0°	56m/0°	69m/0°	94m/0°	94m/0°	116m/0°	119m/0°	119m/0°	145m/0°	201m/0°	154m/0°	154m/0°	188m/0°	268m/0°	206m/0°	298m/0°
		54m/25°	54m/25°	67m/25°	91m/25°	91m/25°	113m/25°	116m/25°	117m/18°	141m/25°	197m/20°	152m/15°	146m/10°	184m/20°	266m/11°	203m/17°	297m/9°
IV/11/3	Vertical Double Cct 2 x 3ph	0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-18°	0-25°	0-20°	0-15°	0-10°	0-20°	0-11°	0-17°	0-9°
	Mk4 Xarm	61m/0°	61m/0°	76m/0°	103m/0°	103m/0°	128m/0°	131m/0°	131m/0°	160m/0°	221m/0°	170m/0°	170m/0°	208m/0°	294m/0°	228m/0°	326m/0°
		61m/25°	61m/25°	76m/25°	103m/25°	103m/25°	128m/25°	131m/25°	131m/18°	160m/25°	221m/20°	170m/15°	146m/10°	208m/20°	294m/11°	228m/17°	326m/9°

Notes:

1. Span and angle limitations reflect strength limitations of components, clearance limitations and avoidance of mid-span clashing. Designers still need to allow for other limitations such as ground clearance, intercircuit clearance and tip loads on poles.
2. Standard crossarm sizes and geometry is assumed. Assumes vibration protection installed on tight-strung lines or other locations susceptible to aeolian vibration.
3. Ice loading case not considered in above limits.
4. Where the middle phase is offset from centre, it should be staggered from one side to the other on alternate poles; otherwise spanning capability is greatly reduced. However, for the span adjoining the strain position, which has the middle phase centred on the pole, the average separation between phases is reduced.

8.4.6 Bare 11kV Mains – Strain Constructions

CONSTRUCTION		SLACK 2% NBL			URBAN 6% NBL			LIMITED 10% NBL				MEDIUM 18% NBL				FULL 22% NBL	
APL	Description	MERCURY	NEPTUNE	FLUORINE	MERCURY	NEPTUNE	FLUORINE	MERCURY	NEPTUNE	FLUORINE	3/2.75 SC/GZ	MERCURY	NEPTUNE	FLUORINE	3/2.75 SC/GZ	FLUORINE	3/2.75 SC/GZ
S/11/3/	Strain FRP X-arm 3ph	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°
FRP		78m/0°	78m/0°	97m/0°	134m/0°	134m/0°	165m/0°	172m/0°	172m/0°	209m/0°	284m/0°	225m/0°	133m/0°	272m/0°	378m/0°	298m/0°	418m/0°
		70m/50°	70m/50°	87m/50°	117m/50°	117m/50°	145m/50°	150m/50°	150m/50°	183m/50°	253m/50°	200m/50°	133m/50°	244m/50°	336m/50°	265m/50°	372m/50°
S/11/1/	Strain FRP X-arm 1ph	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°
FRP		154m/0°	154m/0°	196m/0°	275m/0°	275m/0°	340m/0°	355m/0°	270m/0°	437m/0°	590m/0°	268m/0°	133m/0°	520m/0°	575m/0°	420m/0°	480m/0°
		139m/50°	139m/50°	177m/50°	246m/50°	246m/50°	309m/50°	318m/50°	270m/50°	392m/50°	529m/50°	268m/50°	133m/50°	473m/50°	525m/50°	381m/50°	480m/50°
DELTA	Strain Delta FRP X-arm 3ph	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°
S/11/3/	Small (460mm mid-phase raise)	83m/0°	83m/0°	103m/0°	143m/0°	143m/0°	176m/0°	183m/0°	183m/0°	223m/0°	304m/0°	240m/0°	133m/0°	291m/0°	403m/0°	319m/0°	445m/0°
FRP small		75m/50°	75m/50°	95m/50°	129m/50°	129m/50°	159m/50°	166m/50°	166m/50°	202m/50°	280m/50°	220m/50°	133m/50°	264m/50°	365m/50°	289m/50°	403m/50°
DELTA	Strain Delta FRP X-arm 3ph	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°
S/11/3/	Large (920mm mid-phase raise)	100m/0°	100m/0°	124m/0°	174m/0°	174m/0°	214m/0°	223m/0°	223m/0°	273m/0°	370m/0°	268m/0°	133m/0°	358m/0°	491m/0°	393m/0°	480m/0°
FRP large		94m/50°	94m/50°	117m/50°	163m/50°	163m/50°	201m/50°	208m/50°	208m/50°	255m/50°	350m/50°	268m/50°	133m/50°	336m/50°	461m/50°	369m/50°	480m/50°
SV/11/3/	Strain Vertical FRP X-arms 3ph	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°
FRP		61m/0°	61m/0°	76m/0°	131m/0°	131m/0°	160m/0°	131m/0°	131m/0°	160m/0°	221m/0°	167m/0°	133m/0°	208m/0°	294m/0°	228m/0°	325m/0°
		61m/50°	61m/50°	78m/50°	131m/50°	131m/50°	160m/50°	131m/50°	131m/50°	160m/50°	221m/50°	167m/50°	133m/50°	208m/50°	294m/50°	228m/50°	325m/50°
DE/11/3/ FRP	Dead End FRP X-arm 3ph	78m	78m	97m	134m	134m	165m	172m	172m	209m	284m	225m	133m	272m	378m	298m	418m
DE/11/1/ FRP	Dead End FRP X-arm 1ph	154m	154m	196m	275m	275m	340m	355m	270m	437m	590m	268m	133m	520m	575m	420m	480m
DELTA DE/11/3/ FRP small	Dead End Delta FRP X-arm 3ph Small (460mm mid-phase raise)	83m	83m	103m	143m	143m	176m	183m	183m	223m	304m	240m	133m	291m	403m	319m	445m
DELTA DE/11/3/ FRP large	Dead End Delta FRP X-arm 3ph Large (920mm mid-phase raise)	100m	100m	124m	174m	174m	214m	223m	223m	273m	370m	268m	133m	358m	491m	393m	480m
DEV/11/3/ FRP	Dead End Vertical 2 Cct FRP X-arms 2x3ph	61m	61m	76m	131m	131m	160m	131m	106m	160m	221m	167m	143m	208m	294m	228m	325m

Notes:

1. Span and angle limitations reflect strength limitations of components, clearance limitations and avoidance of mid-span clashing. Designers still need to allow for other limitations such as ground clearance, intercircuit clearance and tip loads on poles.
2. Standard crossarm sizes and geometry is assumed. Assumes vibration protection installed on tight-strung lines or other locations susceptible to aeolian vibration.
3. Ice loading case not considered in above limits.
4. The same limitations apply to underslung constructions as to equivalent bridging pin constructions.

Bare 11kV Mains – Strain Constructions…

CONSTRUCTION		SLACK 2% NBL			URBAN 6% NBL			LIMITED 10% NBL				MEDIUM 18% NBL				FULL 22% NBL	
APL	**Description**	MERCURY	NEPTUNE	FLUORINE	MERCURY	NEPTUNE	FLUORINE	MERCURY	NEPTUNE	FLUORINE	3/2.75 SC/GZ	MERCURY	NEPTUNE	FLUORINE	3/2.75 SC/GZ	FLUORINE	3/2.75 SC/GZ
S/11/3	Strain Mk5 X-arm 3ph	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-40°	0-50°	0-50°	0-50°	0-50°
		55m/0°	55m/0°	68m/0°	93m/0°	93m/0°	114m/0°	117m/0°	117m/0°	143m/0°	198m/0°	151m/0°	95m/0°	184m/0°	264m/0°	202m/0°	293m/0°
		49m/50°	49m/50°	61m/50°	84m/50°	84m/50°	103m/50°	106m/50°	106m/50°	129m/50°	179m/50°	104m/50°	83m/40°	166m/50°	239m/50°	183m/50°	194m/50°
S/11/1	Strain Mk5 X-arm 1ph	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-40°	0-50°	0-50°	0-50°	0-50°
		114m/0°	114m/0°	144m/0°	199m/0°	199m/0°	249m/0°	255m/0°	255m/0°	319m/0°	432m/0°	167m/0°	95m/0°	370m/0°	380m/0°	320m/0°	325m/0°
						194m/25°		248m/25°	216m/25°			167m/25°	95m/20°	360m/25°	380m/25°	320m/25°	325m/30°
		103m/50°	103m/50°	130m/50°	180m/50°	180m/50°	225m/50°	196m/50°	108m/50°	289m/50°	355m/50°	104m/50°	83m/40°	213m/50°	229m/50°	195m/50°	194m/50°
DELTA S/11/3 Small	Strain Delta Mk5 X-arm 3ph Small (460mm mid-phase raise)	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-40°	0-50°	0-50°	0-50°	0-50°
		69m/0°	69m/0°	87m/0°	118m/0°	118m/0°	147m/0°	150m/0°	150m/0°	185m/0°	253m/0°	167m/0°	95m/0°	240m/0°	336m/0°	263m/0°	325m/0°
												167m/25°	95m/20°	233m/30°	324m/30°	254m/30°	325m/30°
		62m/50°	62m/50°	78m/50°	106m/50°	113m/50°	133m/50°	135m/50°	108m/50°	167m/50°	229m/50°	104m/50°	83m/40°	213m/50°	229m/50°	195m/50°	194m/50°
DELTA S/11/3 Large	Strain Delta Mk5 X-arm 3ph Large (920mm mid-phase raise)	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-40°	0-50°	0-50°	0-50°	0-50°
		92m/0°	92m/0°	116m/0°	159m/0°	159m/0°	199m/0°	204m/0°	204m/0°	253m/0°	344m/0°	167m/0°	95m/0°	332m/0°	380m/0°	320m/0°	325m/0°
						155m/25°			199m/25°			167m/25°	95m/20°	324m/25°	380m/25°	320m/25°	325m/30°
		83m/50°	83m/50°	105m/50°	144m/50°	113m/50°	180m/50°	184m/50°	108m/50°	229m/50°	311m/50°	104m/50°	83m/40°	213m/50°	229m/50°	195m/50°	194m/50°
SV/11/3	Strain Vertical Mk5 X-arm 3ph	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-40°	0-50°	0-50°	0-50°	0-50°
		61m/0°	61m/0°	76m/0°	131m/0°	131m/0°	160m/0°	131m/0°	131m/0°	160m/0°	221m/0°	167m/0°	95m/0°	208m/0°	294m/0°	228m/0°	325m/0°
		55m/50°	55m/50°	68m/50°	118m/50°	113m/50°	145m/50°	118m/50°	108m/50°	145m/50°	200m/50°	104m/50°	83m/40°	188m/50°	266m/50°	195m/50°	194m/50°
DE/11/3	Dead End Mk5 X-arm 3ph	55m	55m	68m	93m	93m	114m	117m	117m	143m	198m	151m	95m	184m	264m	202m	293m
DE/11/1	Dead End Mk5 X-arm 1ph	114m	114m	144m	199m	199m	249m	255m	255m	319m	432m	167m	95m	370m	380m	320m	325m
DELTA DE/11/3 Small	Dead End Delta Mk5 X-arm 3ph Small (460mm mid-phase raise)	69m	69m	87m	118m	118m	147m	150m	150m	185m	253m	167m	95m	240m	336m	263m	325m
DELTA DE/11/3 Large	Dead End Delta Mk5 X-arm 3ph Large (920mm mid-phase raise)	92m	92m	116m	159m	159m	199m	204m	204m	253m	344m	167m	95m	332m	380m	320m	325m
DEV/11/3	Dead End Vertical 2 Cct Mk5 X-arm 2x3ph	61m	61m	76m	131m	131m	160m	131m	131m	160m	221m	167m	95m	208m	294m	228m	325m

Notes:

1. Span and angle limitations reflect strength limitations of components, clearance limitations and avoidance of mid-span clashing. Designers still need to allow for other limitations such as ground clearance, intercircuit clearance and tip loads on poles.
2. Standard crossarm sizes and geometry is assumed. Assumes vibration protection installed on tight-strung lines or other locations susceptible to aeolian vibration.
3. Ice loading case not considered in above limits.
4. The same limitations apply to underslung constructions as to equivalent bridging pin constructions.

8.4.7 Bare 22kV Mains – Intermediate Constructions

CONSTRUCTION			SLACK 2% NBL			URBAN 6% NBL			LIMITED 10% NBL				MEDIUM 18% NBL				FULL 22% NBL	
APL	**Description**		MERCURY	NEPTUNE	FLUORINE	MERCURY	NEPTUNE	FLUORINE	MERCURY	NEPTUNE	FLUORINE	3/2.75 SC/GZ	MERCURY	NEPTUNE	FLUORINE	3/2.75 SC/GZ	FLUORINE	3/2.75 SC/GZ
I/22/3/ FRP	Intermediate Flat Pin 3ph FRP Xarm See Note 4	Mid phase centred or staggered	0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-18°	0-25°	0-20°	0-15°	0-10°	0-20°	0-11°	0-17°	0-9°
			72m/0°	72m/0°	88m/0°	124m/0°	124m/0°	150m/0°	157m/0°	157m/0°	191m/0°	261m/0°	220m/0°	220m/0°	248m/0°	345m/0°	271m/0°	381m/0°
			67m/25°	67m/25°	83m/25°	117m/25°	117m/25°	141m/25°	149m/25°	149m/18°	182m/25°	250m/20°	210m/15°	210m/10°	236m/20°	238m/11°	259m/17°	374m/9°
		Mid phase not staggered or centred	0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-18°	0-25°	0-20°	0-15°	0-10°	0-20°	0-11°	0-17°	0-9°
			41m/0°	41m/0°	50m/0°	68m/0°	68m/0°	82m/0°	85m/0°	85m/0°	101m/0°	143m/0°	106m/0°	106m/0°	130m/0°	194m/0°	143m/0°	217m/0°
			38m/25°	38m/25°	47m/25°	64m/25°	64m/25°	78m/25°	80m/25°	80m/18°	96m/25°	138m/20°	102m/15°	103m/10°	124m/20°	191m/11°	137m/17°	213m/9°
		Mid phase offset one end, centred other end	0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-18°	0-25°	0-20°	0-15°	0-10°	0-20°	0-11°	0-17°	0-9°
			57m/0°	57m/0°	70m/0°	97m/0°	97m/0°	118m/0°	123m/0°	123m/0°	148m/0°	205m/0°	160m/0°	160m/0°	192m/0°	273m/0°	210m/0°	303m/0°
			53m/25°	53m/25°	65m/25°	91m/25°	91m/25°	111m/25°	117m/25°	117m/18°	140m/25°	188m/20°	154m/15°	154m/10°	181m/20°	267m/11°	202m/17°	295m/9°
I/22/1/ FRP	Intermediate Flat Pin 1ph FRP Xarm		0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-18°	0-25°	0-20°	0-15°	0-10°	0-20°	0-11°	0-17°	0-9°
			144m/0°	144m/0°	183m/0°	257m/0°	257m/0°	317m/0°	332m/0°	240m/0°	408m/0°	551m/0°	380m/0°	270m/0°	520m/0°	736m/0°	420m/0°	800m/0°
			136m/25°	136m/25°	173m/25°	242m/25°	242m/25°	302m/25°	318m/25°	243m/18°	390m/25°	528m/20°	340m/15°	240m/10°	400m/20°	640m/11°	400m/17°	750m/9°
DELTA I/22/3/ FRP	Intermediate Delta Pin 3ph FRP Xarm & Riser		0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-18°	0-25°	0-20°	0-15°	0-10°	0-20°	0-11°	0-17°	0-9°
			109m/0°	109m/0°	136m/0°	189m/0°	189m/0°	236m/0°	243m/0°	243m/0°	303m/0°	409m/0°	323m/0°	270m/0°	401m/0°	545m/0°	420m/0°	570m/0°
			104m/25°	104m/25°	123m/25°	171m/25°	171m/25°	213m/25°	220m/25°	220m/18°	274m/25°	384m/20°	311m/15°	240m/10°	376m/20°	534m/11°	400m/17°	529m/9°
OFFSET /22/3 /FRP	Offset Pin 3ph FRP Xarm		0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-18°	0-25°	0-20°	0-15°	0-10°	0-20°	0-11°	0-17°	0-9°
			56m/0°	56m/0°	69m/0°	96m/0°	96m/0°	117m/0°	121m/0°	121m/0°	146m/0°	202m/0°	157m/0°	157m/0°	189m/0°	269m/0°	207m/0°	299m/0°
			52m/25°	52m/25°	64m/25°	91m/25°	91m/25°	111m/25°	114m/25°	114m/18°	134m/25°	195m/20°	151m/15°	151m/10°	180m/20°	264m/11°	199m/17°	294m/9°
IV/22/3 /FRP	Vertical Double Cct 2 x 3ph FRP Xarms		0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-18°	0-25°	0-20°	0-15°	0-10°	0-20°	0-11°	0-17°	0-9°
			57m/0°	57m/0°	70m/0°	95m/0°	95m/0°	118m/0°	121m/0°	121m/0°	147m/0°	204m/0°	156m/0°	156m/0°	190m/0°	272m/0°	209m/0°	302m/0°
			57m/25°	57m/25°	70m/25°	95m/25°	95m/25°	118m/25°	121m/25°	121m/18°	147m/25°	204m/20°	156m/15°	146m/10°	190m/20°	272m/11°	209m/17°	302m/9°

Notes:

1. Span and angle limitations reflect strength limitations of components, clearance limitations and avoidance of mid-span clashing. Designers still need to allow for other limitations such as ground clearance, intercircuit clearance and tip loads on poles.
2. Standard crossarm sizes and geometry is assumed. Assumes vibration protection installed on tight-strung lines or other locations susceptible to aeolian vibration.
3. Ice loading case not considered in above limits.
4. Where the middle phase is offset from centre, it should be staggered from one side to the other on alternate poles; otherwise spanning capability is greatly reduced. However, for the span adjoining the strain position, which has the middle phase centred on the pole, the average separation between phases is reduced.

Bare 22kV Mains – Intermediate Constructions …

CONSTRUCTION		SLACK 2% NBL			URBAN 6% NBL			LIMITED 10% NBL				MEDIUM 18% NBL				FULL 22% NBL	
APL	**Description**	MERCURY	NEPTUNE	FLUORINE	MERCURY	NEPTUNE	FLUORINE	MERCURY	NEPTUNE	FLUORINE	3/2.75 SC/GZ	MERCURY	NEPTUNE	FLUORINE	3/2.75 SC/GZ	FLUORINE	3/2.75 SC/GZ
I/22/3 IB/22/3	Intermediate Flat Single Pin 3ph (mid phase centred or staggered) Mk4 Xarm	0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-18°	0-25°	0-20°	0-15°	0-10°	0-20°	0-11°	0-17°	0-9°
		55m/0°	55m/0°	67m/0°	92m/0°	92m/0°	113m/0°	116m/0°	116m/0°	141m/0°	196m/0°	149m/0°	149m/0°	182m/0°	261m/0°	200m/0°	290m/0°
		53m/25°	53m/25°	65m/25°	89m/25°	89m/25°	110m/25°	113m/25°	114m/18°	137m/25°	193m/20°	147m/15°	148m/10°	178m/20°	259m/11°	197m/17°	289m/9°
	Intermediate Flat Single Pin 3ph w. mid phase offset one end, centred other end – see Note 4 Mk4 Xarm	0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-18°	0-25°	0-20°	0-15°	0-10°	0-21°	0-11°	0-17°	0-9°
		40m/0°	40m/0°	50m/0°	67m/0°	67m/0°	81m/0°	83m/0°	83m/0°	100m/0°	142m/0°	105m/0°	105m/0°	129m/0°	192m/0°	142m/0°	215m/0°
		39m/25°	39m/25°	48m/25°	65m/25°	65m/25°	79m/25°	81m/25°	81m/18°	97m/25°	139m/20°	104m/15°	104m/10°	126m/20°	190m/11°	140m/17°	214m/9°
I/22/1	Intermediate Flat Single Pin 1ph Mk4 Xarm	0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-18°	0-25°	0-20°	0-15°	0-10°	0-20°	0-11°	0-17°	0-9°
		116m/0°	116m/0°	146m/0°	201m/0°	201m/0°	252m/0°	259m/0°	259m/0°	323m/0°	438m/0°	344m/0°	344m/0°	427m/0°	582m/0°	469m/0°	642m/0°
								237m/10°	179m/10°			218m/8°	200m/5°	318m/10°		309m/10°	
		113m/25°	113m/25°	142m/25°	196m/25°	194m/25°	246m/25°	133m/25°	122m/18°	315m/25°	431m/20°	150m/15°	146m/10°	205m/20°	420m/11°	229m/17°	450m/9°
IDS/22/3	Intermediate Delta Single Pin 3ph Small (460mm mid-phase raise) Mk4 Xarm	0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-18°	0-25°	0-20°	0-15°	0-10°	0-20°	0-11°	0-17°	0-9°
		67m/0°	67m/0°	84m/0°	114m/0°	114m/0°	142m/0°	145m/0°	145m/0°	179m/0°	246m/0°	190m/0°	190m/0°	233m/0°	326m/0°	255m/0°	361m/0°
								144 m/10°	144 m/10°			189 m/10°	189m/5°	231 m/15°		254 m/10°	
		65m/25°	65m/25°	82m/25°	111m/25°	111m/25°	138m/25°	133m/25°	122m/18°	174m/25°	242m/20°	150m/15°	140m/10°	205m/20°	324m/11°	229m/17°	359m/9°
IDL/22/3	Intermediate Delta Single Pin 3ph Large (920mm mid-phase raise) Mk4 Xarm	0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-18°	0-25°	0-20°	0-15°	0-10°	0-20°	0-11°	0-17°	0-9°
		90m/0°	90m/0°	113m/0°	155m/0°	155m/0°	193m/0°	198m/0°	198m/0°	246m/0°	334m/0°	261m/0°	261m/0°	322m/0°	443m/0°	353m/0°	489m/0°
								197m/10°	179m/10°			218m/8°	200m/5°	318m/10°		309m/10°	
		87m/25°	87m/25°	110m/25°	151m/25°	151m/25°	188m/25°	133m/25°	122m/18°	240m/25°	328m/20°	150m/15°	146m/10°	205m/20°	420m/11°	229m/17°	450m/9°
O/22/3	Offset Single Pin 3ph Mk4 Xarm	0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-18°	0-25°	0-20°	0-15°	0-10°	0-20°	0-11°	0-17°	0-9°
		42m/0°	42m/0°	52m/0°	69m/0°	69m/0°	84m/0°	86m/0°	86m/0°	104m/0°	148m/0°	110m/0°	110m/0°	134m/0°	200m/0°	148m/0°	223m/0°
		40m/25°	40m/25°	50m/25°	67m/25°	67m/25°	82m/25°	83m/25°	84m/18°	101m/25°	145m/20°	109m/15°	109m/10°	131m/20°	199m/11°	146m/17°	222m/9°
TRI/22/3	Trident 3ph or 1ph (Obsolete Construction)	0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-18°	0-25°	0-20°	0-15°	0-10°	0-20°	0-11°	0-17°	0-9°
		51m/0°	51m/0°	64m/0°	86m/0°	86m/0°	106m/0°	109m/0°	109m/0°	132m/0°	184m/0°	140m/0°	140m/0°	171m/0°	246m/0°	187m/0°	274m/0°
		49m/25°	49m/25°	62m/25°	83m/25°	83m/25°	103m/25°	106m/25°	107m/18°	128m/25°	181m/20°	138m/15°	139m/10°	168m/20°	244m/11°	184m/17°	273m/9°
IV/22/3	Vertical Double Cct 2 x 3ph Mk4 Xarm	0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-25°	0-18°	0-25°	0-20°	0-15°	0-10°	0-20°	0-11°	0-17°	0-9°
		57m/0°	57m/0°	70m/0°	95m/0°	95m/0°	118m/0°	121m/0°	121m/0°	147m/0°	204m/0°	156m/0°	156m/0°	190m/0°	272m/0°	209m/0°	302m/0°
		57m/25°	57m/25°	70m/25°	95m/25°	95m/25°	118m/25°	121m/25°	121m/18°	147m/25°	204m/20°	156m/15°	146m/10°	190m/20°	272m/11°	209m/17°	302m/9°

Notes:

1. Span and angle limitations reflect strength limitations of components, clearance limitations and avoidance of mid-span clashing. Designers still need to allow for other limitations such as ground clearance, intercircuit clearance and tip loads on poles.
2. Standard crossarm sizes and geometry is assumed. Assumes vibration protection installed on tight-strung lines or other locations susceptible to aeolian vibration.
3. Ice loading case not considered in above limits.
4. Reduced centre-phase to outer phase spacing can occur on the lower circuit of a double-circuit horizontal construction. While the centre phase is staggered throughout, for the span adjoining the strain position the average separation between phases is reduced.

8.4.8 Bare 22kV Mains – Strain Constructions

CONSTRUCTION		SLACK 2% NBL			URBAN 6% NBL			LIMITED 10% NBL				MEDIUM 18% NBL				FULL 22% NBL	
APL	Description	MERCURY	NEPTUNE	FLUORINE	MERCURY	NEPTUNE	FLUORINE	MERCURY	NEPTUNE	FLUORINE	3/2.75 SC/GZ	MERCURY	NEPTUNE	FLUORINE	3/2.75 SC/GZ	FLUORINE	3/2.75 SC/GZ
S/22/3/FRP	Strain FRP X-arm 3ph	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°
		74m/0°	74m/0°	91m/0°	127m/0°	127m/0°	155m/0°	161m/0°	161m/0°	196m/0°	268m/0°	211m/0°	133m/0°	255m/0°	355m/0°	279m/0°	393m/0°
		65m/50°	65m/50°	80m/50°	111m/50°	111m/50°	136m/50°	140m/50°	140m/50°	127m/50°	237m/50°	186m/50°	133m/50°	223m/50°	311m/50°	244m/50°	344m/50°
S/22/1/FRP	Strain FRP X-arm 1ph	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°
		144m/0°	144m/0°	183m/0°	257m/0°	257m/0°	317m/0°	332m/0°	270m/0°	408m/0°	551m/0°	268m/0°	133m/0°	520m/0°	575m/0°	420m/0°	480m/0°
		129m/50°	129m/50°	164m/50°	230m/50°	230m/50°	285m/50°	297m/50°	270m/50°	365m/50°	494m/50°	268m/50°	133m/50°	520m/50°	575m/50°	420m/50°	480m/50°
SDS/22/3/ FRP Small	Strain Delta FRP X-arm 3ph Small (460mm mid-phase raise)	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°
		79m/0°	79m/0°	97m/0°	135m/0°	135m/0°	168m/0°	173m/0°	173m/0°	210m/0°	287m/0°	226m/0°	133m/0°	274m/0°	380m/0°	300m/0°	420m/0°
		72m/50°	72m/50°	88m/50°	122m/50°	122m/50°	150m/50°	157m/50°	157m/50°	190m/50°	259m/50°	206m/50°	133m/50°	249m/50°	345m/50°	272m/50°	381m/50°
SDL/22/3/ FRP Large	Strain Delta FRP X-arm 3ph Large (920mm mid-phase raise)	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°
		96m/0°	96m/0°	119m/0°	166m/0°	166m/0°	204m/0°	212m/0°	212m/0°	260m/0°	353m/0°	268m/0°	133m/0°	341m/0°	468m/0°	374m/0°	480m/0°
		90m/50°	90m/50°	112m/50°	155m/50°	155m/50°	191m/50°	199m/50°	199m/50°	243m/50°	331m/50°	266m/50°	133m/50°	320m/50°	439m/50°	351m/50°	480m/50°
SV/22/3/FRP	Strain Vertical 2 Cct FRP X-arm 3ph	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°
		57m/0°	57m/0°	70m/0°	95m/0°	95m/0°	118m/0°	121m/0°	121m/0°	147m/0°	204m/0°	156m/0°	133m/0°	190m/0°	272m/0°	209m/0°	302m/0°
		57m/50°	57m/50°	70m/50°	95m/50°	95m/50°	118m/50°	121m/50°	121m/50°	147m/50°	204m/50°	156m/50°	133m/50°	190m/50°	272m/50°	209m/50°	302m/50°
DE/22/3/ FRP	Dead End FRP X-arm 3ph	74m	74m	91m	127m	127m	155m	161m	161m	196m	268m	211m	60m	255m	355m	279m	393m
DE/22/1/ FRP	Dead End FRP X-arm 1ph	144m	144m	183m	257m	257m	317m	332m	270m	408m	551m	268m	133m	520m	575m	420m	480m
DEDS/22/3/ FRP Small	Dead End Delta FRP X-arm 3ph Small (460mm mid-phase raise)	79m	79m	97m	135m	135m	168m	173m	173m	210m	287m	226m	133m	274m	380m	300m	420m
DEDL/22/3/ FRP Large	Dead End Delta FRP X-arm 3ph Large (920mm mid-phase raise)	96m	96m	119m	166m	166m	204m	212m	212m	260m	353m	268m	133m	341m	468m	374m	480m
DEV/22/3/ FRP	Dead End Vertical 2 Cct FRP X-arm 2x3ph	57m	57m	70m	95m	95m	118m	121m	106m	147m	204m	156m	133m	190m	272m	209m	302m

Notes:

1. Span and angle limitations reflect strength limitations of components, clearance limitations and avoidance of mid-span clashing. Designers still need to allow for other limitations such as ground clearance, intercircuit clearance and tip loads on poles.
2. Standard crossarm sizes and geometry is assumed. Assumes vibration protection installed on tight-strung lines or other locations susceptible to aeolian vibration.
3. Ice loading case not considered in above limits.
4. The same limitations apply to underslung constructions as to equivalent bridging pin constructions.

Bare 22kV Mains – Strain Constructions …

CONSTRUCTION		SLACK 2% NBL			URBAN 6% NBL			LIMITED 10% NBL				MEDIUM 18% NBL				FULL 22% NBL	
APL	**Description**	MERCURY	NEPTUNE	FLUORINE	MERCURY	NEPTUNE	FLUORINE	MERCURY	NEPTUNE	FLUORINE	3/2.75 SC/GZ	MERCURY	NEPTUNE	FLUORINE	3/2.75 SC/GZ	FLUORINE	3/2.75 SC/GZ
S/22/3	Strain Mk5 X-arm 3ph	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-40°	0-50°	0-50°	0-50°	0-50°
		50m/0°	50m/0°	62m/0°	85m/0°	85m/0°	104m/0°	106m/0°	106m/0°	130m/0°	181m/0°	137m/0°	95m/0°	167m/0°	242m/0°	184m/0°	269m/0°
		45m/50°	45m/50°	43m/50°	54m/50°	54m/50°	94m/50°	96m/50°	96m/50°	117m/50°	164m/50°	104m/50°	83m/40°	151m/50°	219m/50°	166m/50°	194m/50°
S/22/1	Strain Mk5 X-arm 1ph	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-40°	0-50°	0-50°	0-50°	0-50°
		110m/0°	110m/0°	139m/0°	191m/0°	191m/0°	239m/0°	245m/0°	245m/0°	306m/0°	415m/0°	167m/0°	95m/0°	370m/0°	380m/0°	320m/0°	325m/0°
						186m/25°			216m/25°			167m/25°	95m/20°	360m/25°	380m/25°	320m/25°	325m/30°
		99m/50°	99m/50°	125m/50°	173m/50°	173m/50°	216m/50°	196m/50°	108m/50°	277m/50°	355m/50°	104m/50°	83m/40°	213m/50°	229m/50°	195m/50°	194m/50°
DELTA	Strain Delta Mk5 X-arm 3ph	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-40°	0-50°	0-50°	0-50°	0-50°
S/22/3	Small (460mm mid-phase raise)	65m/0°	65m/0°	81m/0°	110m/0°	110m/0°	137m/0°	140m/0°	140m/0°	172m/0°	236m/0°	167m/0°	95m/0°	223m/0°	314m/0°	244m/0°	325m/0°
Small									133m/35°			167m/25°	95m/20°	217m/25°	303m/30°	235m/30°	325m/30°
		58m/50°	58m/50°	73m/50°	99m/50°	99m/50°	124m/50°	126m/50°	108m/50°	155m/50°	213m/50°	104m/50°	83m/40°	213m/50°	229m/50°	195m/50°	194m/50°
DELTA	Strain Delta Mk5 X-arm 3ph	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-40°	0-50°	0-50°	0-50°	0-50°
S/22/3	Large (920mm mid-phase raise)	88m/0°	88m/0°	110m/0°	151m/0°	151m/0°	189m/0°	194m/0°	194m/0°	240m/0°	327m/0°	167m/0°	95m/0°	315m/0°	380m/0°	320m/0°	325m/0°
Large						147m/25°			189m/25°			167m/25°	95m/20°	307m/25°	380m/25°	320m/25°	325m/30°
		79m/50°	79m/50°	99m/50°	136m/50°	136m/50°	171m/50°	175m/50°	108m/50°	217m/50°	296m/50°	104m/50°	83m/40°	213m/50°	229m/50°	195m/50°	194m/50°
SV/22/3	Strain Vertical 2 Cct	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-40°	0-50°	0-50°	0-50°	0-50°
	Mk5 X-arm 3ph	57m/0°	57m/0°	70m/0°	95m/0°	95m/0°	118m/0°	121m/0°	121m/0°	147m/0°	204m/0°	156m/0°	95m/0°	190m/0°	272m/0°	209m/0°	302m/0°
		51m/50°	51m/50°	63m/50°	86m/50°	86m/50°	106m/50°	109m/50°	108m/50°	133m/50°	m/50°	104m/50°	83m/40°	172m/50°	246m/50°	189m/50°	194m/50°
DE/22/3	Dead End Mk5 X-arm 3ph	50m	50m	62m	85m	85m	104m	106m	106m	130m	181m	137m	95m	167m	242m	184m	269m
DE/22/1	Dead End Mk5 X-arm 1ph	110m	110m	139m	191m	191m	239m	245m	245m	306m	415m	167m	95m	370m	380m	320m	325m
DELTA DE/22/3 Small	Dead End Delta Mk5 X-arm 3ph Small (460mm mid-phase raise)	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m
DELTA DE/22/3 Large	Dead End Delta Mk5 X-arm 3ph Large (920mm mid-phase raise)	88m	88m	110m	151m	151m	189m	194m	194m	240m	327m	167m	95m	315m	380m	320m	325m
DEV/22/3	Dead End Vertical 2 Cct Mk5 X-arm 2 x 3ph	57m	57m	70m	95m	95m	118m	121m	121m	147m	204m	156m	95m	190m	272m	209m	302m

Notes:

1. Span and angle limitations reflect strength limitations of components, clearance limitations and avoidance of mid-span clashing. Designers still need to allow for other limitations such as ground clearance, intercircuit clearance and tip loads on poles.
2. Standard crossarm sizes and geometry is assumed. Assumes vibration protection installed on tight-strung lines or other locations susceptible to aeolian vibration.
3. Ice loading case not considered in above limits.
4. The same limitations apply to underslung constructions as to equivalent bridging pin constructions.

8.4.9 Bare 33kV Mains – Intermediate Constructions

CONSTRUCTION			SLACK 2% NBL		URBAN 6% NBL		LIMITED 10% NBL		MEDIUM 18% NBL	
APL	**Description**		MERCURY	NEPTUNE	MERCURY	NEPTUNE	MERCURY	NEPTUNE	MERCURY	NEPTUNE
I/33/3/FRP	Intermediate Flat Pin CF Xarm See Note 4	Mid phase centred or staggered	0-25°	0-25°	0-25°	0-25°	0-25°	0-18°	0-15°	0-10°
			64m/0°	64m/0°	110m/0°	110m/0°	147m/0°	147m/0°	191m/0°	191m/0°
			59m/25°	59m/25°	105m/25°	105m/25°	142m/25°	142m/18°	182m/15°	182m/10°
		Mid phase not staggered or centred	0-25°	0-25°	0-25°	0-25°	0-25°	0-18°	0-15°	0-10°
			37m/0°	37m/0°	60m/0°	60m/0°	74m/0°	74m/0°	92m/0°	92m/0°
			33m/25°	33m/25°	57m/25°	57m/25°	71m/25°	71m/18°	88m/15°	88m/10°
		Mid phase offset one end, centred other end	0-25°	0-25°	0-25°	0-25°	0-25°	0-18°	0-15°	0-10°
			51m/0°	51m/0°	87m/0°	87m/0°	111m/0°	111m/0°	143m/0°	143m/0°
			47m/25°	47m/25°	83m/25°	83m/25°	106m/25°	106m/18°	136m/15°	136m/10°
OFFSET I/33/3/FRP	Offset Pin 3ph CF Xarm		0-25°	0-25°	0-25°	0-25°	0-25°	0-18°	0-15°	0-10°
			50m/0°	50m/0°	86m/0°	86m/0°	109m/0°	109m/0°	141m/0°	141m/0°
			46m/25°	46m/25°	82m/25°	82m/25°	104m/25°	104m/18°	134m/15°	134m/10°
DELTA I/33/3/FRP	Intermediate Delta Pin Large CF raiser (1252mm mid-phase raise) CF Xarm		0-25°	0-25°	0-25°	0-25°	0-25°	0-18°	0-15°	0-10°
			107m/0°	107m/0°	185m/0°	185m/0°	237m/0°	205m/0°	314m/0°	205m/0°
			101m/25°	101m/25°	177m/25°	177m/25°	260m/25°	145m/18°	170m/15°	165m/10°
IV/22/3/FRP	Vertical Double Cct 2 x 3ph CF Xarms		0-25°	0-25°	0-25°	0-25°	0-25°	0-18°	0-15°	0-10°
			69m/0°	69m/0°	118m/0°	118m/0°	150m/0°	150m/0°	196m/0°	196m/0°
			69m/25°	69m/25°	118m/25°	118m/25°	150m/25°	145m/18°	170m/15°	165m/10°

Notes:

1. Span and angle limitations reflect strength limitations of components, clearance limitations and avoidance of mid-span clashing. Designers still need to allow for other limitations such as ground clearance, intercircuit clearance and tip loads on poles.
2. Standard crossarm sizes and geometry is assumed. Assumes vibration protection installed on tight-strung lines or other locations susceptible to aeolian vibration.
3. Ice loading case not considered in above limits.
4. Where the middle phase is offset from centre, it should be staggered from one side to the other on alternate poles; otherwise spanning capability is greatly reduced. However, for the span adjoining the strain position, which has the middle phase centred on the pole, the average separation between phases is reduced.

8.4.10 Bare 33kV Mains – Strain Constructions

CONSTRUCTION		SLACK 2% NBL		URBAN 6% NBL		LIMITED 10% NBL		MEDIUM 18% NBL	
APL	**Description**	MERCURY	NEPTUNE	MERCURY	NEPTUNE	MERCURY	NEPTUNE	MERCURY	NEPTUNE
S/33/3/FRP	Strain CF X-arm	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°
		69m/0°	69m/0°	119m/0°	119m/0°	151m/0°	151m/0°	197m/0°	133m/0°
		61m/50°	61m/50°	100m/50°	100m/50°	123m/50°	123m/50°	160m/50°	133m/50°
DELTA S/33/3/FRP Small	Strain Delta CF X-arm Small (460mm mid-phase raise)	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°
		74m/0°	74m/0°	122m/0°	122m/0°	162m/0°	162m/0°	212m/0°	133m/0°
		66m/50°	66m/50°	114m/50°	114m/50°	146m/50°	146m/50°	191m/50°	133m/50°
DELTA S/33/3/FRP Large	Strain Delta CF X-arm Large (920mm mid-phase raise)	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°
		92m/0°	92m/0°	158m/0°	158m/0°	202m/0°	202m/0°	267m/0°	133m/0°
		87m/50°	87m/50°	149m/50°	149m/50°	188m/50°	188m/50°	253m/50°	133m/50°
SV/33/3/FRP	Strain Vertical 2 Cct CF Xarms 2 x 3ph	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°	0-50°
		69m/0°	69m/0°	118m/0°	118m/0°	150m/0°	150m/0°	196m/0°	133m/0°
		69m/50°	69m/50°	118m/50°	118m/50°	150m/50°	150m/50°	196m/50°	133m/50°
DE/33/3/FRP	Dead End Flat CF X-arm	69m	69m	119m	119m	151m	151m	197m	133m
DELTA DE/33/3/FRP Small	Dead End Delta CF X-arm Small (460mm mid-phase raise)	74m	74m	127m	127m	162m	162m	212m	133m
DELTA DE/33/3/FRP Large	Dead End Delta CF X-arm Large (920mm mid-phase raise)	92m	92m	158m	158m	202m	202m	267m	133m
DEV/33/3/FRP	Dead End Vertical 2 Cct CF Xarms 2 x 3ph	69m	69m	118m	118m	150m	150m	196m	133m

Notes:

1. Span and angle limitations reflect strength limitations of components, clearance limitations and avoidance of mid-span clashing. Designers still need to allow for other limitations such as ground clearance, intercircuit clearance and tip loads on poles.
2. Standard crossarm sizes and geometry is assumed. Assumes vibration protection installed on tight-strung lines or other locations susceptible to aeolian vibration.
3. Ice loading case not considered in above limits.
4. The same limitations apply to underslung constructions as to equivalent bridging pin constructions.

8.4.11 SWER

CONSTRUCTION		LIMITED 10% NBL		MEDIUM 18% NBL		FULL 22% NBL	
APL	Description	FLUORINE	3/2.75 SC/GZ	FLUORINE	3/2.75 SC/GZ	FLUORINE	3/2.75 SC/GZ
I/12.7/1	Intermediate Single Pin	0-25°	0-25°	0-25°	0-25°	0-25°	0-25°
		868m/0°	>1000m/0°	590m/0°	>1000m/0°	450m/0°	>1000m/0°
		550m/25°	730m/25°	410m/25°	530m/25°	380m/25°	490m/25°
A/12.7/1	Intermediate Flying Angle	25-90°	25-90°	25-90°	25-90°	25-90°	25-90°
		>1000m/90°	>1000m/90°	590m/90°	>1000m/90°	450m/90°	>1000m/90°
S/12.7/1	Strain	0-60°	0-60°	0-60°	0-60°	0-60°	0-60°
		>1000m/60°	>1000m/60°	590m/60°	>1000m/60°	450m/90°	>1000m/60°
DE/12.7/1	Dead End	>1000m	>1000m	>1000m	>1000m	>1000m	>1000m

Notes:

1. Span and angle limitations reflect strength limitations of components and clearance limitations. Designers still need to allow for other limitations such as ground clearance, intercircuit clearance and tip loads on poles.
2. Assumes vibration protection installed on tight-strung lines or other locations susceptible to aeolian vibration.
3. Ice loading case not considered in above limits.

8.4.12 MS HVABC

CONSTRUCTION		SLACK T1000				URBAN T700				LIMITED T400	
APL	**Description**	11kV 35mm^2	22kV 35mm^2	11kV 185mm^2	22kV 185mm^2	11kV 35mm^2	22kV 35mm^2	11kV 185mm^2	22kV 185mm^2	11kV 35mm^2	22kV 35mm^2
I/HVABC	Intermediate Single Suspension	0-45°	0-45°	0-45°	0-30°	0-45°	0-45°	0-20°	0-20°	0-20°	0-15°
		180m/0°	155m/0°	90m/0°	80m/0°	180m/0°	155m/0°	90m/0°	80m/0°	180m/0°	150m/0°
		140m/20°	115m/20°	90m/15°	80m/15°	120m/20°	96m/20°	90m/10°	80m/10°	125m/10°	130m/5°
		115m/45°	80m/45°	35m/45°	45m/30°	69m/45°	44m/45°	62m/20°	50m/20°	80m/20°	80m/15°
D/HVABC	Intermediate Double Suspension	0-45°	0-45°	0-45°	0-45°	0-45°	0-45°	0-45°	0-45°	0-45°	0-45°
		180m/0°	155m/0°	90m/0°	80m/0°	185m/0°	160m/0°	90m/0°	80m/0°	185m/0°	160m/0°
										185m/30°	160m/30°
		180m/45°	155m/45°	90m/45°	80m/45°	185m/45°	160m/45°	90m/45°	80m/45°	175m/45°	120m/45°
S/HVABC	Strain	0-30°	0-30°	0-30°	0-30°	0-30°	0-30°	0-30°	0-30°	0-30°	0-30°
		180m/0°	155m/0°	90m/0°	80m/0°	185m/0°	160m/0°	90m/0°	80m/0°	185m/0°	97m/0°
		180m/30°	155m/30°	90m/30°	80m/30°	185m/30°	160m/30°	90m/30°	80m/30°	185m/30°	97m/30°
DE/HVABC	Dead End	180m	155m	90m	80m	185m	160m	90m	80m	185m	97m

Notes:

1. Span and angle limitations reflect strength limitations of components and clearance limitations. Designers still need to allow for other limitations such as ground clearance, intercircuit clearance and tip loads on poles.
2. Ice loading case not considered in above limits.

8.4.13 ADSS CONSTRUCTIONS

CONSTRUCTION		SLACK T600	URBAN T300	TIGHT T100
APL	**Description**	ADSS	ADSS	ADSS
I/ADSS/W	Intermediate Block	0-20°	0-20°	0-20°
		150m/20°	150m/20°	150m/20°
S/ADSS/W	Strain	0-60°	0-30°	0-20°
		150m/60°	150m/40°	150m/20°
DE/ADSS/W	Dead End or Heavy Angle	150m	150m	150m

Notes:

1. Span and angle limitations reflect strength limitations of components and clearance limitations. Designers still need to allow for other limitations such as ground clearance, intercircuit clearance and tip loads on poles.
2. This table assumes the ADSS 72SM 12.5mm diameter cable is used – refer section 4.3.6.
3. Ice loading case not considered in above limits.

8.4.14PILOT CABLE CONSTRUCTIONS

CONSTRUCTION		SLACK T1000	URBAN T500	LIMITED T250
APL	**Description**	PILOT	PILOT	PILOT
I/P/W	Intermediate Block	0-1°	0-1°	0-1°
		120m/1°	120m/1°	120m/1°
A/P/W	Angle	0-10°	0-10°	0-10°
		100m/10°	100m/10°	100m/10°
S/P/W	Strain	0-60°	0-60°	0-60°
		120m/60°	120m/60°	120m/60°
DE/P/W	Dead End or Heavy Angle	120m	120m	120m

Notes:

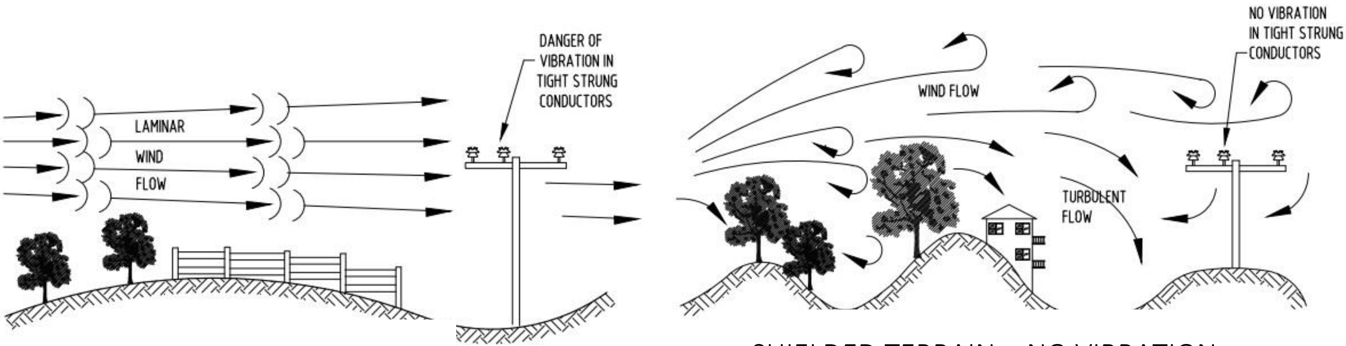
1. Span and angle limitations reflect strength limitations of components and clearance limitations. Designers still need to allow for other limitations such as ground clearance, intercircuit clearance and tip loads on poles.
2. Ice loading case not considered in above limits.

8.5 FITTINGS AND HARDWARE

8.5.1 Vibration Protection

CAUSE OF VIBRATION PROBLEM AND HOW ADDRESSED

Tight-strung conductors are susceptible to aeolian (wind-induced) vibration, particularly in open country (either flat, or gently undulating) with few trees or buildings, coastal areas or natural wind tunnels, such as a river crossing. This phenomenon occurs when laminar (smooth, non-turbulent) air flow occurs, causing vortices (eddies) to be shed alternately from the top and bottom of the conductor. The presence of timber cover, buildings, large hills or other obstructions will generally break up laminar air flows. The winds are not necessarily strong—only in the range 0.5 – 7 m/s (2 – 25km/h); above this turbulence is more common. This causes the conductor to resonate at a frequency typically between 10 Hz and 120 Hz, with a low amplitude of only one or two conductor diameters. (For additional information, refer *AS/NZS 7000* Appendix Y sections Y3 and Y5.)



OPEN TERRAIN > VIBRATION SHIELDED TERRAIN > NO VIBRATION

This vibration can abrade conductors, particularly aluminium which is comparatively soft. Two measures are used to address the problem:

- Conductor armouring (rods/sleeves/tape/helical grips with elastomeric inserts) at intermediate supports, i.e. at pin insulators
- Application of vibration dampers.

CONDUCTOR ATTACHMENT TO PIN INSULATORS

CONDUCTOR STRINGING TENSION	ATTACHMENT TYPE
Slack, Urban or Limited	Preformed Helical Tie
Medium or Full	Armour Rod + Armoured Preformed Helical Tie

VIBRATION DAMPERS

Where Required:

Install vibration dampers on conductors that are:

- strung ≥15%CBL (i.e. medium or full tension)
  AND
- in exposed, open terrain or wind-prone locations, or
- on any spans > 300m in length, or >75m in bushfire-prone areas, or
- on any ADSS spans > 75m
- on spans that need extra reliability or that are difficult to repair (e.g. over a highway, valley or crossing a waterway).

Number of Dampers:

SPAN LENGTH	NUMBER OF DAMPERS	
Up to 250 metres	2 dampers per span	
250 metres to 500 metres	4 dampers per span	(2 subsets of 2)
500 metres to 750 metres	6 dampers per span	(2 subsets of 3)
750 metres to 1125 metres	9 dampers per span	(3 subsets of 3)
1125 metres to 1500 metres	12 dampers per span	(4 subsets of 3)

50% more dampers should be used for water/valley crossings.

Two Vibration Dampers Arranged in a Subset

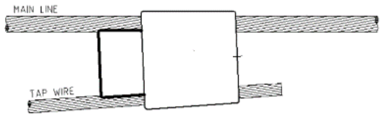
8.5.2 HV Insulator Selection

TasNetworks makes use of 22kV insulators for both 11kV and 22kV lines. On critical 22kV feeders, 33kV insulators may be used to provide greater bird clearances and larger creepage distance. (Another way to address bird problems is by fitting raiser brackets under insulators.)

In areas prone to vandalism, polymeric tension insulators may be used that can withstand rifle and shotgun blasts. Polymeric pin insulators are also available – contact Network Standards for details.

8.5.3 Conductor Joins and Connectors

WEDGE FITTINGS

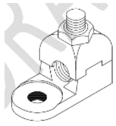


- Wedge connectors must be used for non-tension joints within 2km from terminal or zone substations.

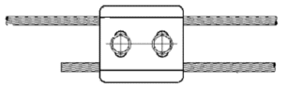
- Not all conductor sizes are catered for – refer *Overhead Construction Standard*. Where no suitable size is available, use non-tension compression sleeves or parallel groove clamps.

BOLTED FITTINGS

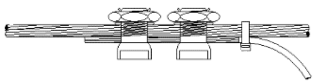
- Bolted connections are used only on conductors that are not under tension.



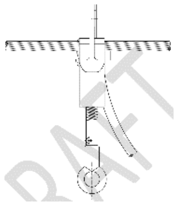
- 'Q' lugs shall be used for terminations at transformers.



- Elsewhere, aluminium and bi-metal parallel groove clamps may be used for non-tension joints of conductors – refer *Overhead Construction Standard* for details of sizes, except where wedge fittings should be used as described above.



- Split bolt clamps may be used on non-tension joints that are not within 2km of a terminal or zone substation provided that 2 clamps are used per conductor.



- Live line clamps to be attached to 'D' loops, not main conductor.

COMPRESSION FITTINGS

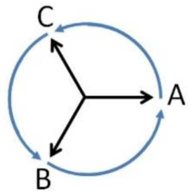
- Conductors under tension must be joined only by compression using tension splices or compression sleeves. Non-tension splices shall be used where conductors are not under tension.

- Conductor terminations at switchgear must be made using compression lugs.

8.6 PHASING AND BRIDGING

Phase Rotation

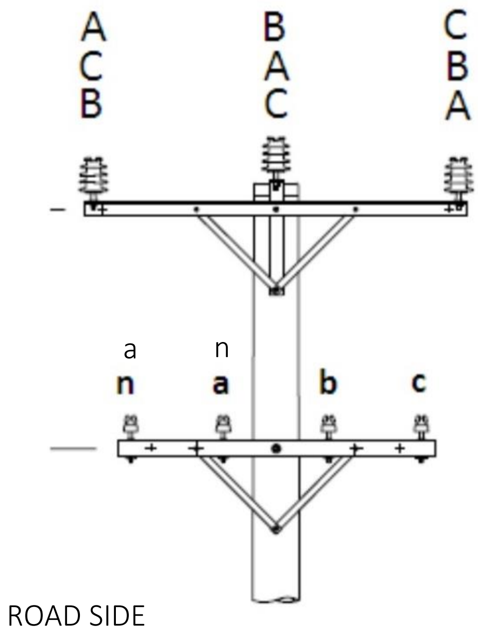
Phase rotation refers to the sequence in which the phases are displaced in time as illustrated in the counter clockwise rotation diagram below. In this example the phase sequence is A-B-C.



It is important to ensure that the correct phase sequence is applied as otherwise motors will turn in the wrong direction and generators will not be able to connect to the network. In the Tasmanian system the phase sequence is A-B-C. From a distribution perspective this means that when looking at a MV distribution line towards the terminal substation then the preferred phase sequence on the pole top is A-B-C as illustrated below. The positions of the phases can be rotated for phase transposition reasons but the sequence should remain unchanged. A clockwise phase configuration for an A-B-C sequence is preferred for triangular pole tops.

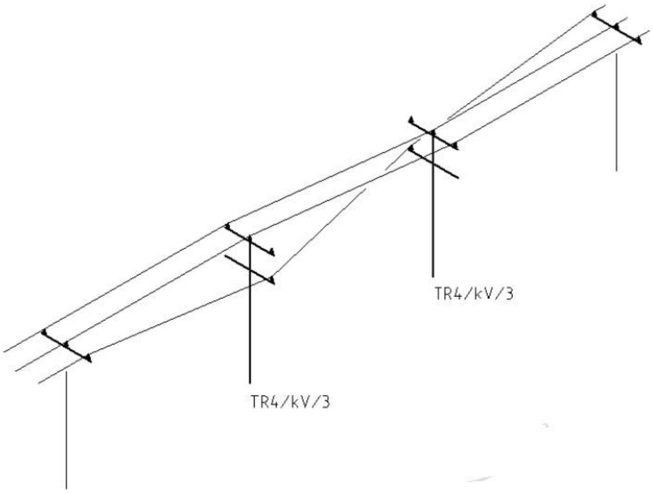
For LV reticulation the phase orientation is generally as shown below where the neutral (n) is located on the road side of the pole top. (In some cases, the neutral is adjacent to the pole.)

This phase sequence pole top orientation is not always achievable, for example, where a distribution line can be supplied from alternative terminal substations. In such a situation the phase configuration on one supply side at the point of interconnection would be A-C-B. Similarly, for LV reticulation where it crosses a road it may be convenient to have the neutral on the side remote from the road.



Phase transpositions may be required on the MV system to help keep phase impedances similar (particularly with flat constructions) and minimise voltage imbalance. For feeders with single phase customers a transposition should occur after every 100kV.A of connected single phase distribution substation capacity. Also, feeders with high point loads (as opposed to distributed loads) should have transpositions every 5km. A complete transposition involves three moves in conductor positions at nominally equal intervals along the feeder length.

A rolling transposition is illustrated below. It preserves the sequence of the phases. Other types of transpositions, such as swapping the inner and an outer phase, or swapping the two outer phases, alter the phase sequence.



LVABC Connection to Transformer LV Terminals

LVABC CORE	TRANSFORMER TERMINAL	
	Hobart District Only	All other Locations
Neutral (multi rib)	Neutral	Neutral
Core 1	C – Red	A – Red
Core 2	B – White	B – White
Core 3	A – Blue	C – Blue

SECTION 9 – POLE MOUNTED PLANT

Version: 3.0

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SECTION 9 – POLE MOUNTED PLANT

9.1 TRANSFORMERS

The table below indicates common size and associated usage:

Size and Phase	Common Use
25kVA and 50kVA single phase	Normally restricted to rural areas
50kVA three phase	Standard light density rural areas
100kVA three phase	Light density urban areas
200kVA three phase	Urban residential or commercial/industrial
300kVA three phase	Urban residential or commercial/industrial
500kVA three phase	Urban residential or commercial/industrial

Transformers need be located as close as possible to the load centre. The length of low voltage lines would normally be limited by voltage drop considerations. LV circuits are generally less than 300m in length.

The high voltage tap selector position on all transformers should be shown on designs. Past practice has been to set the no-load voltage output to between 245 and 250 volts. With the introduction of the new national voltage, no-load output will be set to be between 235 and 240 volts.

Requirements for Pole Transformers

1. The following table details the maximum mass of transformers associated with different mounting methods:

Maximum Mass of Transformer	
platform mounted	2100kg
crossarm hung	2150kg
bolt fixed without mounting plate	750kg
bolt fixed with mounting and backing plate	1750kg

2. When the substation is at the end of an HV spur line, the transformer should be mounted on the side of the pole opposite the HV spur line. *Single customer transformers on private property are excepted.*

3. Poles with 100kVA (and above) transformers are to be installed with a mix of concrete breast block and dry concrete.

4. Poles which will only need to support transformers with a maximum capacity of 50kVA, may be installed with normal earth backfill and without concrete breast block, and without the concrete foundation.

5. Where transformer high voltage leads are to be transposed between the feeder and high voltage bushings, install a transposition bracket (item 20) 920mm below the high voltage arm in place of the insulator bracket.

9.2 SWITCHGEAR

9.2.1 Automatic Sectionalisers

The automatic sectionaliser is similar to an EDO fuse in appearance. In an EDO, the melting of the fuse releases a fuse carrier from its mount, whereas a chemical actuator releases the sectionaliser link. The actuator (which is replaceable) is activated by a small current from a logic circuit. This converts chemical energy into a mechanical movement which, in turn, delatches the sectionaliser.

The electronic logic is contained on a printed circuit board within the link tube and is powered by a current transformer around the tube.

Operation of Automatic Sectionalisers

The logic circuit is activated when the line current exceeds the "actuating current" of the unit, which is factory set and cannot be changed. If the upstream PMR (pole mounted recloser) opens, the incident is stored by the logic circuit as one count. When the PMR recloses and stays closed (because the fault is no longer apparent), the sectionaliser will return to its normal state after the reset time (which is typically 30s). However, if the fault persists, the line current will continue to exceed its "actuating current" and the logic will then count subsequent PMR openings.

The number of times the sectionaliser registers a fault without delatching is determined by the number of fault counts as detailed above. The number of fault counts is also factory set and cannot be changed.

When the set number of counts has been reached, the logic circuit sends a signal to the chemical actuator which activates the delatching mechanism. It takes a minimum of 150ms from the last count on the sectionaliser for the delatching mechanism to operate.

The three phase sectionaliser provides three phase circuit isolation in the event of one or two of the sectionaliser links delatching under a fault condition. The delatched sectionaliser automatically operates an interphase trip mechanism which causes the remaining sectionaliser links to delatch. It takes 680ms for the interphase trip mechanism to operate and delatch all links from the time of the last opening of the upstream PMR.

Selection of Automatic Sectionalisers

TasNetworks will stock sectionalisers rated at 24kV (150kV BIL) which can be utilised at both 11kV and 22kV levels. They are rated to carry continuous current of up to 250A.

As sectionalisers will be used mainly on spur lines, the continuous current capacity is not a constraining criterion. However, careful planning is important in selecting the actuating current, as it is factory set.

The following criteria need to be considered when selecting the actuating current:

1. The actuating current should be greater than the expected maximum continuous current at the location where the sectionaliser is to be installed. Considering overloading, load growth, and a reasonable margin, 1.6 times the continuous current is an acceptable estimation.

2. The actuating current should be less than the minimum available fault current at the end of the zone of protection for the associated PMR on the particular spur protected by the sectionaliser. (The minimum fault current is calculated assuming a resistance to ground of 10 ohms.)

3. The sectionaliser should be set to operate in at least one less count than the associated PMR.

4. In the case of three phase sectionalisers, the associated PMR should have a reclosing interval (dead time) of at least 1.2s, in the particular cycle of the PMR in which the sectionaliser is set to delatch. The reclosing interval should also be shorter than 25s to ensure that the sectionaliser does not reset, and thus retains prior counts, under fault conditions.

Application of Automatic Sectionalisers

The selected sectionaliser will be actuated when a current greater than the actuating current passes through. The upstream PMR timing mechanism will also be activated to open and reclose as programmed. In case of a 2-fast/2-slow reclose setting and a 3-count setting on the sectionaliser, and if the overcurrent persists, the sectionaliser will delatch after the third opening to isolate the sectionalised spur and maintain supply to the main feeder via the PMR.

The open sectionaliser links (swung open) will provide operators good visual indication as to the faulty spur. The sectionaliser is ready to be put back on line after replacing spent actuator/s and clearing the fault. Other than replacing the appropriate actuator, no further adjustment is required. Actuators (standard item for all units) are held as a stock item. (23.63.35)

The automatic sectionaliser is designed to open and close under no load conditions. Opening under no load will occur when there is proper coordination with the upstream PMR. When selecting sectionaliser locations, designers will have to provide suitable three phase switching arrangements for spurs, to ensure sectionalisers close on no load. However, considering local conditions, inserting the three links under load may be permitted. This would be permissible when the total connected load on the spur does not exceed 1000kVA at 22kV, or 600kVA at 11kV. In such cases the operator should insert the three links in succession as quickly as possible in a safe manner to minimise the possible effects of single phasing. (See the section on HV fuses, in the operating manual for pole mounted switchgear.)

9.3 FUSES

Refer to network protection and control standard for more detailed information on fusing types and applications.

EDOs are not to be installed within the High Bushfire Loss Consequence Area. Boric acid fuses or another suitable alternative should be used instead (see Distribution Protection and Control Standard).

Morlyn Power Dropout Expulsion Fuse - 24kV 100A

General

The series of dropout fuses manufactured by Morlyn Power have been replaced by devices manufactured by AB Chance (NGK Stanger).

The RE type dropout expulsion fuse is a delayed dual venting type, single phase, single insulator, crossarm mounting, hook stick operated suitable for both 12kV and 24kV applications.

The sparkless fuses and conventional “K” or “T” type fuse links are available for use in the fuse carrier. The carrier drops open when the fusible element of the fuse link ruptures on excess currents. “Sparkless” fuse elements are not spark-free, but produce fewer sparks than the older elements.

Application

These fuses are used for the protection of distribution transformers and spur lines. The fuse switch drops open to isolate the faulty unit or system section when fault conditions occur. Additionally, a clear indication of the fuse operation is provided. The duty of the fuse fitting should be selected so that its fault rating is not exceeded by the local HV fault level. The removable cap screwed to the top of the fuse carrier is fitted with a 65mm long stainless steel tube. This is to increase the fault rating of the fuse from the standard 6kA to 8kA rating which relates to 300MVA at 22kV and 150MVA at 11kV. The fault rating of the fuse is restricted to 2kA, i.e. 75MVA at 22kV and 37.5MVA at 11kV. This is the case when the dropout fuse fitting is fitted with a spark catcher, this being the maximum fault rating of the spark catcher. (This applies to old installations only.)

Fuse Carriers

The fuse carrier is grey in colour and consists of a fibreglass reinforced tube with a vulcanised fibre lining and has contacts at each end. The top contact consists of an electro-tinned brass casting pressed on to the tube. This casting is provided with contact extensions to engage the contact horns, a hook stick pulling eye and screwed cap. It is fitted with a stainless steel tube for clamping the terminal of the fuse link. The top end of the casting is hollow to allow the fuse link to pass through the assembly and is threaded at the top externally to allow the top cap to be screwed on.

The screwed top cap has a safety disc to allow the tube to double vent at high fault levels. When this happens, the disc must be replaced.

The fuse carrier will fit the standard and heavy duty fuse fittings, and replaces both the standard duty fuse carrier (S.I. No 23.63.75) and the heavy duty fuse carrier (S.I. No 23.63.771).

The existing extra heavy duty fuse carrier (S.I. No 23.63.79) will be held on stock for use in existing extra heavy duty fuse fittings.

The old fuse carriers (with PVC outer sheaths) are substandard components and must be replaced.

Fuse Links

The current rating of fuse links applicable to 22kV and 11kV distribution transformers is tabulated in the appropriate operating manual and the operational manual. The fuse link has the current rating and type stamped on the end terminal.

Sparkless fuses having class “K” characteristics, and are available in sizes up to 16A. These are normally used for the protection of distribution transformers and smaller spur lines.

NGK Stanger Power Dropout Expulsion Fuse - 24kV 100A

General

The type “C” expulsion drop out fuse is manufactured by AB Chance (NGK Stanger) and the series “V” expulsion drop out fuse is manufactured by ASEA Brown Boveri (ABB).

NGK Stanger

The expulsion dropout fuse is a single venting type, with a single insulator. It is crossarm mounting and hook stick operated. It is suitable for a service voltage of 12kV and 24kV with a BIL of 150MVA. Normal current is 100A and symmetrical breaking capacity is 8kA at 11kV and 6kA at 22kV. The dropout fuse carrier will interrupt and drop open when the fusible element of the fuse link ruptures due to excess current.

The expulsion gases are generated by the action of heat from an electric arc on the inner liner of bone fibre of the fuse carrier.

Application

These devices are installed to provide protection for distribution transformers and spur lines. The switch drops open to isolate the faulty unit or system section under fault/overload conditions. It also provides a clear indication of the fuse operation. The duty of the fuse fittings should be selected so that their fault rating of 8kA is not exceeded by the local HV fault level.

Fuse Carrier

The fuse carrier is made of strong fibreglass filament wound tube, with a special ultraviolet resistant external coating. An inner line of bone fibre is used on ablative material for arc quenching.

The fuse carrier is single vented, so that plasma exhausted from the tube during fault operations is vented away from overhead circuits. It will self-align into a spring loaded top socket contact. This socket also ensures that it is not possible to latch the fuse closed without the top being properly fitted. The trunnion design uses a pressure die casting made from high tensile leaded brass.

The fuse carrier is marked with white and red reflective tape so that identifying a blown at night is a great deal easier.

In the ABB Series “V”, the fuse carrier cap is fitted with an arc shortening rod which increases the fault rating of the fitting from 6kA to 8kA. This translates to 300MVA at 22kV and 150MVA at 11kV. The ABB and AB Chance fuse carriers will not fit into Morlyn Power fuse mounts.

Fuse Links

The current rating of fuse links applicable to 22kV and 11kV distribution transformers and spur lines is tabulated in the pole mounted switchgear operation manual. The fuse link has the current rating and type stamped on the end terminal and auxiliary tube.

The ABB and AB Chance fuse links comply with spark performance category “A” to A.S. 1033, however they are not completely spark free.

A range of fuse links are available from 2A to 100A, class “K” (fast).

Refer to installation, operation, and maintenance instructions for the correct method of loading the fuse link into the fuse carrier.

9.4 LINE FAULT INDICATORS

LFIs are installed in the distribution network to reduce the duration of unplanned outages. This is achieved by indicating if the LFI has experienced a fault as well as the direction where the fault had originated. This information allows field crews patrolling a line, following a fault, to initially narrow a faults location to within two LFI (or between a LFI and the start/end of a line), before visual fault identification is commenced.

Information provided by LFI allows Network Operations to isolate the faulted section and restore supply to the remaining customers affected by the fault.

LFI may provide either local or local and remote indication.

For installation details refer to the Overhead Distribution Construction Standard.

SECTION 10 – CLEARANCES

Version: 3.2

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SECTION 10 - CLEARANCES

10.1 DISTRIBUTION MAINS CLEARANCES FROM GROUND AND STRUCTURES

10.1.1 Summary Table

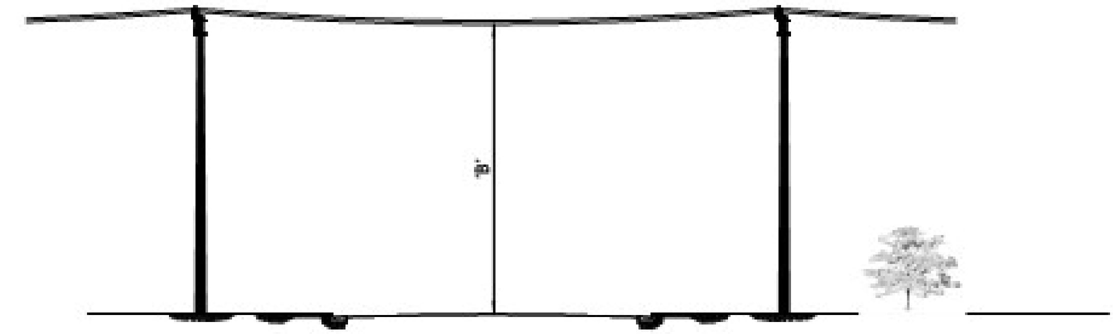
Clearance Type		Location Description	Dimension Code (see 10.1.3)	Direction	LV		HV 1kV – 33kV			HV >33kV, <132kV
					ABC	**BARE**	**Bare & Covered Conductor**	**Insulated without Earth Screen**	**Insulated with Earth Screen**	**Bare & Covered Conductor**
Ground	**Roads**	Over the carriageway	A	Vertically	5.5m	5.5m	6.7m	6.0m	5.5m	6.7m
		Over roadway other than the carriageway	B	Vertically	5.5m	5.5m	5.5m	5.5m	5.5m	6.7m
	Other	Private driveways and land traversable by vehicles more than 3m in height (except service stations and farms)	C	Vertically	5.5m	5.5m	5.5m	5.5m	5.5m	6.7m
		Areas not normally accessible to vehicles more than 3m in height (e.g. swampy areas, gradient > 1:1)	C1	Vertically	4.5 m	4.5m	4.5 m	4.5m	4.5m	5.5m
		Cuttings, embankments and easement boundaries		Horizontally	1.5m	1.5m	2.1m	2.1m	1.5m	5.5m
Structures / Buildings		Unroofed terraces, balconies, sun decks, paved areas etc. that are subject to pedestrian traffic only	E	Vertically (Note 1)	2.7m	3.7m	4.5m	3.7m	2.7m	5.0m
			F	In any other direction	1.0m	1.5m	2.1m	1.5m	1.5m	3.0m
		Roofs or similar structure not normally accessible to persons but on which a person may stand	G	Vertically (Note 1)	2.0m	2.7m	3.7m	2.7m	2.7m	4.5m
			H	In any other direction	1.0m	1.5m	2.1m	1.5m	1.5m	3.0m
		Covered places such as verandahs, balconies and windows which can be opened	I	In any direction	1.0m	1.5m	2.1m	1.5m	1.5m	3.0m
		Parts of any structure not normally accessible to persons, incl. blank walls and windows that cannot be opened	K	Vertically (Note 1)	0.6m	2.7m	3.7m	2.7m	2.7m	4.5m
			L	Horizontally	0.1m	0.6m	1.5m	0.6m	0.1m	2.5m
Other High-Risk Situations		Service Poles in the vicinity of OH conductors (refer 10.2.4)		Vertically	1.5m	1.5m	1.65m	1.65m	1.5m	3.0m
				Horizontally	1.0m	2.0m	2.2m	1.5m	1.5m	3.0m
		Overdimension high load transport routes		Vertically	6.7m minimum for all conductors (incl. stay wires and services)					
		Temporary structures including scaffolding		Vertically	Not permitted					
				Horizontally	1.0m	1.5m	2.1m	2.1m	2.1m	3.0m
		Quarries, mines, farms etc. where activities will be in close proximity to power lines (Note 3)			Subject to risk assessment					
		Farms utilising irrigation		Vertically	5.5m	7.5m	7.5m	7.5m	7.5m	7.5m
				Horizontally	7.9m	7.9m	8.5m	8.5m	7.9m	13.0m

See notes on next sheet

Notes regarding Distribution Mains Ground and Structure Clearances table:

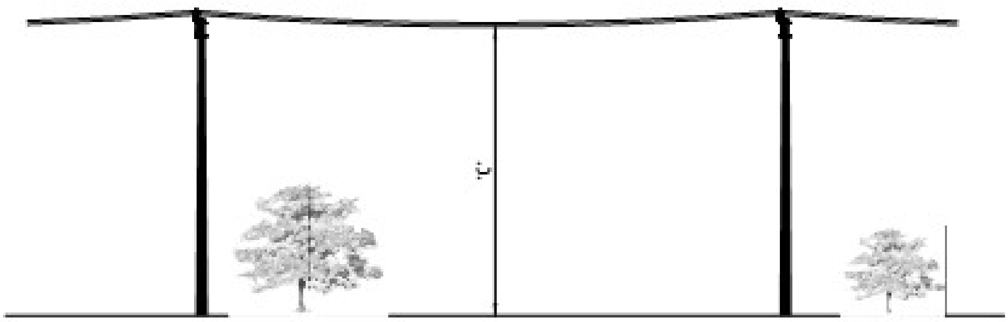
1. This should not be taken as meaning only the literal vertical. The actual clearance may also extend outwards in an arc until it interacts with the relevant intersecting dimension.
2. Minimum clearance values are for the following conductor conditions:
    a. Maximum conductor temperature of:
        i. 75ºC for LVABC
        ii. 50ºC for bare open LV,11kV, 12.7kV & 22kV mains
        iii. 50ºC for HVABC
        iv. 50ºC for bare open 33kV mains
    b. Worst condition of conductor swing - 15ºC and 500Pa Wind load
    c. Allowance to be made for inelastic stretch of conductors following installation.
3. The above clearances are a minimum and at times a higher clearance may be warranted. For high-risk locations where machinery and plant are likely to operate in close proximity to power lines a risk assessment should be conducted to determine the most appropriate solution to minimise the risk of contact. Examples of potential high-risk locations include quarries, mines, farms with a need to transport tall centre pivots or grain augers. Possible solutions to be considered include:
    a. relocation of power line to an alternate location
    b. increasing clearances
    c. use of an insulated conductor type
    d. use of an underground cable
    e. installing powerline markers or insulated barriers/covers.
4. The clearances in the above table are for vehicles with a maximum height of 4.6m. Vehicles exceeding 4.6m require a permit from the Government and as part of the permit approval process TasNetworks may be required to survey the intended route.

10.1.2 Distribution Mains Minimum Clearances from Ground



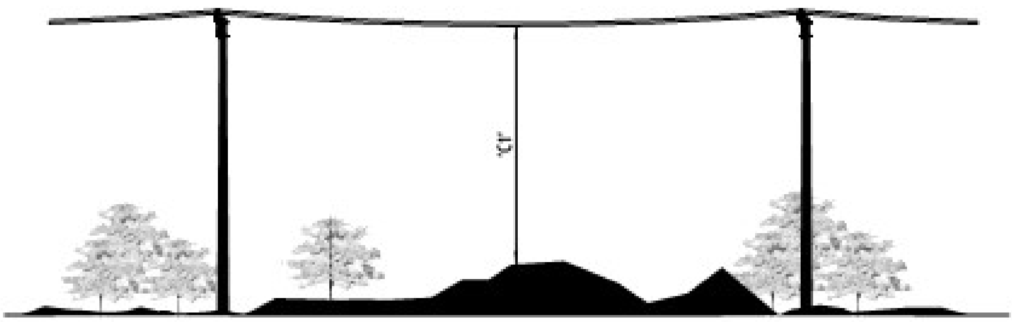
CLEARANCE OVER, ACROSS OR ALONG A ROADWAY

DIMENSION 'B'
5.5m FOR ANY CONDUCTOR LESS THAN 1000V
6.7m FOR BARE OR COVERED CONDUCTOR GREATER THAN 1000V BUT LESS THAN OR EQUAL TO 33KV
6.7m FOR BARE OR COVERED CONDUCTOR GREATER THAN 33KV BUT LESS THAN OR EQUAL TO 132KV
5.5m FOR INSULATED CONDUCTOR WITH EARTHED SCREEN, GREATER THAN 1000 V
6.0m FOR INSULATED CONDUCTOR WITHOUT EARTHED SCREEN GREATER THAN 1000 V



CLEARANCE OVER LAND OTHER THAN A ROAD RESERVE

DIMENSION 'C'
5.5m FOR ANY CONDUCTOR LESS THAN 1000V
5.5m FOR BARE OR COVERED CONDUCTOR GREATER THAN 1000V BUT LESS THAN OR EQUAL TO 33KV
6.7m FOR BARE OR COVERED CONDUCTOR GREATER THAN 33KV BUT LESS THAN OR EQUAL TO 132KV
5.5m FOR INSULATED CONDUCTOR WITH EARTHED SCREEN, GREATER THAN 1000 V
5.5m FOR INSULATED CONDUCTOR WITHOUT EARTHED SCREEN GREATER THAN 1000 V

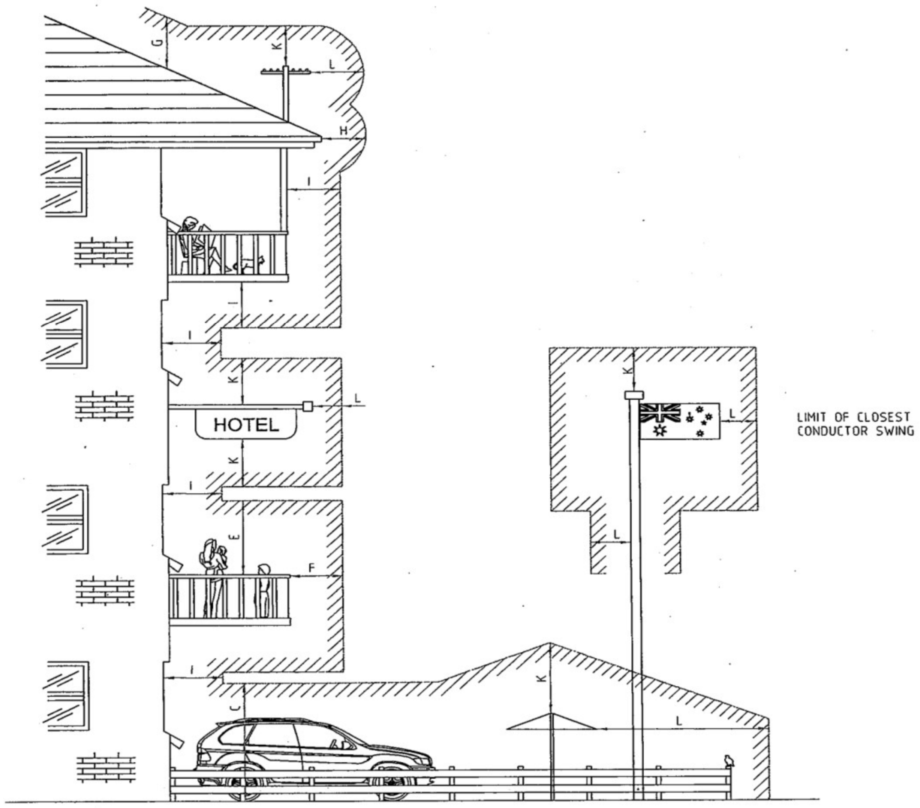


CLEARANCE OVER LAND NOT TRAVERSABLE BY A VEHICLE MORE THAN 3m IN HEIGHT

DIMENSION 'C1'
4.5m FOR ANY CONDUCTOR LESS THAN 1000V
4.5m FOR BARE OR COVERED CONDUCTOR GREATER THAN 1000V BUT LESS THAN OR EQUAL TO 33KV
5.5m FOR BARE OR COVERED CONDUCTOR GREATER THAN 33KV BUT LESS THAN OR EQUAL TO 132KV
4.5m FOR INSULATED CONDUCTOR WITH EARTHED SCREEN, GREATER THAN 1000 V
4.5m FOR INSULATED CONDUCTOR WITHOUT EARTHED SCREEN GREATER THAN 1000 V

10.1.3 Distribution Mains Minimum Clearances from Structures

For minimum clearance distances, refer summary table in section 10.1.1.



MINIMUM CLEARANCES FROM STRUCTURES

10.2 SERVICE CLEARANCES FROM GROUND AND STRUCTURES

10.2.1 Summary Table

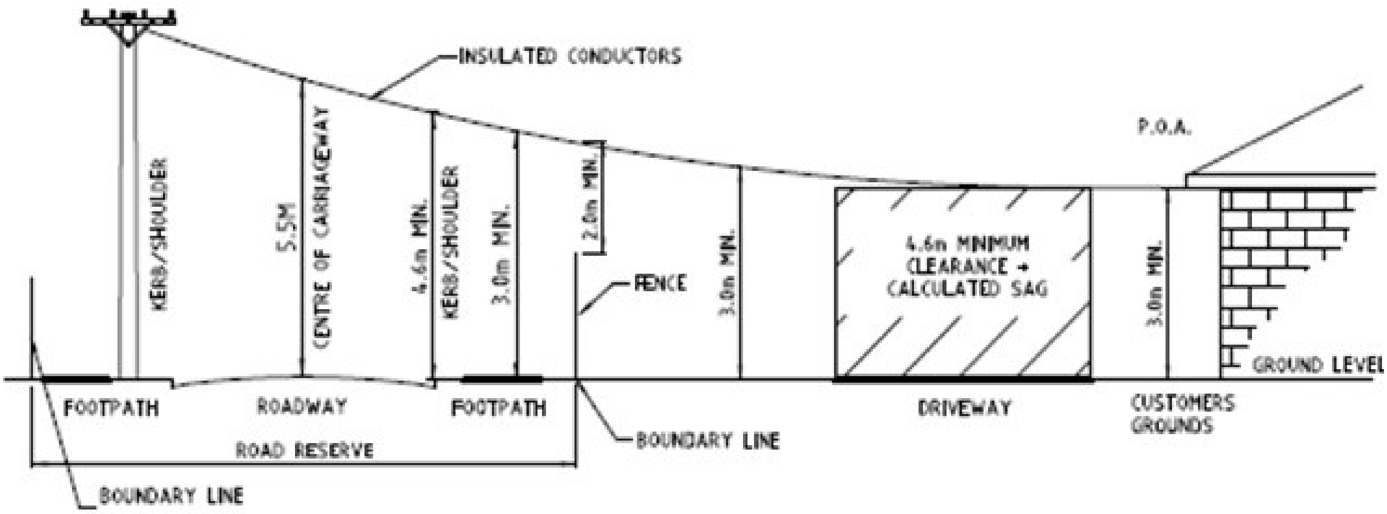
Clearance Type		Location Description	Direction	Insulated Service Conductor Clearance
Ground	Roads	At centre of carriageway	Vertically	5.5m
		At kerb line (bottom of kerb)	Vertically	4.6m
		At verge	Vertically	3.0m
		At fence alignment	Vertically	3.0m
		At fence alignment (from top of fence)	Vertically	2.0m
	Other	Private driveways and land traversable by vehicles more than 3m in height (except service stations, farms, caravan parks and other high-risk locations)	Vertically	4.6m
		Areas not normally accessible to vehicles	Vertically	3.0m
Structures / Buildings		Unroofed terraces, balconies, sun decks, paved areas etc. that are subject to pedestrian traffic only	Vertically	3.0m
			Horizontally	1.0m
		Roofs or similar structure not normally accessible to persons but on which a person may stand	Vertically	2.0m
			Horizontally	1.0m
		Covered places normally accessible to persons, including for example windows capable of being opened, roofed open verandahs and covered balconies	In any direction	1.0m
		Blank walls / windows which cannot be opened	In any direction	0.1m
		Other structures not normally accessible to persons	Vertically	2.0m
			Horizontally	1.0m
Other High-Risk Situations		Gas Storage Cylinders	Horizontally	1.5m
		Swimming pools.	Vertically	Not permitted
			Horizontally	3.5m
		Rotary clothes line, Radio/TV antennae.	Vertically	0.6m
			Horizontally	0.1m
		Areas where trailable sailing craft, farm machinery and irrigation pipes may be used	Vertically	5.5m
		Service Poles in the vicinity of OH conductors	Vertically	Refer 10.1.1
			Horizontally	
		Caravan parks	Vertically	5.5m
		Service station and farm driveways	Vertically	5.5m
Telecommunications		Telephone or Broadband Communications Cables	Vertically	1.2m

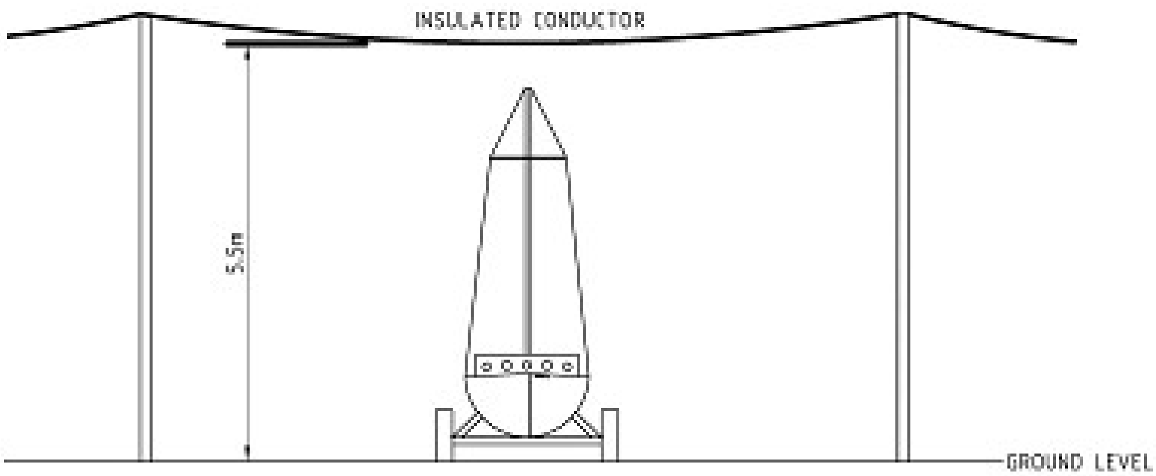
Notes:

1. All clearances are a minimum to which a conductor may sag or swing under any of the following conditions:
    a. Rated maximum conductor temp in still air (75ºC)
    b. Conductor temperature of 15ºC with a wind pressure of 350Pa (blowout condition)
    c. Conductor temperature of 5ºC in still air

   An additional 200mm to vertical clearance shown measured under normal stringing temperature is to be added to allow for sag increase under maximum operating conditions.

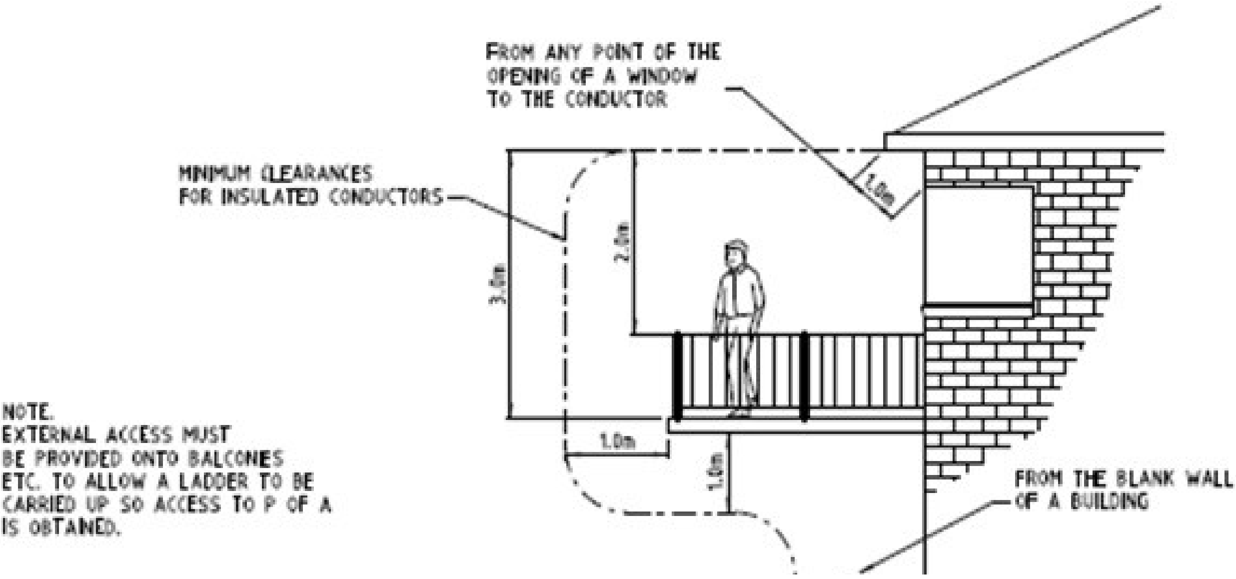
10.2.2 Service Clearances from Ground

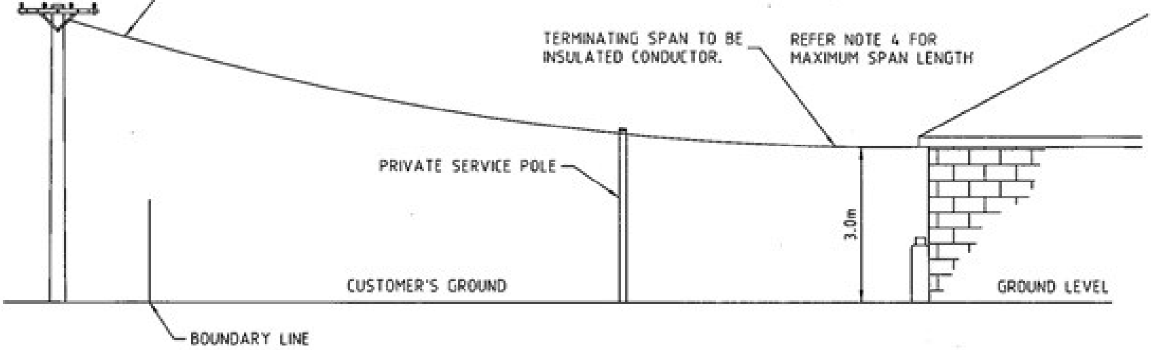




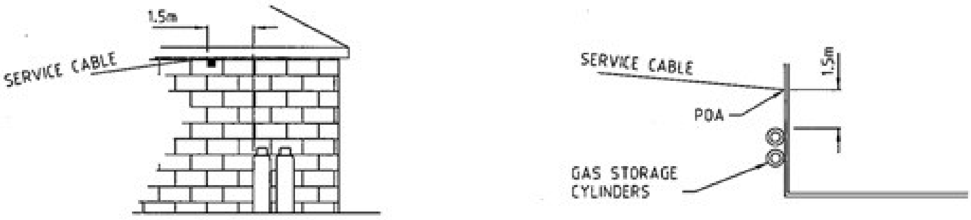
TYPICAL SERVICE CLEARANCE ABOVE AREAS WHERE
TRAILABLE YACHTS, IRRIGATION EQUIPMENT ETC. MAY BE USED

10.2.3 Service Clearances from Structures





TYPICAL MULTI SPAN SERVICE



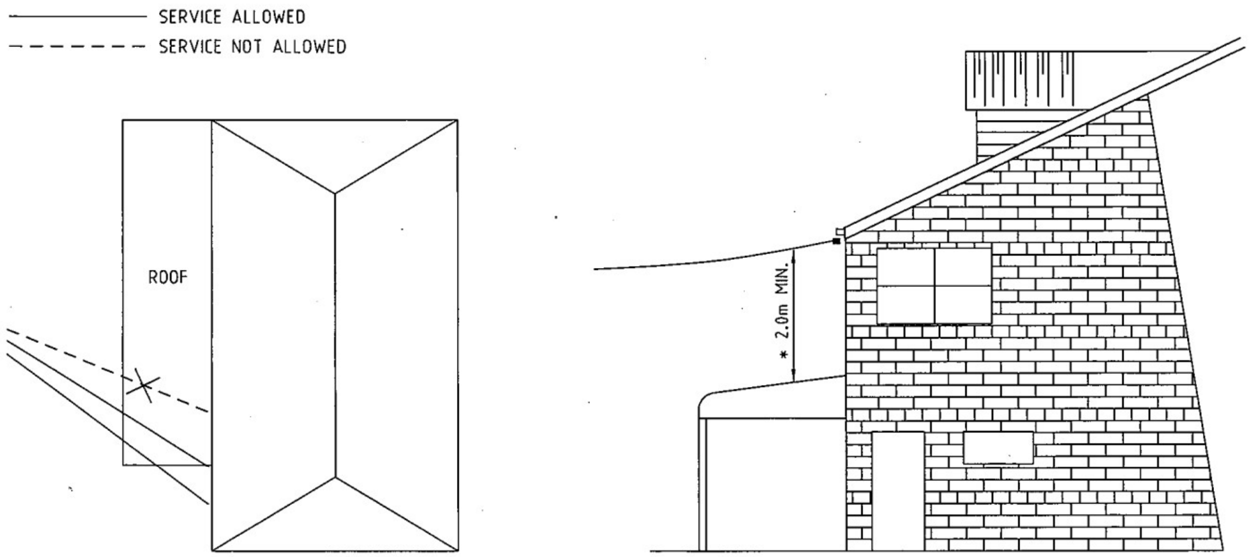
CLEARANCE BETWEEN SERVICE & LPG

CROSSING OVER L.P.G. STORAGE TANKS/CYLINDERS WITHIN 1.5m MEASURED HORIZONTALLY FROM THE VERTICAL PLANE OF CONDUCTORS MUST BE AVOIDED. (AS PER SEC 3.2.4 OF AS 1596). ALSO ENSURE COMPLIANCE WITH AS/NZS 3000 SECTION 7 PART 7.9

NOTES

1. ALL DIMENSIONS SHOWN ARE MINIMUM CLEARANCES IN METRES, TO WHICH A CONDUCTOR MAY SWING OR SAG.
2. WHEREVER POSSIBLE SERVICES SHOULD BE LOCATED TO AVOID DRIVEWAYS ON CUSTOMER'S PROPERTY DUE TO HIGHER CLEARANCE REQUIREMENTS
3. A CONDUCTOR 'DRIP LOOP' OF NOT MORE THAN 150mm IS REQUIRED BELOW THE POINT OF ATTACHMENT.
4. NORMAL TERMINATING SPAN TO BE TWISTED INSULATED CONDUCTOR NO GREATER THAN 46m FOR 2C 25mm² LVABC AND 33m FOR 4C 25mm² LVABC.

Service Clearances from Structures Cont'd



SERVICES OVER ROOFED-AREAS ARE RESTRICTED TO APPLICATIONS THAT ARE UNAVOIDABLE BECAUSE LINESPERSONS MAYBE PLACED IN POTENTIALLY UNSAFE SITUATIONS WHEN SERVICE REPAIRS ARE REQUIRED EG:

LINESPERSONS COULD BE FORCED TO WORK FROM AN EARTHED PLATFORM (METAL ROOF) INSTEAD OF AN INSULATED PLATFORM (EWP OR LADDER).

VERANDAHS MAY NOT BE STRUCTURALLY SOUND.

DAMAGE MAY BE SUSTAINED TO THE ROOF AREA WHEN ACCESS IS REQUIRED.

SERVICE CONDUCTOR MAY COME IN CONTACT WITH THE ROOF DUE TO CONDUCTOR MOVEMENT DUE TO SEVERE WIND CONDITIONS.

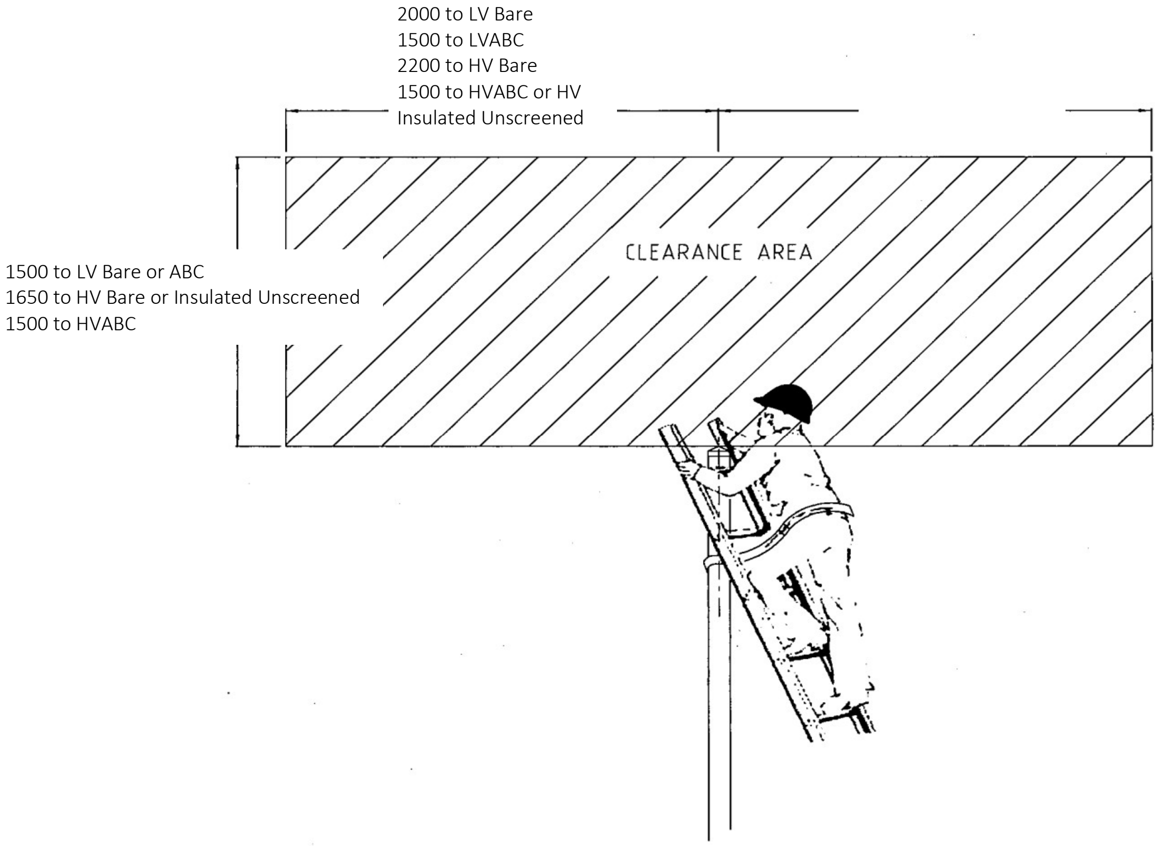
SERVICE OVER ROOFED AREAS ARE ONLY PERMITTED WHEN ALL THE FOLLOWING CONDITIONS ARE MET:

1. THE SERVICE ROUTE OVER THE ROOF IS UNAVOIDABLE, AND
2. THE POINT OF ATTACHMENT AND SERVICE FUSE(S) MUST BE ACCESSIBLE FROM A LADDER FIRMLY FOOTED ON THE GROUND, AND
3. SERVICE FUSE(S) MUST BE ACCESSIBLE DIRECTLY FROM GROUND LEVEL TO ENABLE DISCONNECTION OF SUPPLY BY FUSE STICKS.

* THE MINIMUM CLEARANCE BETWEEN THE ROOF AND THE SERVICE LINE IS 2.0M AFTER SAG AND
INTO CONSIDERATION. EG VERTICAL CLEARANCE OVER A ROOF SITUATED UNDER THE CENTRE OF A
CORE AL XLPE, WILL NORMALLY MEAN A VERTICAL CLEARANCE OF 2.3M AT A STRINGING TEMPER

THE WIRING CONNECTING TASNETWORKS AERIAL SERVICE CONDUCTORS TO THE CUSTOMERS INSTALLATION IS REQUIRED TO BE AT LEAST ARMS LENGTH, (NOMINALLY 2.5M VERTICALLY 1.25M HORIZONTALLY) FROM GROUND OR ELEVATED AREA. REFER TO AS/NZS WIRING RULES 3000 FIG 1.1.

10.2.4 Minimum Clearance of Service Poles from Mains



Clearances must be met for maximum design temperature of conductor and for blowout conditions.

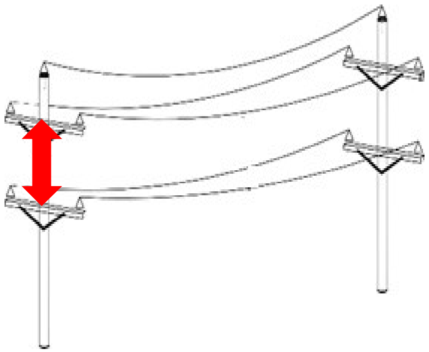
10.3 INTERCIRUIT CLEARANCES

10.3.1 Minimum Spacing Between Circuits at a Pole

			Upper Circuit						
			HV >33kV ≤ 66kV	HV 1kV – 33kV		LV		Other	
			Bare Conductor	Bare and covered conductor, insulated without earthed screen	Insulated with earthed screen	Bare and covered conductor	LVABC	Conductive e.g. Pilot Cable	Non-conductive e.g. ADSS
Lower Circuit	**HV: 33kV > *U* ≤ 66kV**	**Bare conductor**	1.5m						
	HV: 1kV – 33kV	**Bare and covered conductor, insulated without earthed screen**	1.5m	0.92m	0.92m				
		Insulated with earth screen	1.5m	0.92m	0.2m				
	LV	**Bare and covered conductor**	1.84m	1.84m	1.84m	0.3m			
		LVABC	1.84m	1.84m	1.84m	0.3m	0.3m		
	Other	**Conductive e.g. Pilot Cable**	2.0m	2.0m	2.0m	0.3m	0.3m	0.3m	0.2m
		Non-conductive e.g. ADSS[3]	2.0m	2.0m	2.0m	0.3m	0.3m	0.3m	0.2m

Notes:

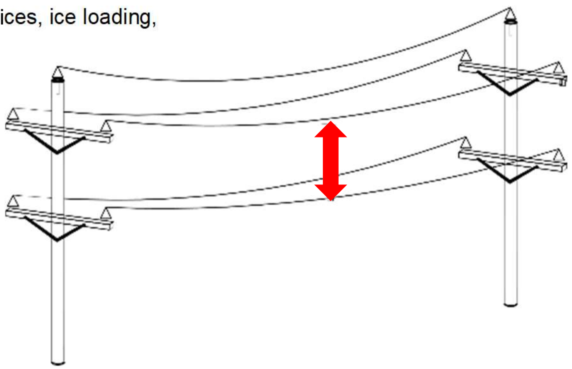
1. The clearances listed are distance between kingbolts of upper and lower circuit constructions. Consideration should be given to increasing clearances when designing at clearance limits in situations where there is a height loss on the top circuit and/or a height gain on the lower circuit, e.g. a strain construction or suspension construction above and a pin construction below.
2. The clearances may need to be increased to account for safe approach distances required for construction, operation or maintenance activities.
3. This is a minimum clearance for live line work practice. This dimension may be reduced to an absolute minimum of 1.2m via consultation with TasNetworks on a case-by-case basis.



10.3.2 Minimum In-span Spacing between Circuits on Common Poles

			Upper Circuit					
			HV 1kV – 33kV		LV		Other	
			Bare or covered conductor, insulated without earthed screen	Insulated with earthed screen	Bare and covered conductor	LVABC	Conductive e.g. Pilot Cable	Non-conductive e.g. ADSS
Lower Circuit	HV: 1kV – 33kV	Bare and covered conductor, insulated without earthed screen	0.5m					
		Insulated with earthed screen	0.5m	0.3m				
	LV	Bare and covered conductor	0.5m	0.38m	0.38m			
		LVABC	0.5m	0.38m	0.3m	0.3m		
	Other	Conductive e.g. Pilot Cable	0.5m	0.38m	0.38m	0.3m	0.3m	0.2m
		Non-conductive e.g. ADSS	1.2m	1.2m	0.3m	0.3m	0.3m	0.2m

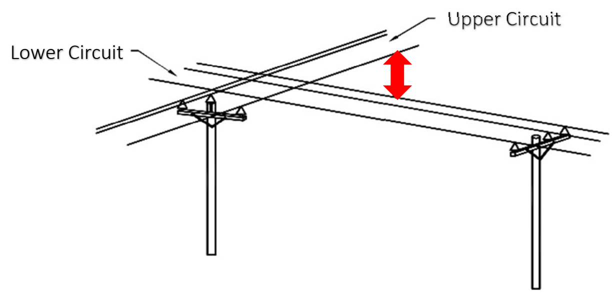
Notes:
1. The clearances may need to be increased to account for safe approach distances required for construction, operation or maintenance activities.
2. The clearances are based on the upper circuit being at maximum operating temperature, and the lower circuit at 5ºC.
3. Mid span clearances may need to be increased in situations where the circuit transitions from horizontal to vertical orientation.
4. Consideration should be given to local factors that may adversely affect in-span clearances including bird strike, aircraft warning devices, ice loading, use of irrigators etc.



10.3.3 Minimum In-span Spacing between Circuits at Unattached Crossing

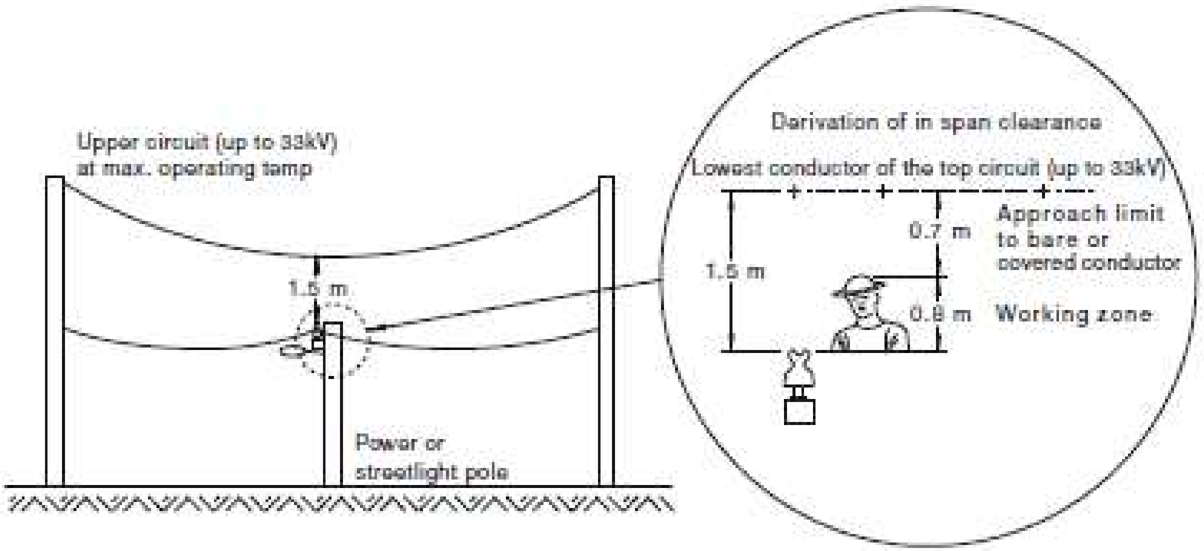
			Upper Circuit					
			HV >33kV ≤ 66kV	HV 1kV – 33kV		LV	Other	
			Bare Conductor	Bare and covered conductor, insulated without earthed screen	Insulated with earthed screen	Bare and covered conductor	Conductive e.g. Pilot Cable	Non-conductive e.g. ADSS
Lower Circuit	**HV: 33kV > U ≤ 66kV**	**Bare conductor**	1.8m					
	HV: 1kV – 33kV	**Bare and covered conductor, insulated without earthed screen**	1.8m	1.2m				
		Insulated with earth screen	1.8m	1.2m	0.6m			
	LV	**Bare, covered and insulated**	1.8m	1.2m	0.6m	0.6m		
	Other	**Conductive e.g. Pilot Cable**	1.8m	1.2m	0.6m	0.6m	0.6m	0.4m
		Non-conductive e.g. ADSS	1.8m	1.2m	1.2m	0.6m	0.3m	0.3m

Notes:
1. The clearances may need to be increased to account for blowout on large spans or safe approach distances required for construction, operation or maintenance activities.
2. The clearances are based on the upper circuit being at maximum operating temperature and the lower circuit at 5ºC.
3. In-span clearances may need to be increased in situations where the circuit transitions from horizontal to vertical orientation.
4. Consideration should be given to local factors that may adversely affect in-span clearances including bird strike, aircraft warning devices, ice loading, use of irrigators etc.



10.3.4 Minimum Spacing from Inter-span Poles

The use of interspan poles is an obsolete practice. As a general rule, when arrangements of this type are encountered, they should be redesigned with a full height pole with all conductors attached.



Note: Separation between HV and LV conductors at a pole increased to 1.84m.

10.4 CLEARANCES FROM TELECOMMUNICATIONS INFRASTRUCTURE

10.4.1 Pilot Cables Clearances from Ground and Structures

Clearance Type	Location Description	Direction	Clearance
Ground	Over the carriageway	Vertically	5.0m
	Over roadway other than the carriageway	Vertically	4.7m
	Areas not normally accessible to vehicles	Vertically	3.5m
	Over commercial/industrial/farm driveways	Vertically	5.0m
Structures / Buildings	Unroofed terraces, balconies, sun decks, paved areas etc. that are subject to pedestrian traffic only	Vertically	2.7m
		Horizontally	1.0m
	Roofs or similar structure not normally accessible to persons but on which a person may stand	Vertically	2.0m
		Horizontally	1.0m
	Covered places normally accessible to persons, including for example windows capable of being opened, roofed open verandahs and covered balconies	In any direction	1.0m
	Blank walls / windows which cannot be opened	In any direction	0.6m
	Other structures not normally accessible to persons	Vertically	0.6m
		Horizontally	0.1m

10.4.2 ADSS and Main Fibre Optic Cable (FOC) Clearances from Ground

Location Description	Min. Clearance
Roads, freeways	5.5m[3]
Designated high load highways, freeways and truck refuelling depots	6.0m[3]
Private or public land parcels that vehicles or machinery may traverse (including commercial property, farmland and paddocks)	5.5m
Commercial, farmland or designated paddock driveways (including residential access to farm properties)	5.5m
Residential driveways	4.6m
Other land not normally accessible to vehicles	4.5m
Navigable waterways or river[4]	12.0m
Railway Line[5]	5.5m

Notes:

1. For NBNCo service drop cables, refer TasNetworks TS-02 document.
2. All clearances are based on FOC temperature of 30ºC.
3. For roadway verge the minimum requirement may be reduced to 4.6m where vehicles cannot traverse.
4. Navigable waterway to be measured at Highest Astronomical Tide for tidal waterways or full capacity for a dam or lake.
5. Railway crossings are to be constructed with a weak link attachment to the poles on either side of the crossing.

10.4.3 FOC Pit and FDH cabinet clearances from TasNetworks Poles

Pole Type	Clearances for Splice Pits and FDH from Poles with HV Conductors or Apparatus	Clearances for Splice Pits and FDH from Poles with LV Conductors or Apparatus	Clearances for Haulage Pits from HV & LV Poles
Conductive poles (steel/conc)	15m	3m	3m
Timber poles with HV earth attached	15m	3m	3m
All other wood poles	3m	3m	3m

10.4.4 ADSS / FOC Clearances from TasNetworks Pole-mounted Hardware

Refer to Section 8 ‘Communications’ of the Overhead Construction Standard for details of minimum clearances from pole-mounted hardware to ADSS/FOC cables have been prepared for the following situations:

- Transformer/Recloser/Load Break Switch tanks and associated control cabinets
- Pole-mounted Capacitor Banks and associated control cabinets
- Regulators and associated control cabinets
- Transformer HV & LV bushes and bridging
- LV and Service Fuse assemblies
- HV & LV Underground cable termination crutch
- Air Break Switches including operating handles
- Drop-out fuse carriers
- Streetlight brackets
- Pilot Wire assemblies
- Consumer underground mains terminations
- Overhead services
- Consumer house service attachments and property poles.

10.4.5 Minimum Clearances from PSTN (Telephone) Cables on JU Poles

TasNetworks Poles

Distribution Network Component	On Pole	In Span
Bare HV Mains >33kV mains	3.0m	2.4m
Bare or Covered HV Mains ≤33kV mains	2.4m	1.8m
NMSHVABC mains	1.2m	1.2m
MSHVABC (metallic earthed screen) mains	0.6m	1.2m
Bare LV or SL mains	1.2m	1.2m
LVABC mains	0.6m	1.2m
Streetlight leads, brackets or fittings	0.05m	0.15m
Stay fittings	0.05m	0.15m
Earth downleads	0.05m	

Telstra Poles

Min. 1.2m clearance between TasNetworks services and Telstra cables/equipment

10.4.6 Minimum Clearances Between Earthing and Telecommunications Plant

Minimum clearances are given in section 11.6.

10.5 CLEARANCES FROM STAY WIRES

10.5.1 Ground Clearance for Aerial Stay Wires

Situation	Required Min. Clearance
Over Carriageway	5.5m
Over Private Driveways	4.6m
Other Locations	3.0m

10.5.2 Clearance from Mains to Stay Wires

Mains Type	Required Min. Clearance
ADSS, Pilot Cable	0.15m
LV bare neutral, LVABC	0.15m
LV bare mains active	0.23m
HV bare or covered mains	0.46m
HVABC	0.15m
Operating Platforms	2.6m vertically

10.6 CLEARANCES FROM STREETLIGHTS

10.6.1 Clearance from streetlights/outreaches mounted on a distribution pole

Mains Type	Required Min. Clearance
ADSS, Pilot Cable	0.23m
LV bare neutral, LVABC	0.3m
LV bare mains active	0.6m
HV bare or covered mains	1.2m
HVABC	0.3m

10.6.2 Clearance from free-standing non-frangible streetlight poles

Mains Type	Required Min. Clearance
ADSS, Pilot Cable	0.1m in any direction
LV bare neutral, LVABC, Insulated Service	0.6m vertically 0.3m horizontally
LV bare mains active	1.5m vertically 0.6m horizontally
HV bare or covered mains	1.5m vertically 1.5m horizontally
HVABC	1.5m vertically 0.3m horizontally

10.6.3 Clearance from free-standing frangible streetlight poles

Situation	Required Min. Clearance
Potential impact to the streetlight pole would result in the pole falling clear of the overhead conductors. Note 1	0.6 x SL mounting height
Potential impact to the streetlight pole would result in the pole falling toward the overhead conductors. Note 1	1.2 x SL mounting height

Frangible poles are not to be used in areas of high pedestrian volume (e.g. near schools, bus stops, shopping centres)

10.7 TRANSMISSION LINES UNDERCROSSINGS

Transmission Voltage	Required Min. Clearance	
	Undercrossing Conductors	Supporting Structures[4]
110kV	2.4m	3.8m
220kV	3.4m	4.8m

Notes:
1. Clearance is for transmission conductor at maximum design temperature and distribution conductors at 5°C.
2. Where the clearance between transmission conductors and distribution conductors is restricted to the minimum allowable, the span of the undercrossing distribution line shall be such that its maximum sag does not exceed 0.5m.
3. Crossings of distribution lines under transmission lines in mid-span are generally to be avoided. Crossings should be located close to towers where possible.
4. The minimum horizontal clearance from a supporting structure apply when the structure is within 15m of the centre of the transmission line.
5. Normal ground and other clearances must be achieved for the undercrossing conductors.

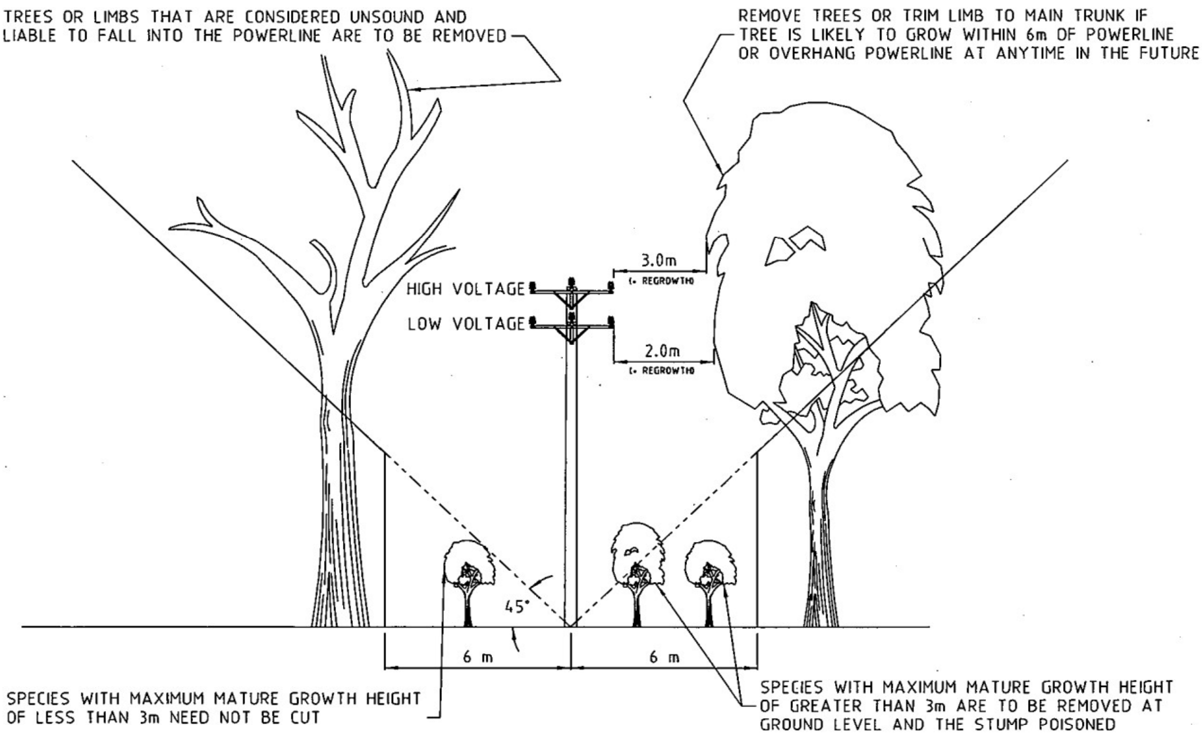
10.8 VEGETATION CLEARANCES

10.8.1 Bare Conductor Vegetation Clearances

NEW OR UPGRADED POWERLINES

THE AIM OF CLEARING FOR NEW OR UPGRADED POWERLINE ROUTES IS FOR TASNETWORKS TO UNDERTAKE MINIMAL VEGETATION CLEARING IN THE FUTURE.

ACHIEVEMENT OF THIS AIM MAY NECESSITATE THE CONSIDERATION OF OTHER SUPPLY ALTERNATIVES EG. UNDERGROUND, AERIAL BUNDLED CONDUCTOR, ALTERNATIVE LINE ROUTE ETC.



IT IS ACCEPTED THAT ACHIEVEMENT OF THESE CLEARANCES MAY NOT BE POSSIBLE FOR SOME TREES IN URBAN AREAS AND ALONG SOME ROADSIDES. IN THESE SITUATIONS, WHERE BARE OVERHEAD CONSTRUCTION IS STILL REQUIRED, CLEARANCES LISTED IN THE RELEVANT TABLES IN CHAPTER 8A OF THE TASMANIAN ELECTRICITY CODE SHOULD BE INCREASED TO ALLOW FOR A FURTHER TWO CYCLES OF RE-GROWTH.

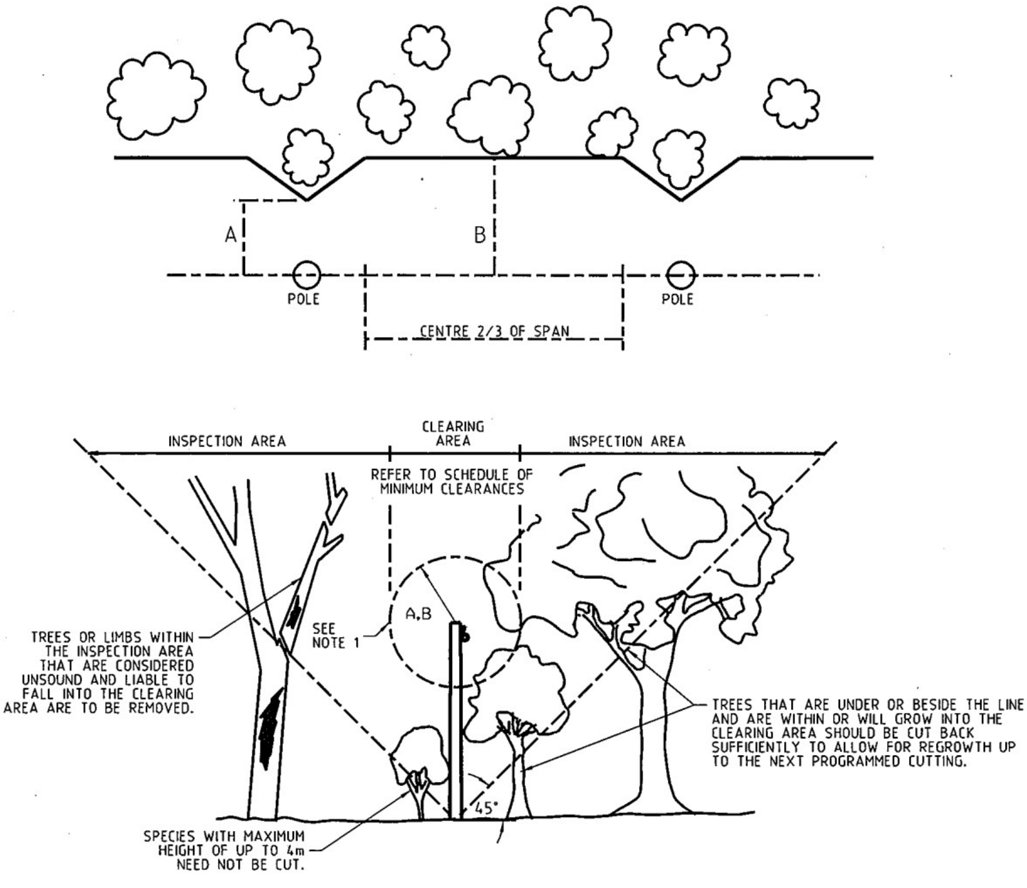
NOTES:

* CYCLES ARE GENERALLY TWO YEARS IN RURAL AREAS, AND ONE YEAR IN URBAN AREAS.
* HAZARDOUS VEGETATION OUTSIDE THE CLEARANCE ZONE TO BE REMOVED OR TRIMMED.
* OVERHANGING LIMBS IN RURAL AREAS ARE GENERALLY NOT ALLOWED. EXCEPTIONS ARE TO BE RARE AND SUBJECT TO A RIGOROUS RISK MANAGEMENT ASSESSMENT AND RECORDING.
* ACCESS TO THE EASEMENT MUST BE ACHIEVED TO ALLOW FOR FUTURE MAINTENANCE AND FAULT RESPONSE.

10.8.2 ABC Vegetation Clearances

Voltage	Clearance at Pole	Clearance to Still Cable Centre 2/3 of Span		
		Span <45m	Span 45 – 75m	Span >75m
LV	0.6m	*0.6m*	*1.0m*	*Urban (~50m): 1.5m*
				Rural (~150m): 2.1m
HV	0.7m	*0.7m*	*1.2m*	*Urban (~75m): 1.8m*
				Rural (~150m): 3.0m

NOTE:
THESE ARE THE MINIMUM CLEARANCES AND AT THE TIME OF CUTTING AN ALLOWANCE OF THREE YEARS REGROWTH SHOULD BE MADE.
LOW VOLTAGE SPACERS SHOULD BE APPLIED AS PER STANDARD FOR BARE CONNECTORS

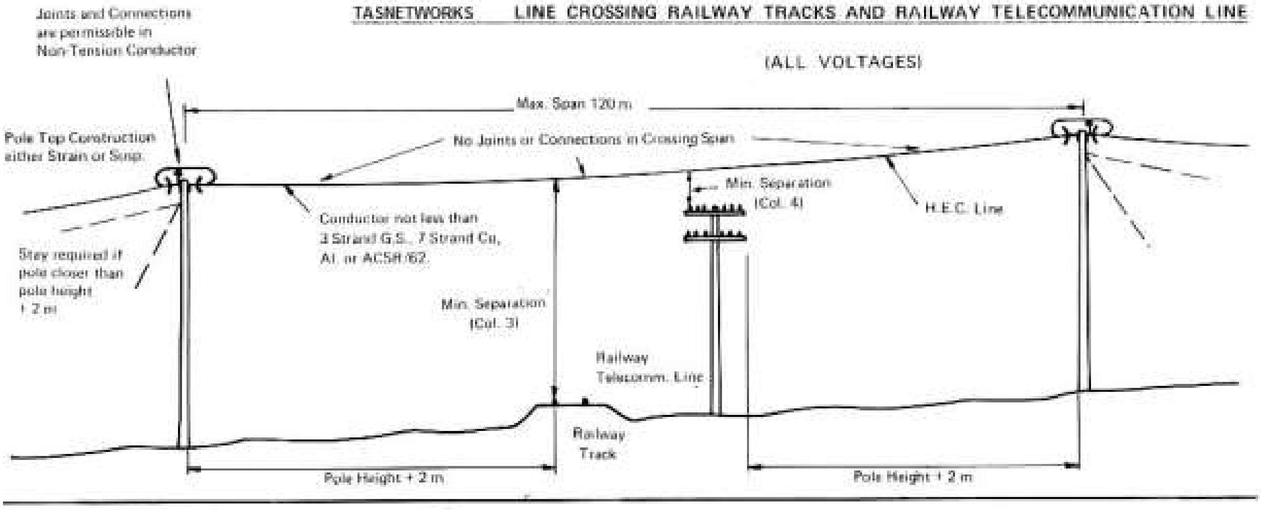


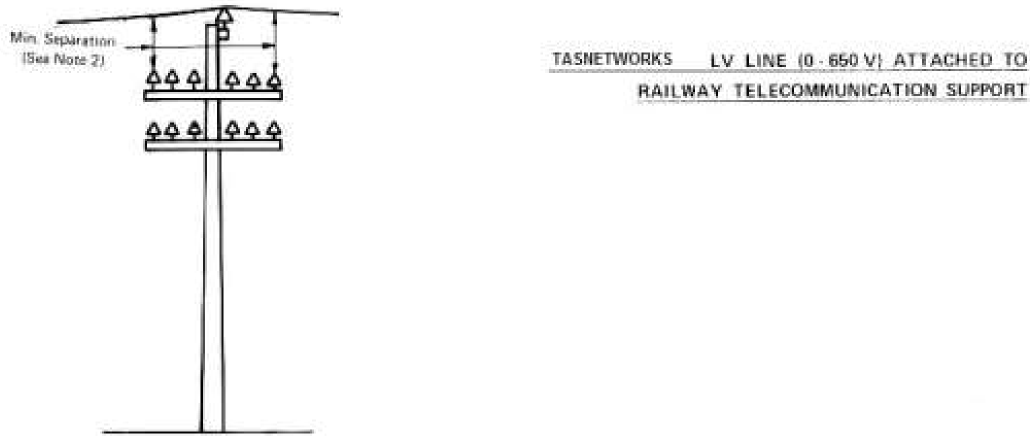
10.8.3 ADSS / FOC Vegetation Clearances

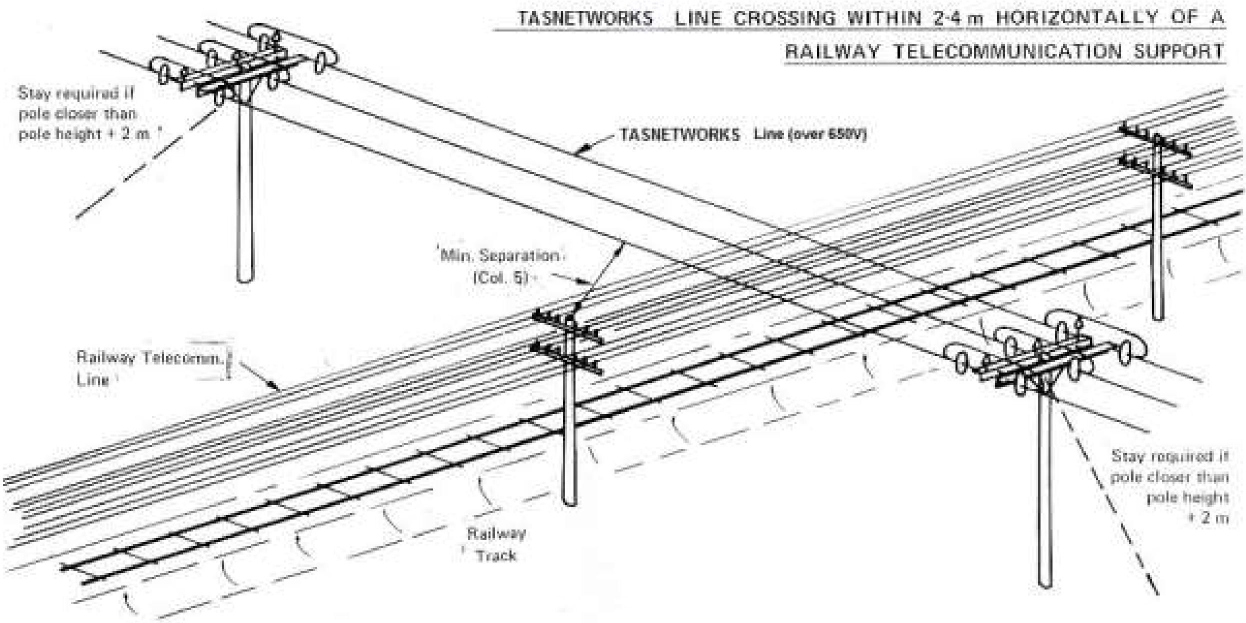
Clearance at Pole	Clearance to Still Cable		
	Span <40m	Span 40 – 70m	Span >70m
0.6m	0.3m	0.6m	0.9m

Radial clearances apply – both vertical and horizontal.
Initial clearing should allow for regrowth over clearing cycle.

10.9 CLEARANCES OVER RAILWAYS







Clearance over Railways Cont'd

TasNetworks shall, before undertaking work on any new crossing or rearranging an existing crossing, consult with TasRail and obtain approval of the proposal.

		Minimum Separation (m)		
Col 1	Nominal Voltage of Power Conductors	Railway Tracks (Nearest Rail)	Telecommunications Conductors/Cables	Telecommunications Support
1	Up to 650V	5.5	0.9	By approved attachment (Note 2)
2	Over 650V to 11kV	6.7	1.2	3.7
3	Over 11kV to 66kV	6.7	2.1	4.0
4	Over 66kV to 132kV	6.7	3.0	4.6
5	Over 132kV to 220kV	6.7	3.7	5.1

Notes:
1. Separations in column 5 apply to where Tasnetworks conductors are within a horizontal distance of 2.4m from the vertical projection of the nearest point of a telecommunication support.
2. Where TasNetworks LV conductors share the same pole as TasRail's conductors, there shall be a separation of 2.4m for bare LV or 1.8m insulated LV.

REQUIREMENTS FOR SPANS CROSSING RAILWAY INFRASTRUCTURE

1. Maximum Span Length: 120m
2. Angle of crossing: 45° - 90°
3. Minimum conductor size: 3/2.75 SC/GZ, or at least 7 strands for other materials
4. Constructions on adjacent poles: strain or suspension types
5. No tension joints or connections in crossing span
6. Poles to be:
   - located at a distance equal to pole height + 2m away from track or telecommunications conductors, OR
   - stayed so that they cannot fall onto tracks or telecommunications conductors in the event of pole base failure.

10.10 CLEARANCES OVER NAVIGABLE WATERWAYS

10.10.1 Risk Assessment

When planning a crossing of a navigable waterway, a formal risk assessment shall be carried out in accordance with *AS/NZS 4360*. The risk assessment should identify and consider the following:

a) potential hazards
b) the risks associated with those hazards
c) the potential circumstances under which the risks could arise
d) the consequences of the risks
e) the treatment options that can be applied.

The purpose of the risk assessment is to ensure that crossings are designed, constructed and maintained such that the overall level of risk is as low as reasonably practicable, particularly in relation to risks associated with the safety of persons.

10.10.2 Design Considerations

Following completion of the risk assessment, the design of the overhead crossing shall consider the following to determine the minimum height of the conductors:

a) Maximum height of the water
   - For tidal waterways, this is to be calculated as the Highest Astronomical Tide (HAT) plus wave effects.
   - For non-tidal waterways this is to be calculated as the known full supply level for a lake or dam, or known high water mark for a river, plus wave effects.

b) Maximum expected vessel height
   - This is the maximum vessel height, determined via the risk assessment, that can be reasonably expected to use the waterway near the proposed overhead crossing.

c) Safety margin
   - An allowance for unexpected events, such as movement of supporting poles/towers and attachments as determined via the risk assessment. As a standard, 2.2m is to be used as minimum for bare conductor crossings.

d) Electrical clearance
   - The minimum clearance in air to withstand the maximum likely switching surge for the nominal system voltage as shown in the table below.

Electrical Clearance for Waterways Crossings (to be added to Safety Margin)

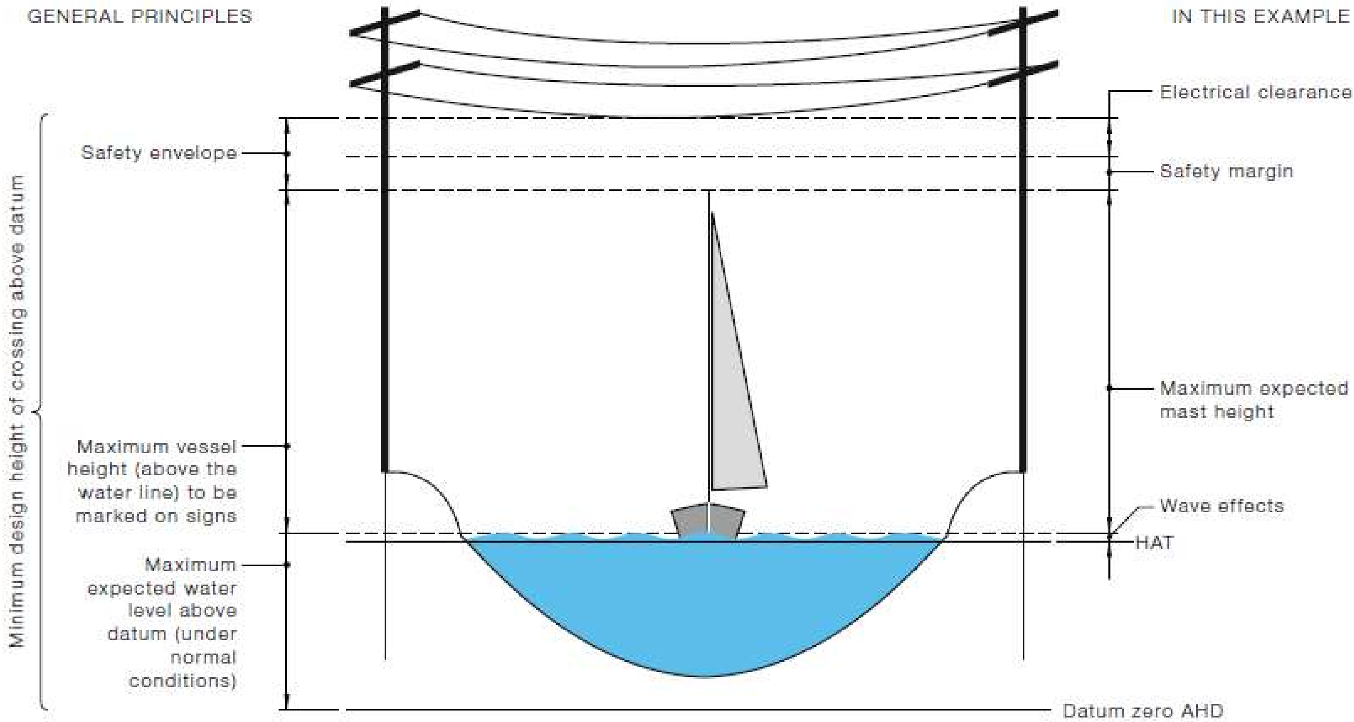
Nominal System Voltage	Electrical Clearance
Up to and including 33kV	0.3m
Greater than 33kV – up to and including 132kV	0.8m

e) Safety envelope
   - This is the sum of the safety margin and the electrical clearance. This dimension is the clearance to be maintained between the minimum design height and the maximum expected vessel height at the time of maximum water level.

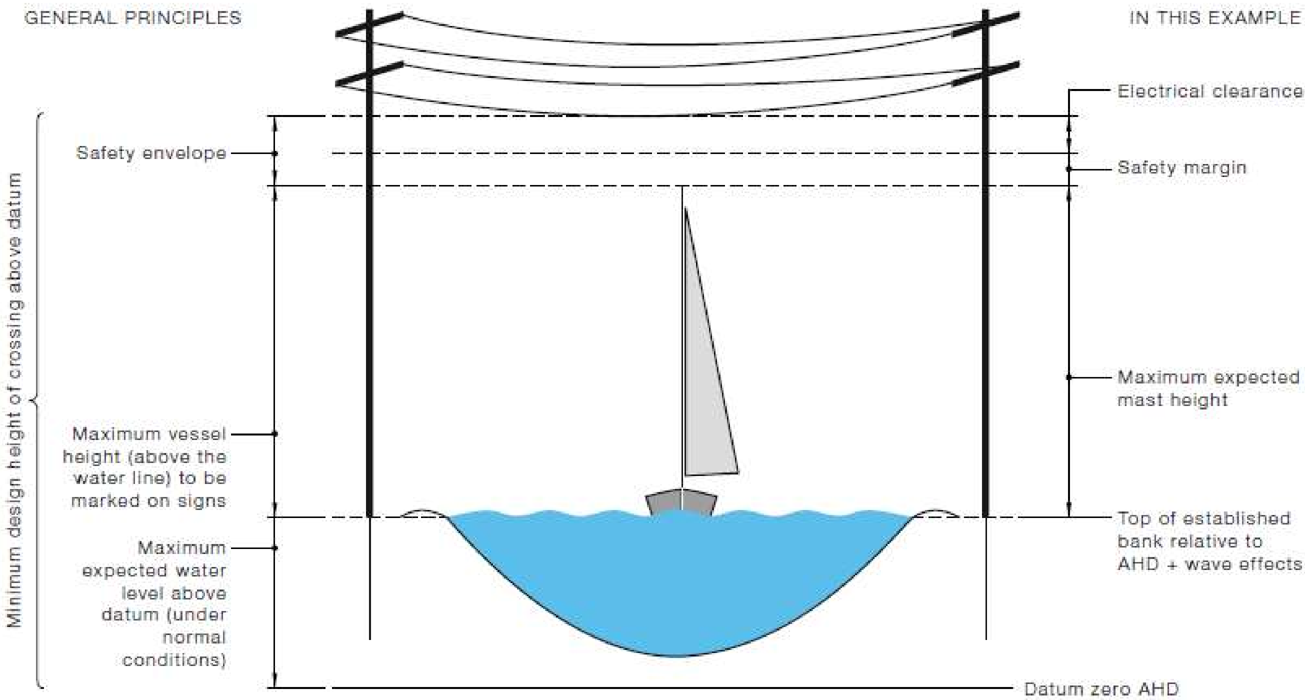
f) Maximum conductor operating temperature.

Clearance over Navigable Waterways Cont'd

Factors to be considered for navigable *tidal* waterways



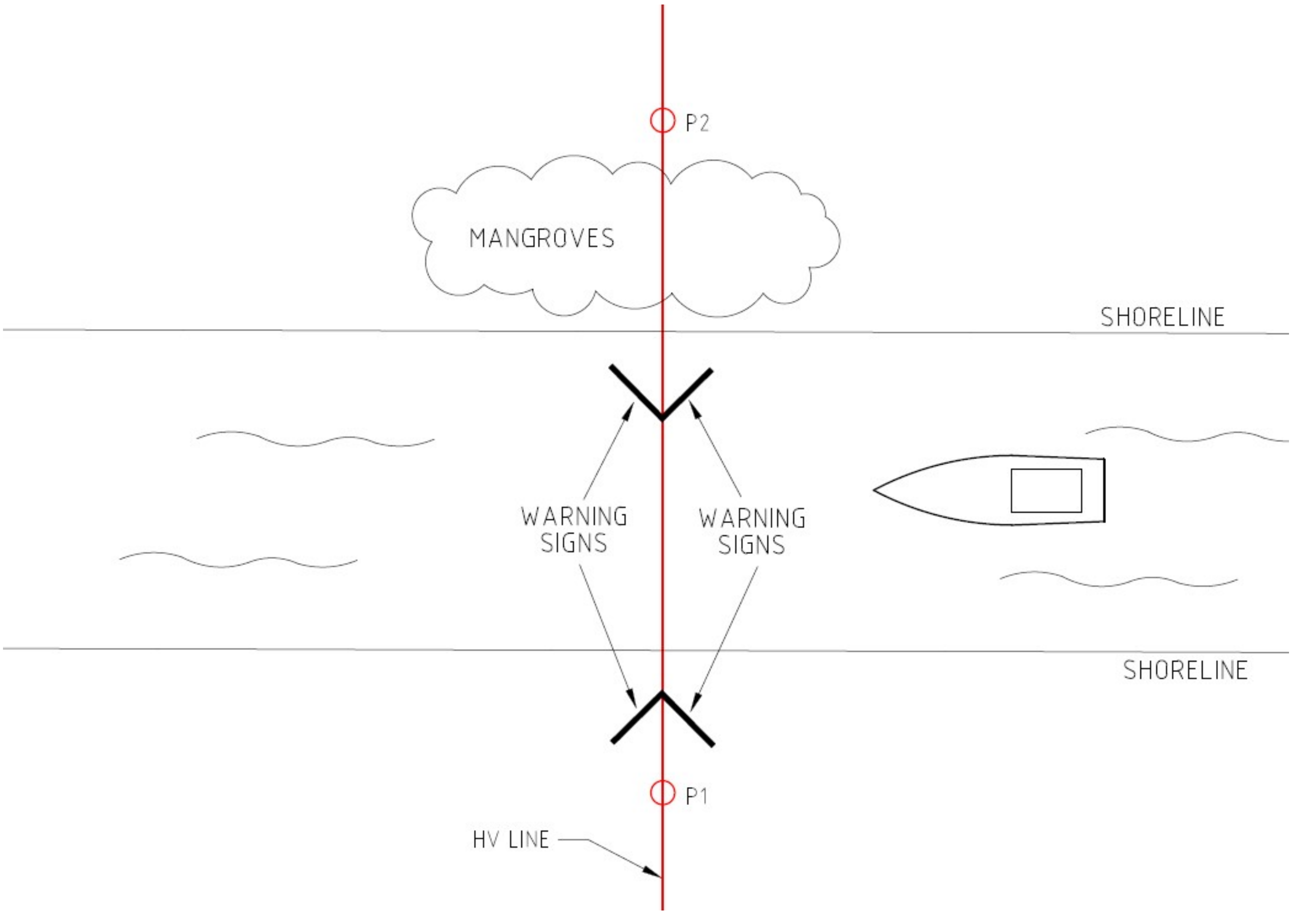
Factors to be considered for navigable *non-tidal* waterways



Clearance over Navigable Waterways Cont'd

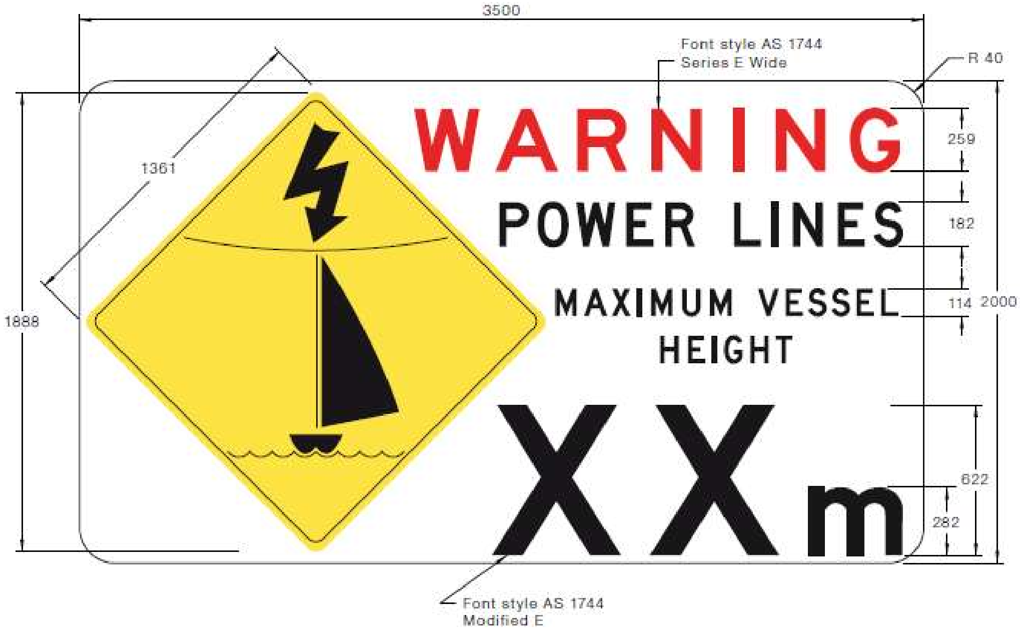
10.10.3 Warning Markers and Signage

Where the risk assessment process has determined that signage and/or warning markers are required, these shall be installed in a position that provides an unobstructed view to boat users travelling in any direction. Typically, this should be on the shoreline and directly beneath the overhead crossing, angled at 45º to the shoreline. Where shoreline obstructions exist, the sign should be positioned in-water to ensure an unobstructed view.



Clearance over Navigable Waterways Cont'd

Large overhead conductor crossing warning sign

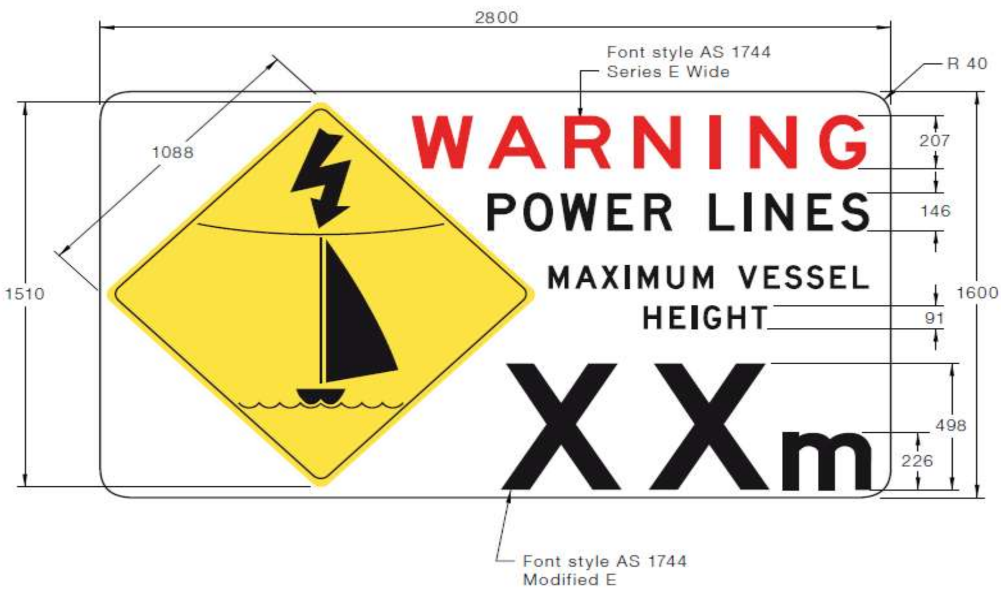


Dimensions in millimetres

Font style Series D Medium UNO in accordance with AS 1744

Colours
Red R13-Signal Red (PMS 186C, 1795U) in accordance with AS 2700
Yellow Y15-Sunflower (PMS 136C, 115U) in accordance with AS 2700
Black 00E53 in accordance with BS 5252
White 00E55 in accordance with BS 5252

Small overhead conductor crossing warning sign



Dimensions in millimetres

Font style Series D Medium UNO in accordance with AS 1744

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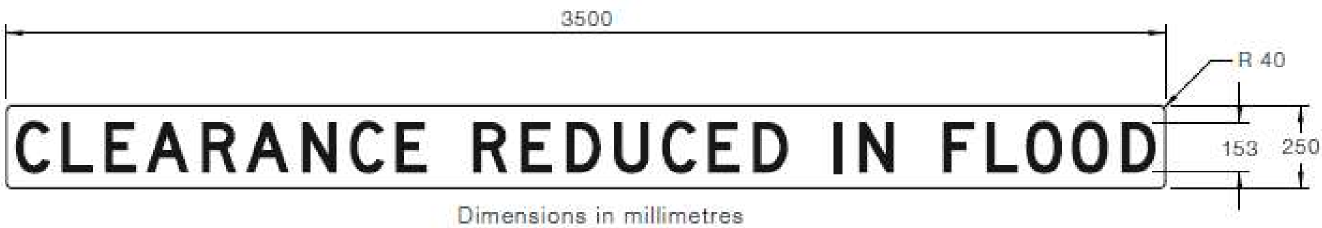
Red R13-Signal Red (PMS 186C, 1795U) in accordance with AS 2700
Yellow Y15-Sunflower (PMS 136C, 115U) in accordance with AS 2700
Black 00E53 in accordance with BS 5252
White 00E55 in accordance with BS 5252

Clearance over Navigable Waterways Cont'd

For conductor crossings over waterways that are subject to temporary increases in water height above maximum height of water due to flooding, supplementary signage shall be attached to the warning signage.

Large complementary flooding sign

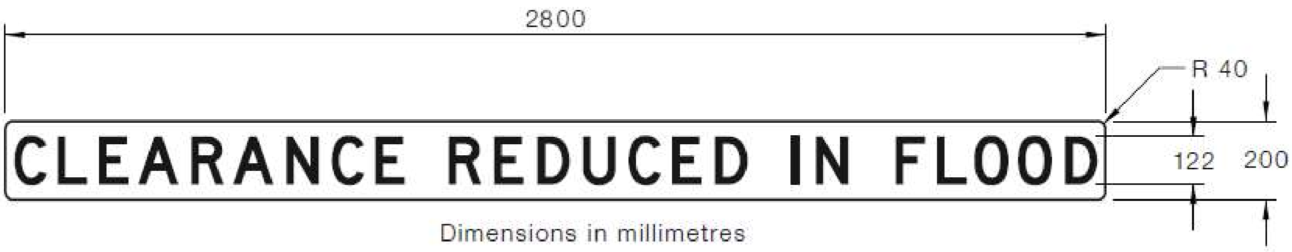


Dimensions in millimetres

Font style Series D Medium UNO in accordance with AS 1744

Colours
Black 00E53 in accordance with BS 5252
White 00E55 in accordance with BS 5252

Small complementary flooding sign



Dimensions in millimetres

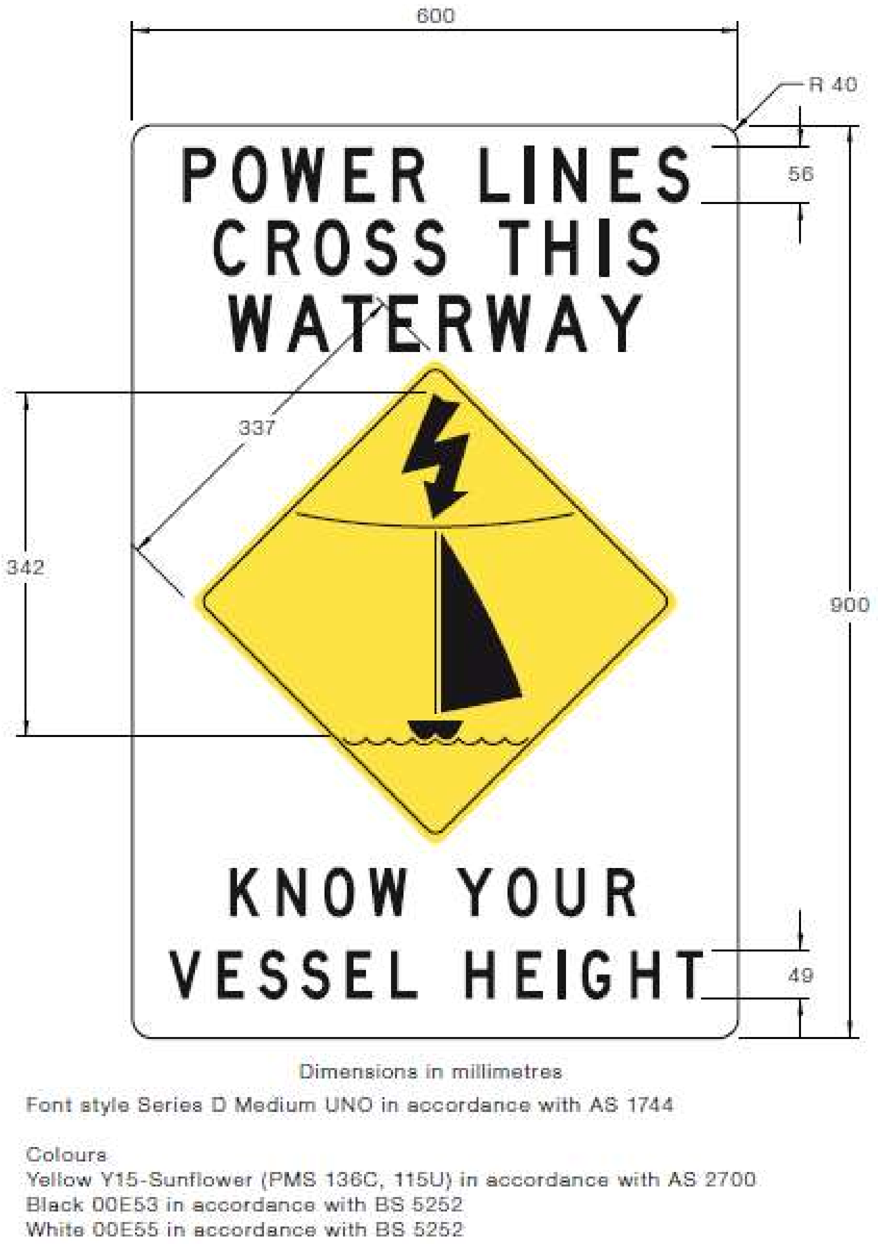
Font style Series D Medium UNO in accordance with AS 1744

Colours
Black 00E53 in accordance with BS 5252
White 00E55 in accordance with BS 5252

Clearance over Navigable Waterways Cont'd

For navigable waterways with overhead conductor crossings installed, signage shall be installed at formal boat launching sites that provide access to the waterway within 5km of any overhead conductor crossing.

Overhead crossing awareness signage



Cable markers

Where the risk assessment findings warrant, cable markers may also be installed on the overhead crossing conductors. Markers should generally be in accordance with *AS3891*, or equivalent.

10.11 CLEARANCES OVER FLOODWAYS

The clearances below are to be applied to all river-crossing spans where flood and river height data is available. For navigable waterways, these flood clearances are required to be achieved while also achieving the clearance requirements for navigable waterway crossings.

Nominal System Voltage	Minor Floodl[1]	Major Flood[2]	
	Vessels with No Masts	Large Catchments[3]	Small Catchments[4]
Bare or covered conductor up to 33 kV	5.0m	4.0m	3.0m
Bare or covered conductor >33kV, ≤132kV	5.5m	4.5m	3.5m

Notes:

1. A minor flood event is likely to affect minor roads but cause no evacuations.
2. A major flood event is a 1-in-50-year or 1-in-100-year event that will cause extensive property damage and evacuations.
3. Large Catchments: Associated with a river that will remain at major flood for a number of days. It is expected that watercraft or emergency vessels will traverse it while in flood, but these are not expected to have a mast.
4. Small Catchments: Associated with a creek that will both rise and fall within short time periods (hours). It is not expected that there will be vessels or craft in the waterway.
5. When assessing conductor clearance allow for sag at maximum operating temperature, settling in and creep of conductors.
6. When a power line crosses a waterway navigable by boat (i.e. recreational fishing, sailing) then the crossing should be designed in accordance with AS*6947 - Crossing of Waterways by Electricity Infrastructure*.

Distribution network poles supporting water crossing conductors should be located a minimum distance of 10m from the riverbank edge and backstayed (with a ground stay).

10.12 EASEMENT WIDTHS

Classification of Lines	Total Easement Width
HV & LV lines in rural areas	12m
HVABC lines in rural areas	6m
HV & LV lines in urban areas	9m
LVABC in rural and urban areas	6m

Increased width, e.g. 20m, may be required for very long spans where blowout is substantial.

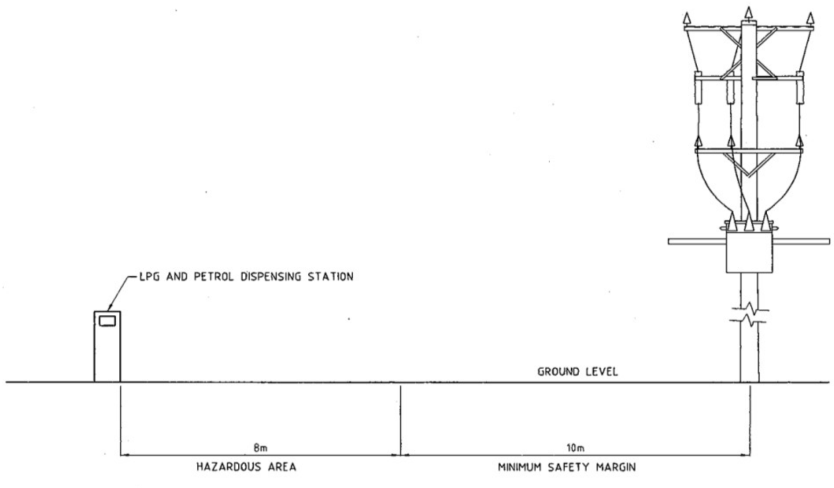
10.13 CLEARANCES FROM FLAMMABLE MATERIALS

Distribution Equipment	Hazardous Area			Minimum Safety Margin (to be added to Hazard Zone)	**Recommended Horizontal Clearance[2]** (Hazardous Area + Safety margin)		
	Petrol and LPG Storage Tanks	Diesel Storage Tanks & Dispensing Station	Petrol and LPG Dispensing Station[3]		**Petrol and LPG Storage Tanks[1]**	**Diesel Storage Tanks & Dispensing Station**	**Petrol and LPG Dispensing Station**
Distribution pole or substation with EDO fuses	15m	5m	8m	10m	25m	15m	18m
HV Links, air-break switches, HRC fuses and lightning arresters	15m	3m	8m	5m	20m	8m	13m
Ground type substations and indoor substations	15m	4m	8m	1m	16m	5m	9m
LV pole with fuses, pillars and turrets, or LV service fuses	15m	3m	8m	1m	16m	4m	9m

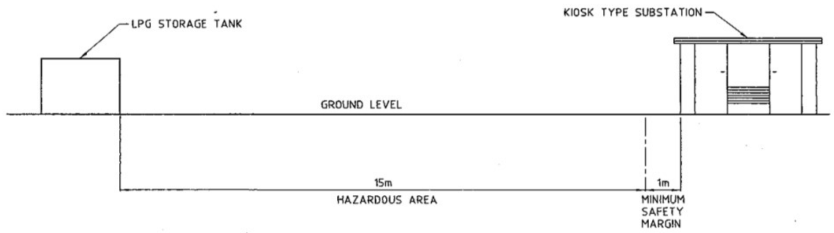
Refer *AS2430* Part 3 - Classification of Hazardous Areas – Specific occupancies. None of the distribution equipment listed should be located within the recommended horizontal clearance, measured from the source of the hazard.

Notes:

1. Where the recommended minimum horizontal clearance cannot be achieved, the hazardous area may be reduced in accordance with *AS2430* Part 3 Section 9.2.4.
2. The recommended horizontal clearance indicated is the horizontal distance measured in any direction from the source of the hazard to the boundary of the equipment installed at ground level, or centre of pole for overhead equipment.
3. The hazardous area for LPG dispensing stations is either 8m horizontally from the cabinet or 3m horizontally from the hose nozzle, whichever is the greater.
4. a) Cylinder filling: The hazardous area for outdoor cylinder filling is 7m horizontally from the fill point.
   b) Outdoor cylinder installation, in situ fill type: The hazardous area extends 10m horizontally from any cylinder valve. The hazardous area may be reduced in accordance with AS2340 Part 3 Section 9.2.4.



EXAMPLE 1



EXAMPLE 2

10.14 NON- STANDARD CLEARANCES AT SPECIAL HIGH-RISK LOCATIONS

Sections 10.1 and 10.2 give standard clearances to be met at various high-risk locations, e.g. in the vicinity of large machinery or irrigators. These clearances will be suitable for most situations, but on occasions, special situations may be encountered where these clearances are insufficient to adequately address risks.

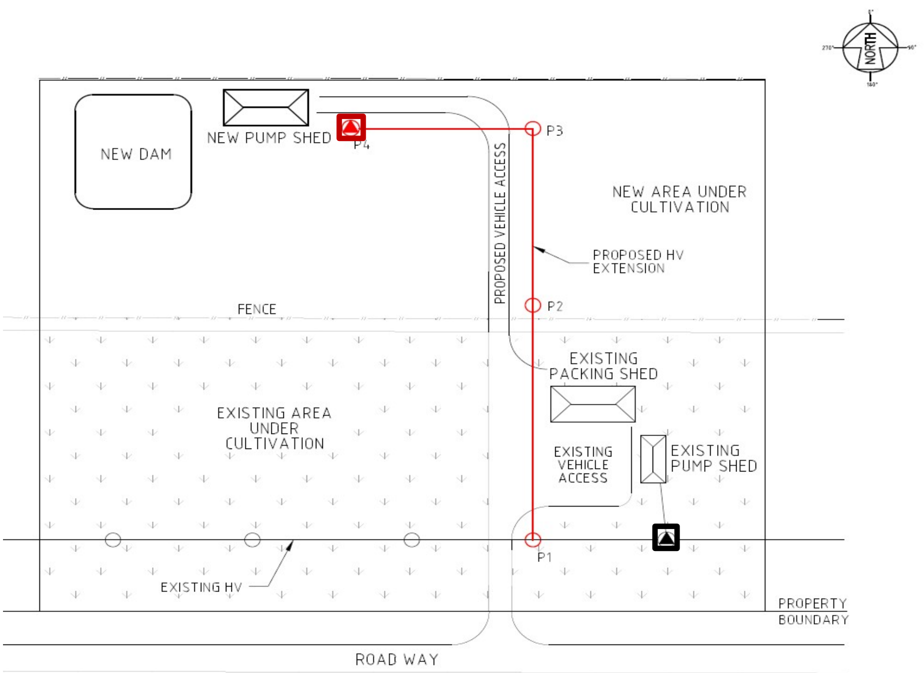
What clearance is reasonable depends upon the actual and foreseeable use of the land beneath the line. The designer is responsible for determining the most appropriate solution to minimise the risk of any contact with live power lines by equipment or persons. Suitable solutions may include:

- increased clearances
- altering line route
- installation of powerline markers
- use of insulated conductors or underground cable.

Once an appropriate solution is determined, the designer should ensure a file note is prepared detailing conversations with land owners and considerations and the rationale used to arrive at the solution. The key elements should be also added to the project scope statement and the final design plan so that it is communicated to all relevant parties.

<u>Example of Custom Risk Assessment</u>

A farm that is currently utilises traveling irrigators is undergoing expansion and is now requesting supply to a new dam. This will require a HV extension, teeing off the existing line, to a new pole transformer. The line route will follow a heavy vehicle access route to the dam and pump location, passing a loading area at a packing shed, as well as crossing land to be irrigated.



In assessing the risk associated with the HV extension from P1 to P4, the intended activities to be conducted on the property are investigated and found to be:

a) produce processing and vehicle loading around the existing packing shed
b) use of travelling irrigators in the existing area under cultivation and new area under cultivation
c) Use of harvesting machinery in the existing area under cultivation and new area under cultivation.

For each of the above activities, the foreseeable location that machinery may operate, and at what height is thoroughly investigated. This includes scenarios where it may be reasonably expected that a person may climb up or on top of machinery from time to time.

Span P1 - P2

It is determined that the maximum height of forklifts (including their load) and trucks in the vehicle access area is 4.5m and that there are no foreseeable circumstances where a person would climb on top of the vehicle/forklift load while in the vehicle access area.

Irrigation and harvesting machinery will not operate underneath the span but will travel underneath with maximum travelling heights of 3.0m and 3.6m respectively.

Therefore, this span does not require any additional height beyond the minimum clearance of 6.7m.

Spans P2 - P4

It is determined that no forklifts or loading trucks will operate under these spans, however it is intended the harvester will be used, traveling east-west between the dam and the eastern property boundary.

A travelling irrigator will operate in in three arcs: two on the western side of the access road, and one on the eastern side. The travelling irrigator will be a total of 20m in width with a maximum height of 4.0m. Climbing access is provided at the wheel locations, with the highest point a person could stand measured at 2.8m, hence anticipated total reach height for a person standing with outstretched arms is 5.2m (2.8m + 2.4m). There are no plans for end gun extensions at this stage.

It is determined the arcs through which the irrigator will operate in the western paddock will not pass under the line and will maintain a horizontal clearance of 20m from P4. Even with 6m end gun extensions, which could reasonably be expected to be added in the future, there is greater than 8.5m horizontal clearance, so no additional clearance requirements need be specified.

For the eastern paddock, it is determined the arc through which the irrigator will operate will pass under the line. Clearance to the proposed pole locations is anticipated to be 15m from P3 and 30m from P2, hence even with 6m end gun extensions, which could reasonably be expected to be added in the future, there is greater than 8.5m horizontal clearance, so no additional horizontal clearance requirements need be specified. Considering vertical clearances where the irrigator will pass under the line, if an operator were to climb onto the irrigator while it was at mid span, which is assessed as reasonable, then with outstretched arms an operator at 5.2m will breach approach limits for conductors at less than 8.2m. *Accordingly, for this scenario the span between P2 and P3 requires a minimum design height of 8.2m.*

Considering the harvester, the maximum height is 3.6m, and occasionally, the machine will jam requiring the operator to climb to the top of the chute to clear the obstruction. In doing this activity, an operator may stand on a ledge on the machine at 2.4m, hence the anticipated total reach height is 4.8m, which is well short of the minimum 6.7m clearance.

In summary, the design requires a minimum ground clearance of 8.2m for P2-P3, but only 6.7m in the other spans.

SECTION 11 – EARTHING

Version: 1.0

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SECTION 11 – EARTHING

11.1 ROLE OF DESIGNER

Designers need a good understanding of earthing systems in order to specify suitable earthing arrangements for the various types of equipment and cables used within the network at various locations. Incorrect earthing can be more hazardous than no earthing in certain circumstances. Designers need to be able to recognize any incorrect earthing arrangements in the field and nominate suitable remedial actions. Section 11.2 provides an overview of the various earthing systems employed within the TasNetworks distribution network. Sections 11.3 and 11.4 provide guidance on earthing arrangements for various types of equipment on non-conductive and conductive poles.

Designers need to recognize locations when it may be difficult to achieve the required earth resistance values due to poor soil, e.g. dry sand, rock, mountain tops with low salt content. In such instances, earth resistivity may need to be measured and an earthing system undertaken to determine the best way to achieve the required resistance. Likewise, if an area is known to be rocky, the designer may need to specify deep drilled earths rather than driven rods. This is addressed in section 11.7.3 and 11.7.4.

Designers need to recognize situations when a special risk-based earthing design is required, as discussed in section 11.5.

Finally, designers need to recognize situations affecting the location of earthing, e.g. the need to maintain adequate clearances from telecommunications equipment, consumer earthing, metal pipelines or railway earthing.

11.2 DISTRIBUTION EARTHING SYSTEMS

11.2.1 Low Voltage MEN System

AS3000 specifies the 4-wire multiple earthed neutral (MEN) system as the standard distribution system in Australia. Under the MEN system the LV neutral conductor is solidly earthed at the source of supply, at regular intervals throughout the system, and at each electrical installation connected to the network.

To achieve a low resistance between the neutral and ground, the low voltage neutral in a MEN system should be earthed at the following locations:

- the LV neutral terminal of the transformer
- the end of radials (i.e. terminal poles, cable termination poles)
- every 3rd pole or every 250m of circuit length, whichever is the lesser distance
- LV switches (disconnect links on poles)
- Tee-off poles.

The local low voltage earth shall be less than 30Ω disconnected and 10Ω when in-service, connected in parallel with the area MEN.

Also, inside the customer’s installation, the neutral conductor is connected to a local earth at the customer’s switchboard. Consequently, all metalwork of appliances, tools etc are also connected to the low voltage neutral. Therefore, it is essential that the neutral conductor be kept at, or close to, earth potential.

All accessible earthed metalwork at a pole base should be bonded together to ensure it is at the same potential. In general, it should be bonded to the LV MEN earthing system (except on conductive HV poles).

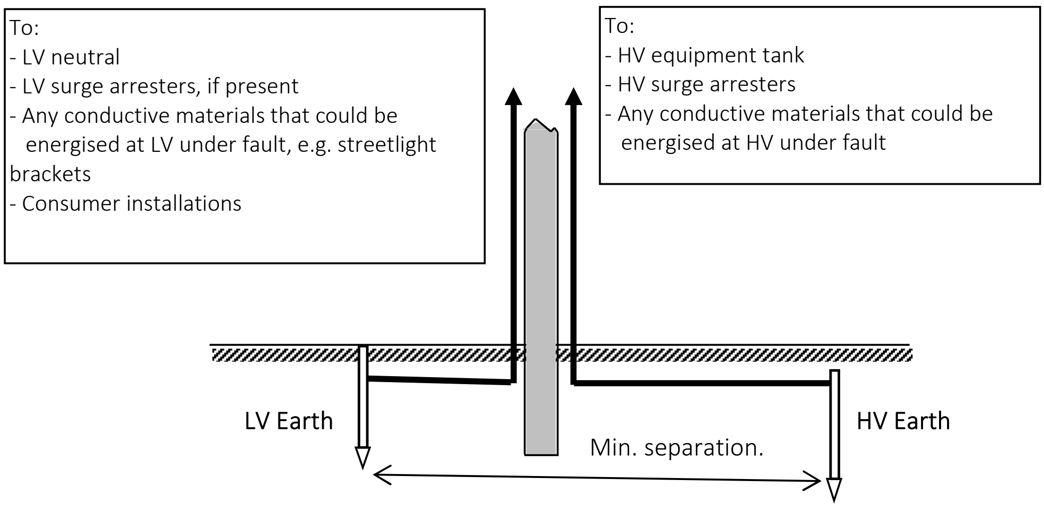
11.2.2 Separate HV Earthing

A high voltage earthing system provides an earth return path for plant and equipment capable of being energised by the high voltage system (e.g. HV surge arresters, transformer tank, HV cable sheaths).

Within the TasNetworks overhead distribution network, the general policy is to keep the HV earthing system electrically separate from the LV MEN system. The HV earthing system shall not be connected to the LV MEN system unless it has been checked that conditions are met for establishment of a CMEN system – see section 11.2.3. This separation is required to ensure high voltage earth faults, lightning impulses or switching surges (e.g. conducted to earth through surge arresters) are not injected onto the LV MEN system which extends into consumer premises and cause excessive earth potential rise (EPR).

Separation between the HV and LV MEN earthing system needs to be maintained:
- by ensuring adequate clearances and insulation between the two earth systems on the pole
- by ensuring adequate clearances and insulation between the earth electrodes in the ground – typically a minimum of 4m.

Designers should ensure that there will be no inadvertent connection between these two systems, for example:
- reinforced concrete or metal fencing in close proximity to both HV and LV earth electrodes
- inadequate insulation between a HV cable sheath (HV earth) and a metallic cable guard (bonded to LV MEN).



11.2.3 Common Multiple Earthed Neutral (CMEN)

In urban areas where there is a large interconnected MEN system spread over a wide area, many utilities connect the HV earthing system to the LV MEN system to create a single, common earthing system. Due to the very low resistance to earth on such a large grid, HV fault currents do not cause unacceptably high voltages on the LV network. Also, the low earth resistance substantially reduces the voltage rise and potential gradients in the vicinity of high voltage plant. These areas are known as 'bonded areas'.

TasNetworks utilise CMEN earthing on much of the urban underground distribution network. However, CMEN earthing is generally not used on the TasNetworks overhead network since new overhead reticulation is primarily now only installed in non-urban areas. Also, earth fault currents on the TasNetworks distribution system are relatively high since no earth fault current limiting equipment is used at zone substations, so commoning of earth systems would have potential to inject very large currents into the LV MEN system.

Should a CMEN system be required, the following conditions would be required, or else a risk-assessment study carried out:

- less than 1Ω resistance between the network neutral and earth (i.e. 'connected' resistance)

AND

- a maximum of 1000A of HV fault current available at the point of connection.

OR

- a prospective EPR less than 1000V.

It is expected that the LVMEN system would have at least 100 earth rods connected to ensure stability of the low resistance reading with seasonal soil moisture variation.

There is also the additional general requirement that individual earth resistance (i.e. disconnected from the network neutral) must be less than 30Ω for pole-mounted plant and less than 10Ω for ground-mounted plant.

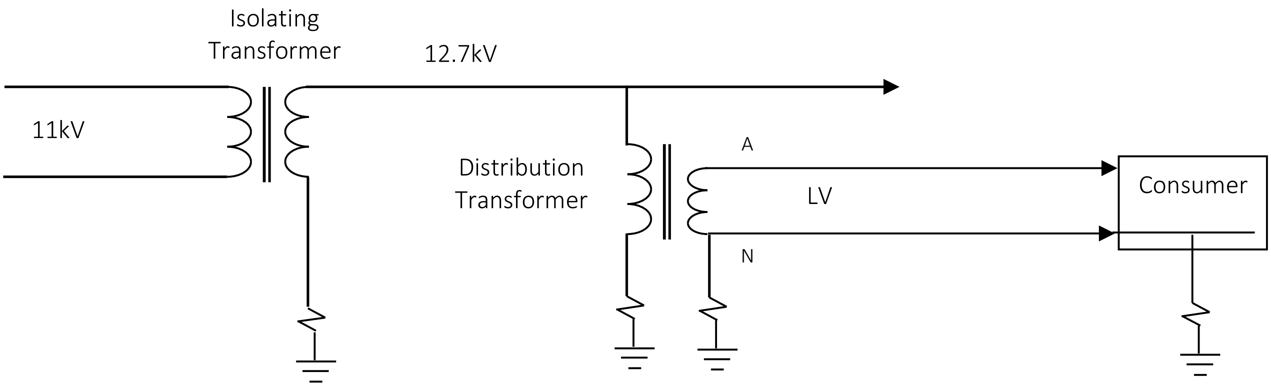
Advantages of the CMEN system are:

- only one earthing system need be installed
- overcomes issues of trying to maintain separation between two earthing systems and avoids any issues with potential difference between them
- step and touch potential problems are reduced
- earth potential rise (EPR) problems associated with electrical plant in proximity to telecommunications plant are reduced
- suited to use with conductive poles
- A transformer low voltage winding fault has a return path through both the HV and LV earthing systems. With separate earthing, such a fault will usually not be seen by upstream protection and will result in a continuous voltage on the transformer tank.

11.2.4 Single Wire Earth Return (SWER)

The Single Wire Earth Return system requires separate and distinct high voltage and low voltage earthing systems.

SWER systems consist of a single isolating transformer (typically 100 - 150kV.A, 5 - 8A) and a number of individual SWER distribution transformers. The isolating transformer carries all the load of the SWER scheme connected to it. The primary winding of the isolating transformer is connected between two phases of the conventional 11kV (or 22kV) system. The secondary winding has one terminal forming the high voltage (Single Wire) of the SWER line (typically 12.7kV) and the other is connected to earth. The individual distribution transformers have one terminal connected to the high voltage line, and the other to earth. The earth acts as the return conductor back to the isolating transformer to complete the circuit (Earth Return).



In normal three-phase systems, earthing of 11kV equipment is merely a protective measure and current flows in the earth circuit only for the duration of a fault. However, in the case of a SWER system, the 12.7kV earthing installation carries the load current of the circuit as well as any fault current. This aspect brings the earthing system of the SWER line into greater prominence than that of the conventional line.

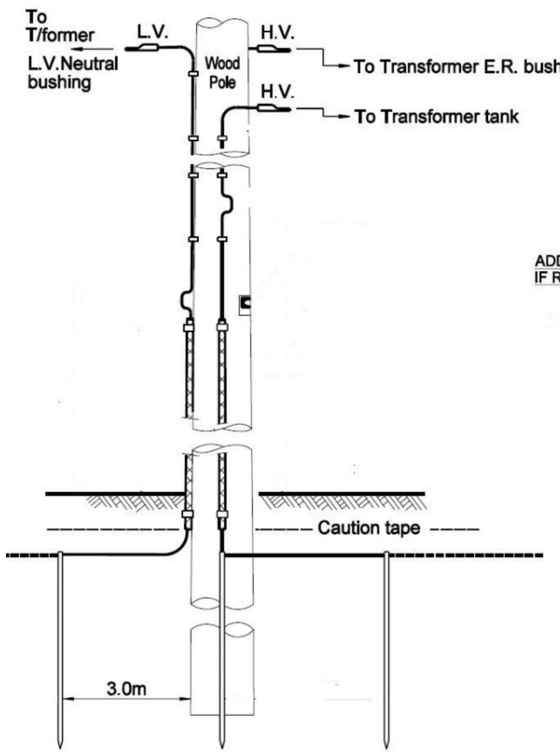
The system must be designed to limit the standing voltage on the SWER distribution HV earth to a safe value – 20V typically.

Opportunities for hazard exist if the resistance on the ground connections increases. This can easily occur at the isolator location where the combined ground current can cause heating which can dry out and substantially increase the earth resistance.

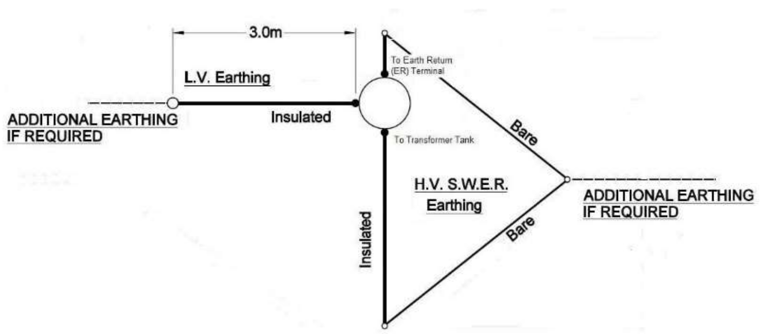
A minimum of 3m clearance must be maintained between HV and LV earthing systems at distribution transformers. Designers should ensure that there will be no inadvertent connection between these two systems, for example reinforced concrete or metal fencing in close proximity to both HV and LV earth electrodes.

At SWER distribution transformers, two separate and distinct earthing systems must be provided, as illustrated below, with separation and insulation maintained on the pole and in the ground. There are two HV downleads for enhanced reliability, one from the Earth Return bushing of the transformer and one from the transformer tank and HV surge arrester. Mechanical and electrical protection of the earth downleads is critical, and there are no disconnection points as full HV potential would appear across any break in the earthing system.

Elevation



Plan view



The maximum SWER earth lead (HV earth) voltage under operating conditions shall not exceed 20V.

The low voltage earth is used for earthing the low voltage neutral, metalwork associated with the low voltage and the low voltage surge arresters.

11.2.5 Other Earthing

Overhead earth wire (lightning intercept) and OPGW downleads should be kept separate from LV and HV earths.

Likewise, communications cable earths (e.g. pilot cable screen and catenary earthing) should be kept separate from power system earths.

11.3 EARTHING OF VARIOUS ITEMS ON NON-CONDUCTIVE POLES (WOOD & COMPOSITE FIBRE)

11.3.1 Pole Transformers

Except where CMEN earthing is specified, two separate and distinct earthing systems shall be provided, with separation and insulation maintained on the pole and in the ground.

11.3.2 Air-Break Switches (ABS)

The metalwork of the ABS is connected to a HV earth. Within TasNetworks, operating handles of Air break Switches are typically at a height of 5m from ground and operated from an insulated ladder. Therefore, the handle, which is below the insulated rod section, can simply be connected to the HV earth downlead.

11.3.3 HV Pole-mounted Plant

Except where CMEN earthing is specified, HV earthing shall be kept separate from any LV MEN system earthing, with separation and insulation maintained on the pole and in the ground. The HV earth should be positioned as far away as practicable from any LV earth on the pole – ideally on the opposite side (180° offset).

Any control boxes for reclosers or regulators should be mounted above 2.4m to avoid any problems with touch potential. Typically, the control box earth is made continuous with the recloser main tank (HV) earth. Some manufacturers specify a single bonding point for both the main tank and the control box in order to minimise the potential difference that can occur along an earth downlead subject to lightning impulse current. Potential differences can also occur when auxiliary AC supply for the control box is sourced remotely from the pole on which the recloser is installed. Some variations exist between manufacturers and the relevant installation manual should be consulted to confirm the specified earthing arrangement.

Separate HV and LV earthing systems may be utilised with pole-mounted capacitors and HV metering units, with the control box connected to the LV earthing system.

11.3.4 Underground Cable Terminations

TasNetworks does not earth metallic cable guards on wood poles. There should be adequate insulation and separation between HV cable sheaths/earths and metallic cable guards.

A MEN LV earth is provided at all LV main cable terminations on poles.

For HV cable terminations on poles, the surge arrester bases require earthing. HV cable screens will generally also be earthed. However, for underground feeder 'tails' emanating from substations, this is not always the case—these should be referred to Asset Engineering for a determination as to whether the screens should be earthed at both ends or the substation end only.

11.3.5 Stay Wires

Insulators are fitted to stays on non-conductive structures to provide Isolation of the upper section of a failed stay from contact by persons at ground level. The insulator shall be placed such that the base of the insulator is higher than 2.7m from ground and the end of the insulator is below the lowest conductor. The insulator shall also be located more than 1.5m horizontally from the pole (refer *AS/NZS7000*). The insulator can also address risk of corrosion due to leakage currents or dissimilar metals being connected.

The stay wire itself is generally not bonded to the HV or LV earthing system associated with the structure, however the lower section of an intact stay is inherently earthed through contact of the stay anchor hardware with the ground.

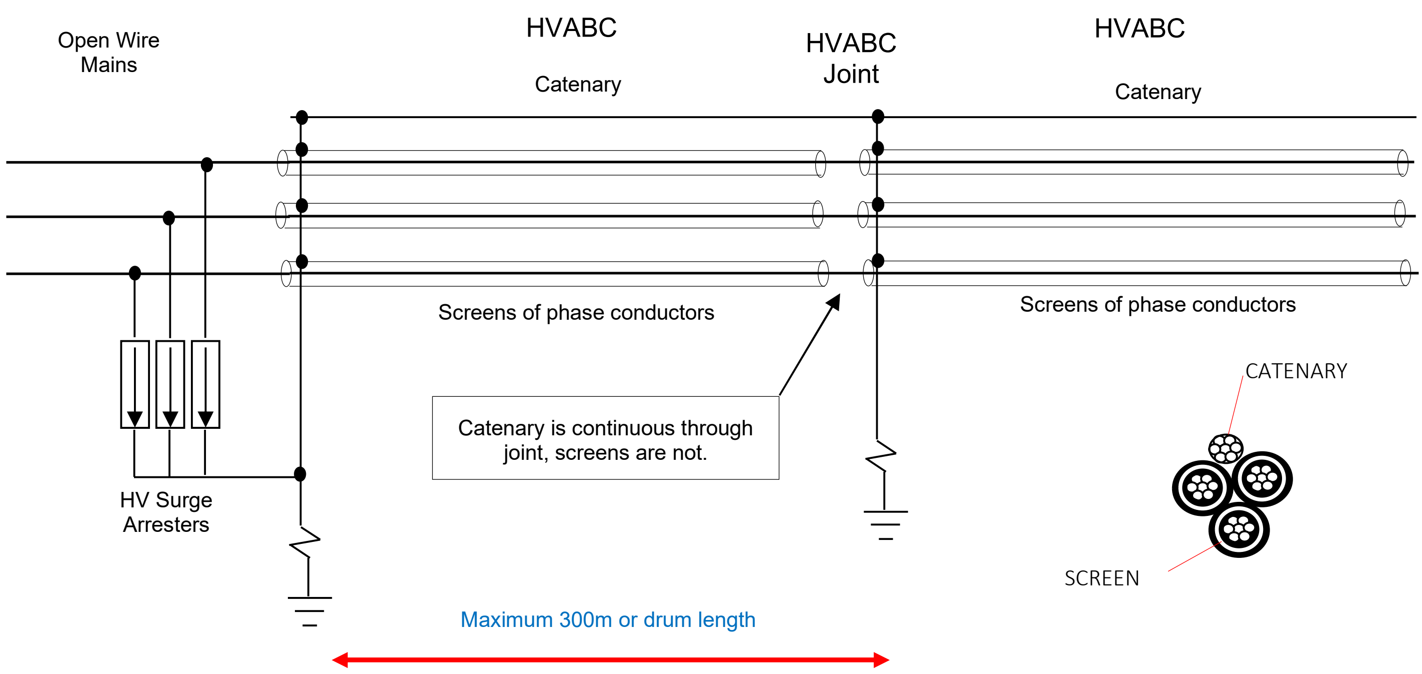
11.3.6 HVABC

The catenary wire of HVABC (i.e. aerial bundled cable) shall be connected to the high voltage earth, as it is capable of being energised by the high voltage conductors. The catenary shall be earthed at the following locations:

- overhead/underground transition (i.e. surge arresters)
- at the ends of strain sections, tee-offs and dead ends
- every fourth pole or 250m, whichever is the lesser distance.

The catenary shall be electrically continuous along the entire HVABC run.

The screens on HVABC have a modest current rating so as to minimise cable weight. The screens shall have only one earth connection and must not be continuous through joints. This is to prevent circulating currents or development of large voltages on the screen.

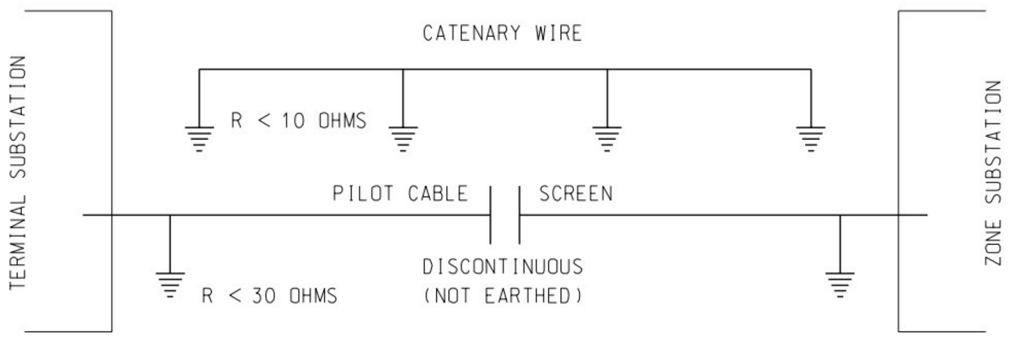


11.3.7 Pilot Cables

Pilot cables shall be sectionalised at 1000m intervals in a junction box attached to the pole. Cable shall be straight-through jointed between junction boxes with joints at pole positions where practicable.

The pilot cable catenary should be earthed at intervals of approximately 500m.

The pilot cable screen shall be earthed at substation ends but discontinuous at the mid-point of the run. Midpoint insulation shall be able to withstand 5kV for 5s. The screen earth shall have min. 600mm clearance from all other earthing systems on the pole and have a footing resistance not exceeding 30 ohm.



11.3.8 Steel HV crossarms

Within TasNetworks, steel HV crossarms are not normally earthed.

11.3.9Earth Downleads

Minimum sizes for downleads are as follows:

Standard LV MEN, not part of a pole substation	16mm^2 Cu
LV MEN associated with a pole substation	50mm^2 Cu
Standard HV earth associated with a pole substation	50mm^2 Cu
Standard HV Equipment earth	70mm^2 Cu
HV earth within 1.2km of a zone substation or associated with 33kV surge arresters	120mm^2 Cu
Pilot cable catenary earth	50mm^2 Cu

11.4 EARTHING OF CONDUCTIVE POLES (STEEL, CONCRETE, STOBIE)

11.4.1 Usage of Conductive HV Poles

Conductive poles carrying HV mains must be earthed as part of the *HV earthing system*, as they could become enlivened at HV in the event of a fault. This creates concern regarding touch voltage at the pole base.

Therefore, conductive HV poles should not be installed in an area frequented by the public except where:

- CMEN earthing is used, OR
- other touch potential mitigation measures are used such as:
    - o connecting adjacent poles together via an overhead earth wire for distribution of ground fault currents and reduction of net resistance to earth
    - o use of grading rings or concrete aprons around poles
    - o application of insulation to the pole bases
    - o installation of asphalt or crushed rock around pole bases
- AND a risk assessment study has demonstrated that risk is acceptably low.

11.4.2 Earth Connection via Pole

The structural steelwork in conductive poles provides an integral system of earthing conductor to which high voltage plant and the structure footing can be readily connected. Any earthing connections made on concrete poles must be made at a dedicated earth ferrule (welded to the internal reinforcing of the pole); attachment via a bolt through a tube is not sufficient.

MEN connections to ground may be made through the pole on LV-only poles, but on HV/LV poles only where CMEN earthing is used. On LV only poles, each pole should be bonded to the neutral of the LV mains.

11.4.3 Pole Transformers

Although it is possible to physically separate low and high voltage earthing on a conductive pole, the most practical approach is to use conductive poles to support transformers *only in CMEN areas*.

11.4.4 Pilot Cables

Catenary, pilot cable and wrapping wires shall be kept as far as possible from any HV conductive pole. Also, earth rods in the ground must be kept well clear of conductive pole footings.

11.4.5 Steel Crossarms

As the steel crossarm is itself a conductive element that is installed in an integrally-earthed situation, it is recommended that the crossarm be positively bonded to the structure. This ensures the surface of the crossarm remains equal in potential with adjacent surfaces should lineworkers access the structure.

11.4.6 Streetlight Brackets

Streetlight brackets shall only be mounted on conductive HV poles where CMEN earthing is used or where the wiring to the luminaire is double insulated.

11.5 RISK-BASED EARTHING DESIGN PROCESS

11.5.1 Triggers for Risk-based Design Approach

The following risk-based methodology described in this subsection should be used where there is to be an installation of:

- a conductive pole supporting HV mains in a separately earthed area
- a conductive HV pole in a CMEN area but with no connection to the LVMEN system
- a pole with an HV earth in a "special" location such as:
  - highly-frequented areas, e.g. outside a school or playground
  - 'wet' areas near swimming pools, beaches or water parks
  - Locations with high fault levels (>5kA).

Risk assessment studies may be referred to TasNetworks Engineering Standards section where assistance is required.

11.5.2 General Methodology

The principal references for earthing design on TasNetworks overhead distribution system are Section 10 and Appendix T of *AS/NZS 7000:2015* and ENA *EG-0:2010*.

The philosophy is to apply a risk management process to quantify the risk of fatality due to electric shock and ensure it is acceptably low rather than simply meet target earth resistance values and assume these will be sufficient to ensure safety. The initial aim of each design is to achieve the lowest total probability of fatality reasonably achievable (ALARA). All reasonable measures that can be applied to reduce the level of risk should be implemented – even beyond the point where the nominal target of $1x10^{-6}$ p.a. is achieved.

11.5.3 Required Parameters

PARAMETER	DESCRIPTION	INITIAL / DEFAULT
Soil resistivity (ρ)	Soil profile determined through on-site measurements.	50Ω-m
Fault frequency (f_r)	Determined by the effective reach of the interconnected earthing network (number of structures over which a significant portion of current is distributed), and the expected number of faults per year on these structures.	0.1/year
Footing resistance (R_f)	Calculated resistance of pole earthing system.	30Ω
Net earthing resistance (R_s).	Calculated resistance of interconnected earthing system	1Ω
Fault current (I_f)	Calculated maximum line to ground fault current at the site	1000A
Protection clearing time (t_c)	Time for nearest upstream protection device to clear fault current I_f.	0.5s
Site exposure information	Identification of salient factors regarding persons frequenting site : • Regular grouping events – bus stops, retail outlets, schools , sporting fields etc • Residential or industrial area • Site on route to popular destination – passers by	DU

11.5.4 Standard Curves

The applicability of the site exposure information can be used to assess the suitability of the standard contact scenarios listed in section 10.5.2 of *AS/NZS 7000* and Appendix E of ENA *EG0:2010*.

Should site conditions align with one of the standard scenarios, the permissible touch voltage can be determined by reading off the 'Y' axis value for the respective curve at the 'X' axis value corresponding to the protection clearing time t_c.

In the absence of detailed site data, it is suggested permissible touch voltage be based on the "Distribution Urban (DU)" scenario:

Individual exposure: 135 contacts / year for 4 seconds
Societal exposure: 75 contacts / year for 4 seconds averaged for a group of 43 people.

11.5.5 Assessing Compliance

It is recommended that a software model of the pole and its earthing system be developed in order that the surface voltage profile away from the structure under fault conditions can be calculated. The touch voltage V_t at the structure is the EPR minus the surface voltage at one metre.

If V_t is less than the permissible touch voltage for the relevant contact scenario the design complies.

If not, then additional measures should be considered to reduce the touch voltage at the structure, or increase the permissible touch voltage:

Increasing insulation Installing an insulating sleeve over the bottom 2.4m of the conductive structure, or adding an insulating surface material around the base of the pole increases the permissible touch voltage.

Equipotential grading Installing a conductive material around the base of the pole that is bonded to the pole earthing system (e.g. bonded reinforced concrete) will reduce the touch voltage by effectively flattening the surface voltage profile in the metre adjacent to the pole.

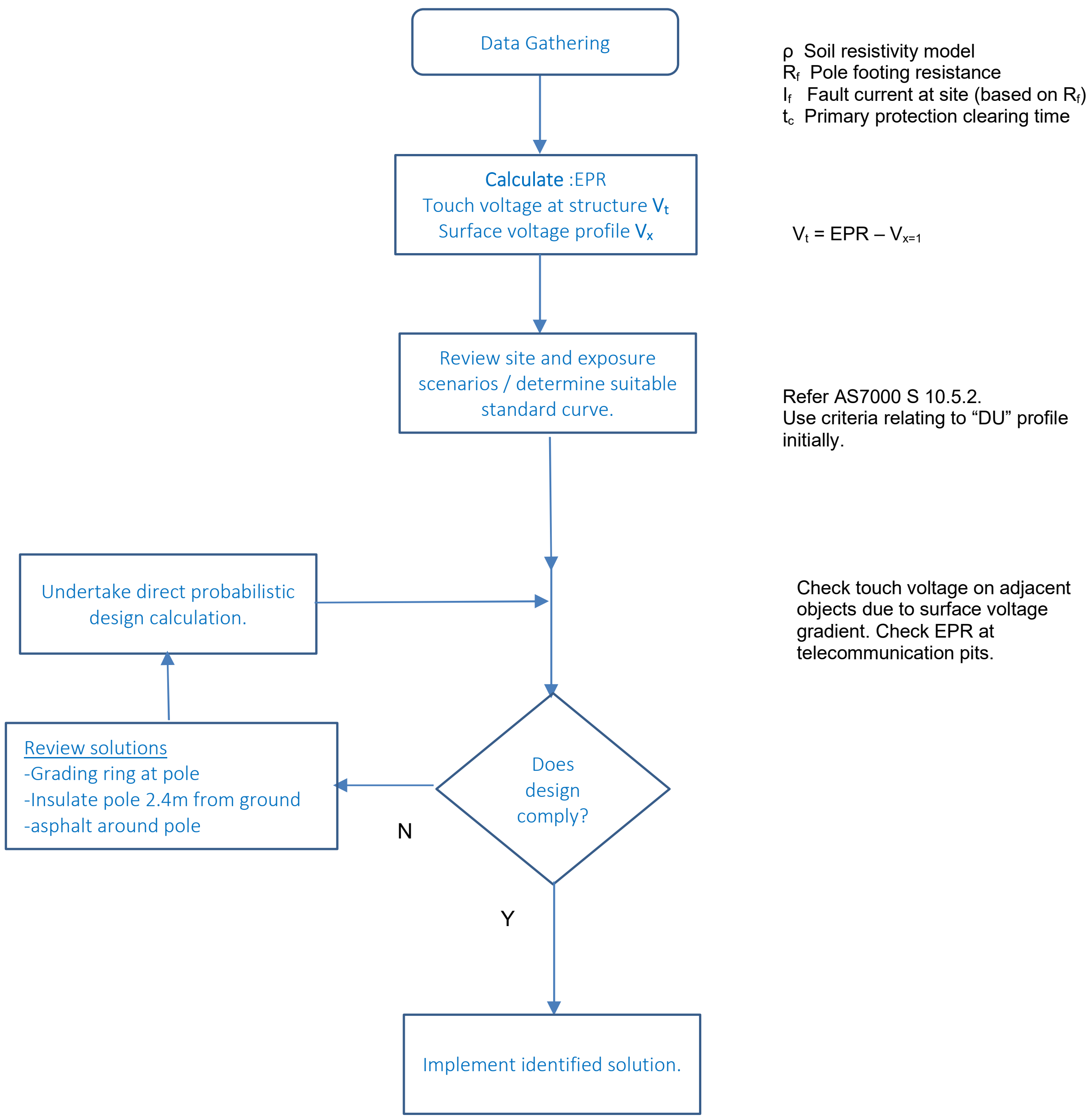
11.5.6 Individual Design Using *ARGON*

Where the identified site exposure information does not align with any of the standard contact scenarios, software such as *ARGON* may be used and the relevant data entered. Compliance can be checked for individual and societal risk with respect to the calculated touch voltage for the site/structure.

11.5.7 Process

A basic flowchart has been developed that describes the risk-based earthing design process on TasNetworks high voltage overhead distribution assets. The preceding items 11.5.3 – 11.5.5 provide direction for content that is required in the application of the design process. Further information is available in ENA *EG-0*.

RISK-BASED DESIGN PROCESS DISTRIBUTION OVERHEAD



11.6 COORDINATION WITH TELECOMMUNICATIONS

Minimum clearances to be maintained between TasNetworks earths (including conductive poles) and telecommunications infrastructure (pits, pillars, ground-mounted plant) are as shown below.

Power System Earth Type		Pits, pillars, cabinets, payphones	Exchange equipment
LV		0.3m	1m
HV Earth	Separate	15m	15m
	CMEN	2m	2m
SWER Distribution Transformer		15m	30m
SWER Isolating Transformer		25m	50m

11.7 ENGINEERING BACKGROUND

11.7.1 Function of Earthing

The electrical earthing system is designed to provide safe and correct operation of the network under normal, earth fault and transient conditions. It both facilitates disconnection of supply in the event of a short circuit and limits the voltage rise on exposed conductive parts of equipment during such faults.

During earth fault conditions, large fault currents may flow via the general mass of earth en route to the neutral point of the source transformer. The impedance of any 'earthed' metalwork (transformer tanks, switchgear enclosures, earth grids etc) with respect to the 'true' or 'reference' earth can lead to a rise in potential. Thus, something that is earthed is not necessarily at 'zero volts' and safe to touch. If unmanaged, this potential may pose a significant hazard to TasNetworks staff and/or the general public.

11.7.2 Objectives of Earthing

The design of the earthing system should ensure that:

- All metalwork and equipment able to be touched by a person standing on the ground (i.e. up to 2.4m above ground) are earthed;
- Hazardous touch, step and transfer voltages are mitigated during fault conditions (50Hz or transient);
- A low impedance path is available for lightning, switching surges and 50Hz earth fault current to limit thermal and mechanical damage of plant and to ensure protective devices such as protection relays, fuses and surge arresters operate;
- Minimal underground alterations are required if the installation is to be modified in the future.

Earthing electrodes, joints and conductors should be designed to:

- ensure earth fault currents are conducted to earth without damage to the earthing components;
- minimise the possibility of mechanical damage;
- avoid inadvertent interference;
- minimise chemical deterioration.

It is important to ensure three-phase loads are balanced to minimise the out-of-balance current flow in the neutral which also flows to earth. Harmonic currents may also cause an increase in neutral current which flows to earth.

11.7.3 Soils and Earthing

Although the earth itself is an excellent conductor due to its great mass, connecting to 'true earth' can be a challenge since we must connect through electrodes driven into soil and rock.

Conduction in soil is primarily ionic. Consequently, the resistivity of soil is determined by the quantity of moisture and dissolved conductive salts within the soil. When completely dry, most soils are non-conductive.

The main factors, which determine the resistivity of soil, are:

- type of soil
- salt dissolved in the contained water
- moisture content
- temperature
- grain size
- closeness of packing and pressure.

The structure of the soil at most locations will be non-homogeneous, consisting of multiple layers of soil types of differing resistances. The best way of accurately determining the soil resistivity at a particular site is to measure it directly.

Earthing can be expected to require less effort in the following conditions:

- soil with humus and moisture
- alluvial soils
- clay soils.

In the following areas, earthing can be expected to be difficult and designers may need to give consideration to the placement of plant and equipment requiring earthing and how resistance target values will be met:

- rock
- mountain tops—generally salt-depleted and rocky
- coarse sand and gravel
- near sandy beaches (since moisture tends to drain from sand).

It should also be recognised that soil resistivity varies with the seasons. In wetter months the soil resistivity will be low and in drier months it will be higher. Adequate earthing should be installed to ensure the target resistances are achieved in the drier periods.

Typical soil resistivity values are shown below.

Soil Type	*Typical Resistivity (Ω.m)*
Wet organic soil	*10*
Clay silt	*50*
'Typical' soil	*100*
Moist sand and gravel	*200*
Loam and broken stone	*300*
Slate, shale, sandstone	*500*
Very dry soil	*1 000*
Dry sand	*2000*
Stony / rocky ground	*2000*
Dry gravel	*3000*
Bed rock	*10 000*

11.7.4 Earthing Electrodes

Earthing systems consist of vertical electrodes interconnected with earthing cable. The standard electrode used for distribution earthing within TasNetworks is a copper-clad steel rod of dimensions 1800mm x 13mmØ. The steel core provides the strength necessary to drive the rod into the ground and the copper cladding provides corrosion resistance and allows a direct copper to copper connection between the earthing conductor and the electrode. The rod is driven so that its top is 500mm below surface level, so that there is adequate protective cover for the cable connected to it and to minimise the effect of seasonal variation in the upper layers of soil.

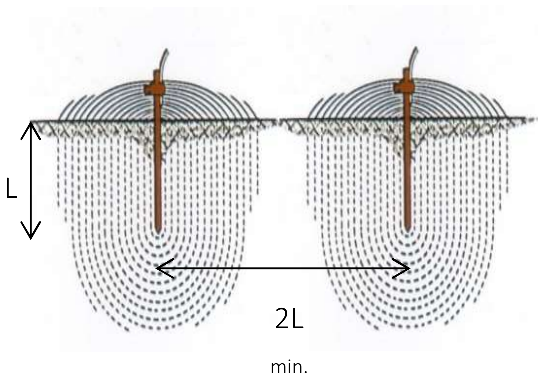
Some conductive poles make use of the pole butt itself as an earth electrode.

Measurements are made of the earth resistance at the time of construction (before and after connection to the neutral of the network) and additional electrodes are added until the required target earthing resistance is achieved. If soil resistivity increases with depth (e.g. soil over rock) then additional electrodes are installed over a wider area. Where resistivity decreases with depth, earth rods may be joined or coupled to achieve a deeper penetration to reach the lower resistivity soils.

The table below shows earth resistance for three simple earth electrode combinations subject to varying soil resistivity.

Soil Resistivity (Ω.m)	Earth Resistance (Ω)		
	Single Rod (1.8m x 13mm Dia.)	Two Rods 3.6m Horizontal Separation	Two Rods Joined Vertically
10	5.3	2.9	3
20	10.6	5.8	5.9
30	15.9	8.6	8.9
40	21.3	11.5	11.9
50	26.6	14.4	14.8
60	31.9	17.3	17.8
70	37.2	20.1	20.7
80	42.5	23	23.7
90	47.8	25.9	26.7
100	53	28.8	29.6
200	106	58	59
500	266	144	148
1000	531	288	296

There should be adequate horizontal spacing between electrodes to ensure effectiveness; otherwise the rods are connecting into the same patch of soil with little additional benefit. In fact, a separation distance of twice the electrode depth is recommended, as shown below. In practice, there should be a minimum of several metres spacing between electrodes.



Earth electrodes should be installed by mechanical driving or in drilled holes. In rocky areas, the soil resistivity is often high and earth rods cannot be installed by driving without causing breakage, so deep-drilled (or bored) earths should be installed in these areas. Copper clad steel rods and/or bare stranded copper cable is lowered into the bored holes and backfilled with a slurry made from gypsum, bentonite clay and water.

A ‘rule of thumb’ is that if target earth resistance cannot be met after the addition of ten earthing electrodes, then the soil resistivity must be measured and an earthing electrode design undertaken.

11.7.5Fault Currents and Clearing Times

The 11kV and 22kV windings at TasNetworks substations are star connected with neutral points generally solidly connected to ground. The line-to-ground fault currents at TasNetworks 11kV and 22kV distribution busbars are therefore not restricted by any neutral impedance, and therefore vary according to transformer rating and net source impedance. Currents range in value from a few hundred amperes to over 11kA, with the average maximum line to ground fault current just over 4kA.

In the first instance it is recommended that earthing design be based on the typical primary protection fault clearing times listed below:

Primary protection (touch voltages): 0.5 second

Backup protection (thermal sizing): 2.0 seconds

Consideration of the actual prospective fault clearing times based on the protection settings relevant to the installation can be made at the detailed design stage. It is understood distribution feeder protection typically includes standard overcurrent/earth fault (OC/EF) and Sensitive earth fault (SEF) protection elements to detect and initiate clearing of these line faults. It is noted that for transformer faults on non-conductive poles, that the clearing time is determined by the HV drop-out fuse operating characteristic.

SECTION 12 – SOFTWARE

Version: 3.1

TasNetworks | Powering a Bright Future

SECTION 12 - SOFTWARE

12.1 INTRODUCTION

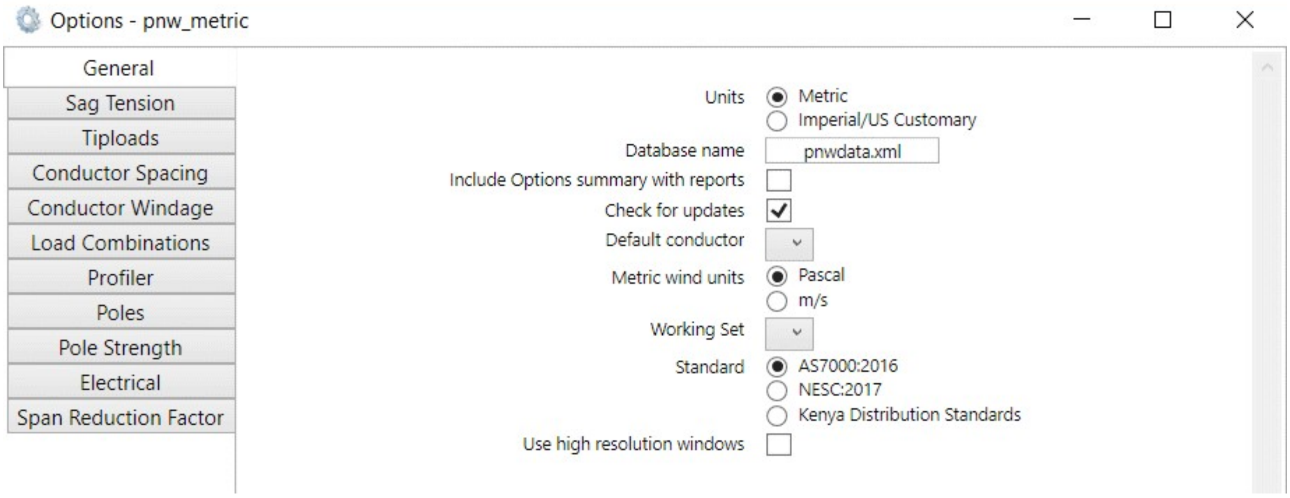
This section provides assistance with setting up various software packages commonly used for overhead network design.

Software other than the packages considered may be used provided that it can be demonstrated that it produces accurate results compliant with *AS/NZS7000* and TasNetworks standards where applicable.

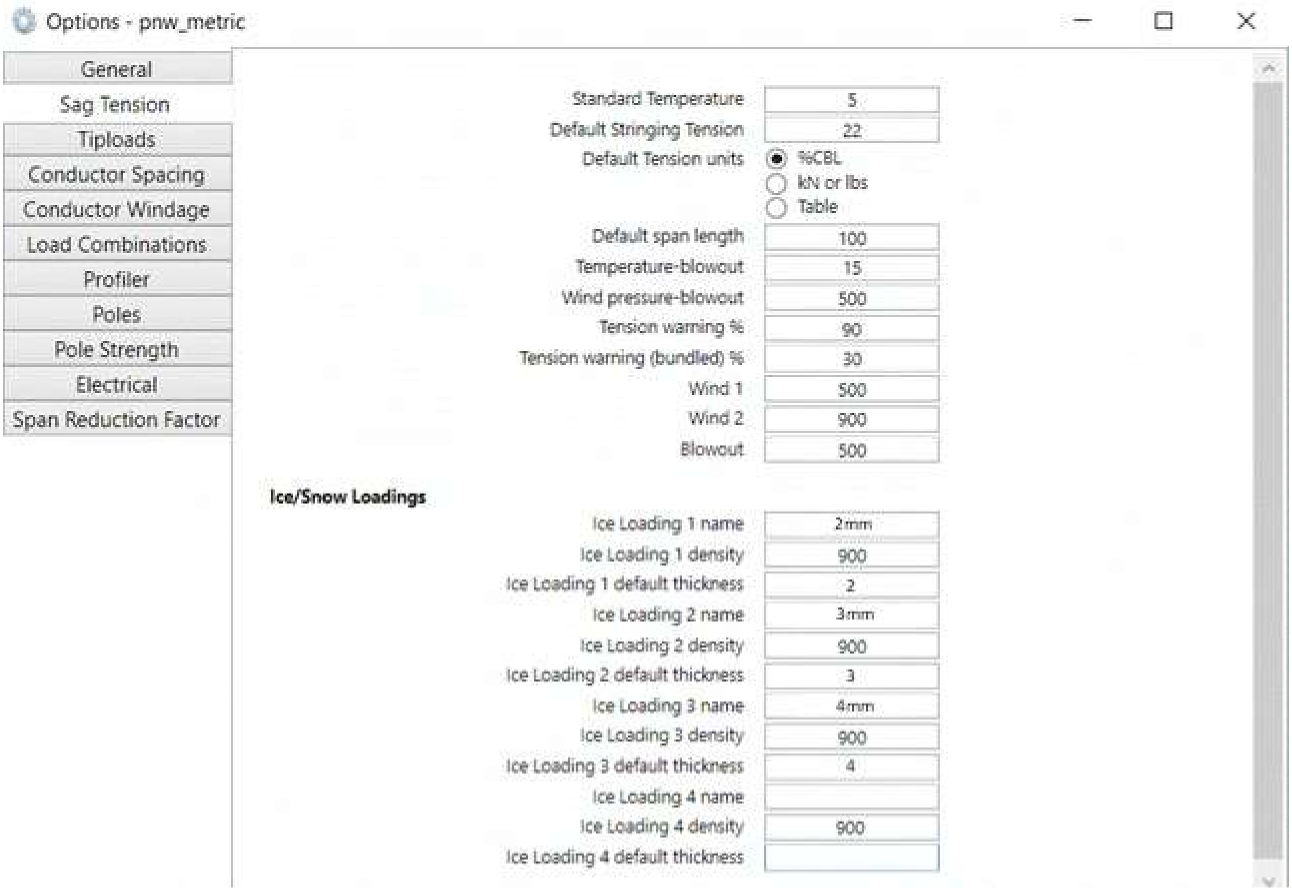
Most of the information pertaining to the set up for line design software is taken from Section 2 of this document.

12.2 *POLES 'N' WIRES* SET UP

General Set Up

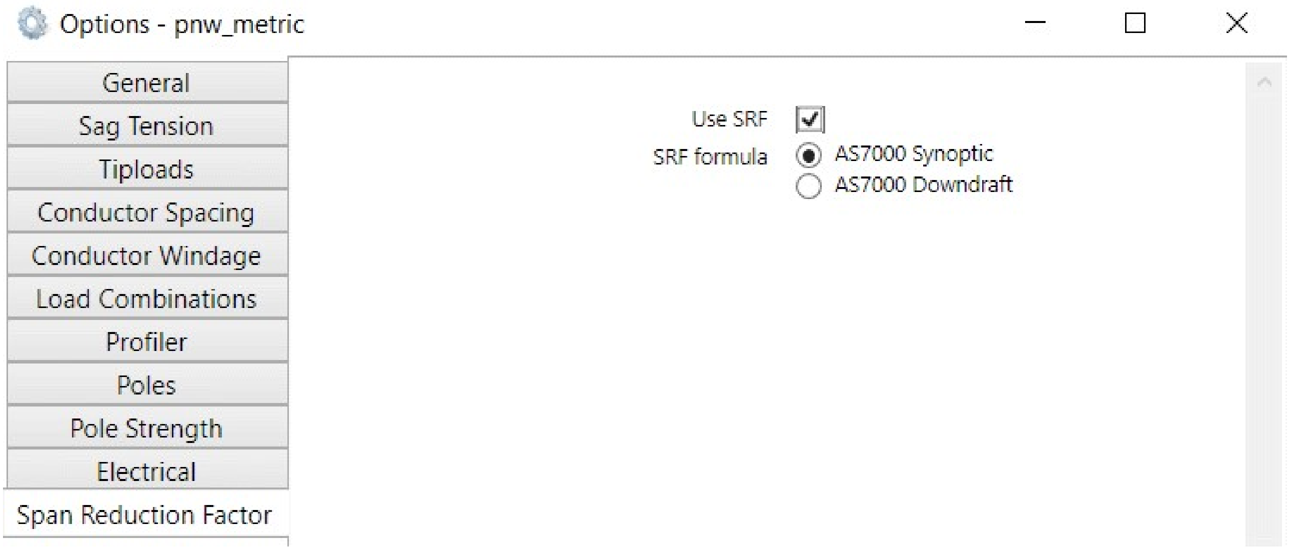


Sag Tension Calculations

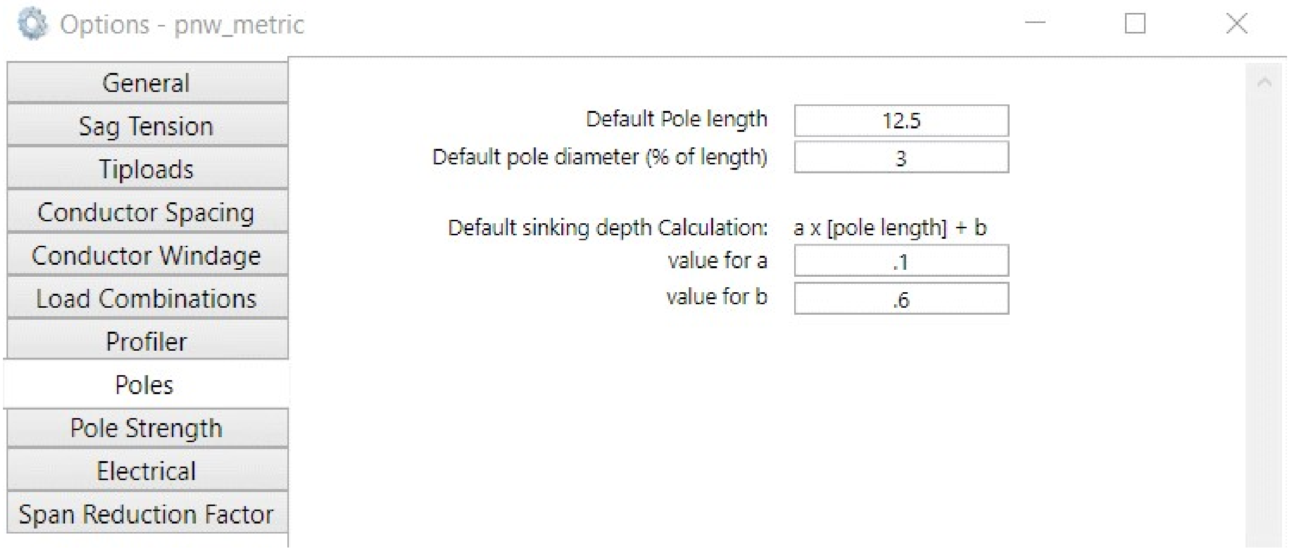


Actual ice thickness will depend on conductor size – refer section 2.3.4.

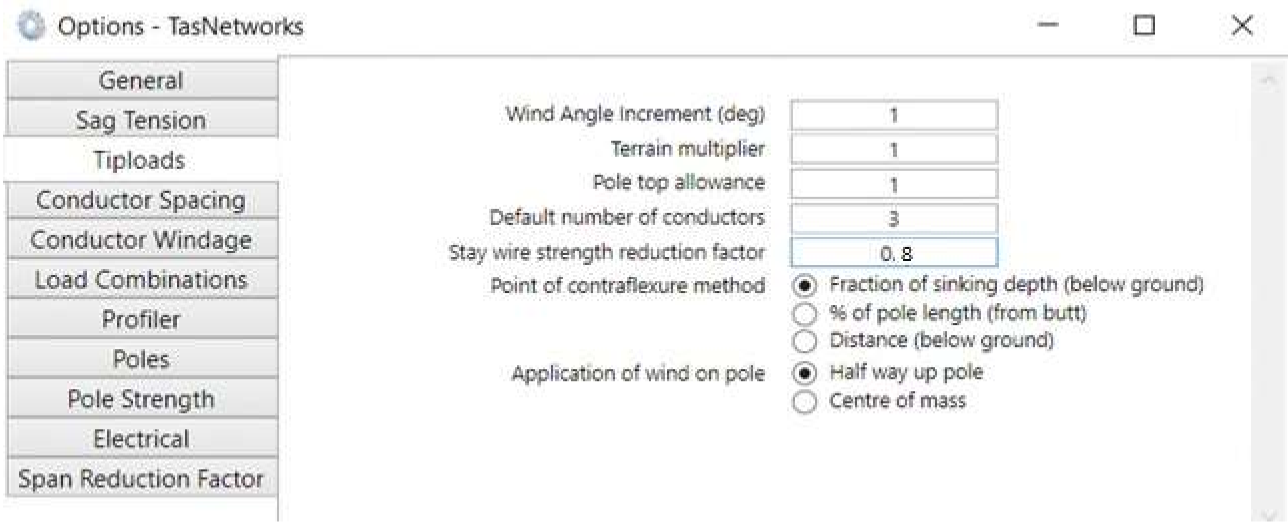
Span Reduction Factor



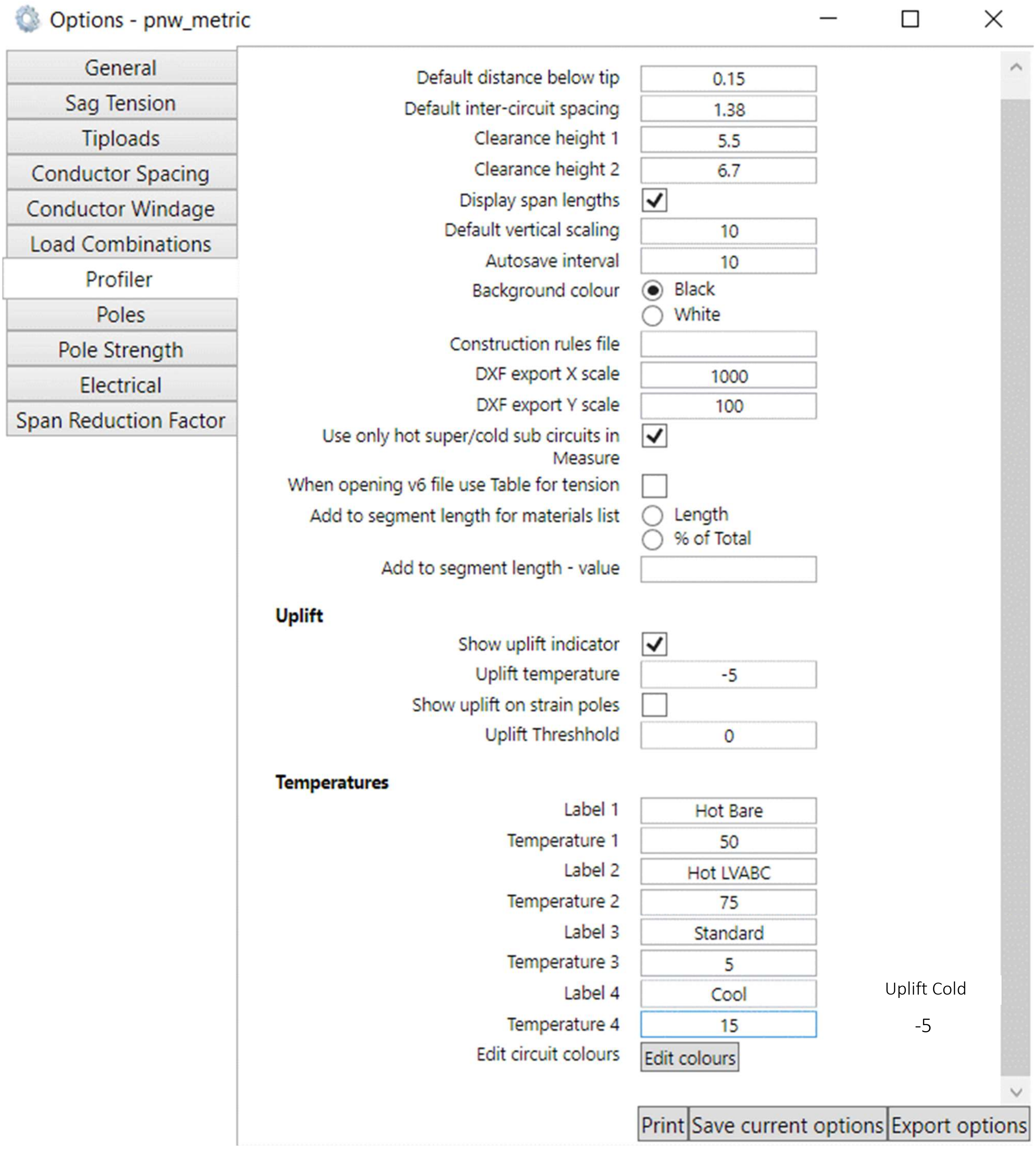
Poles



Tip Loads



Profiler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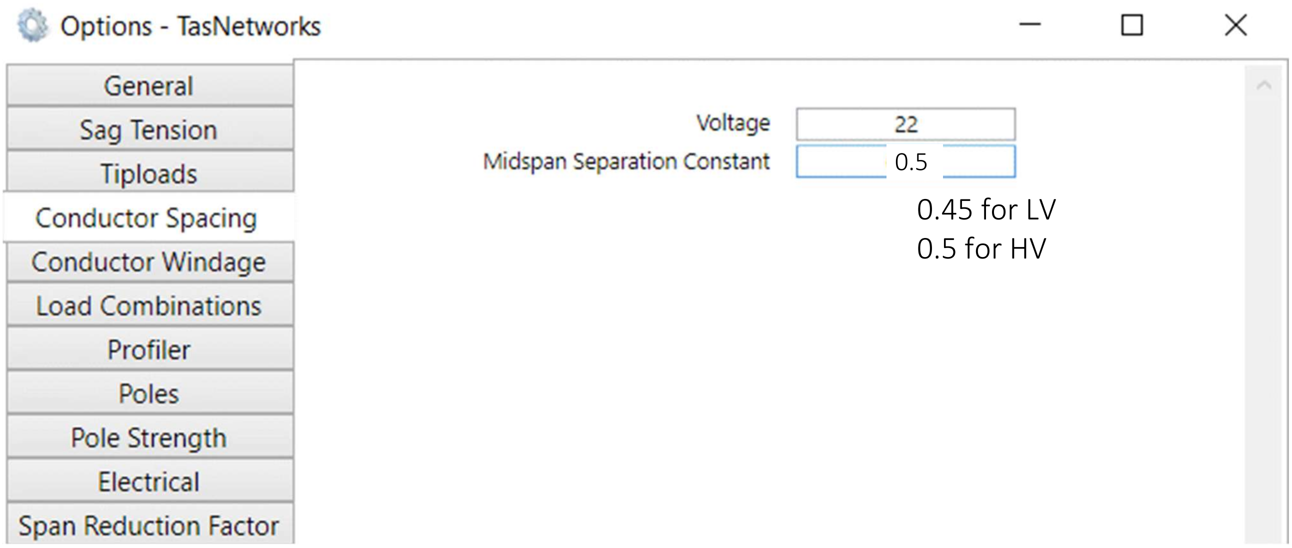
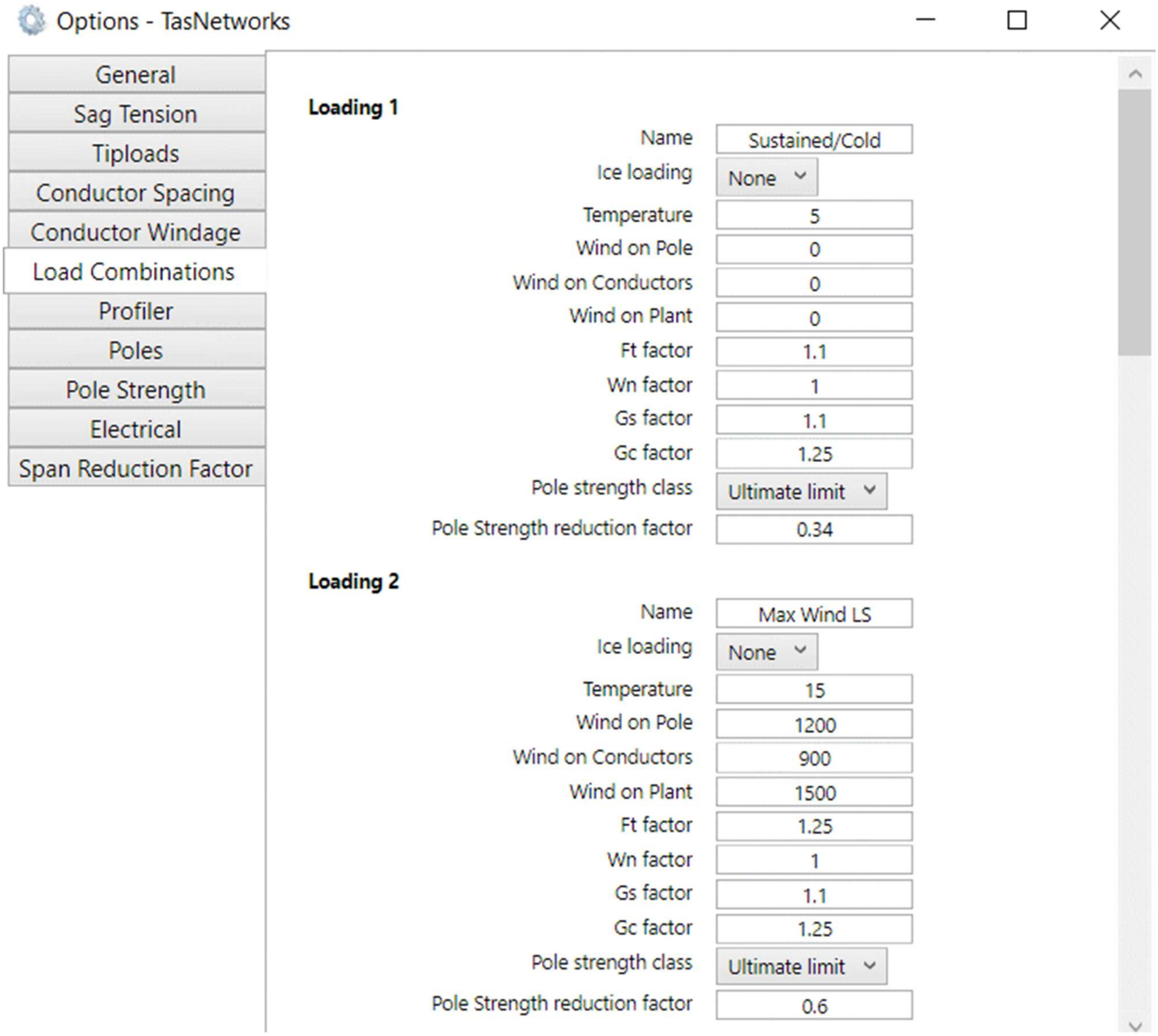
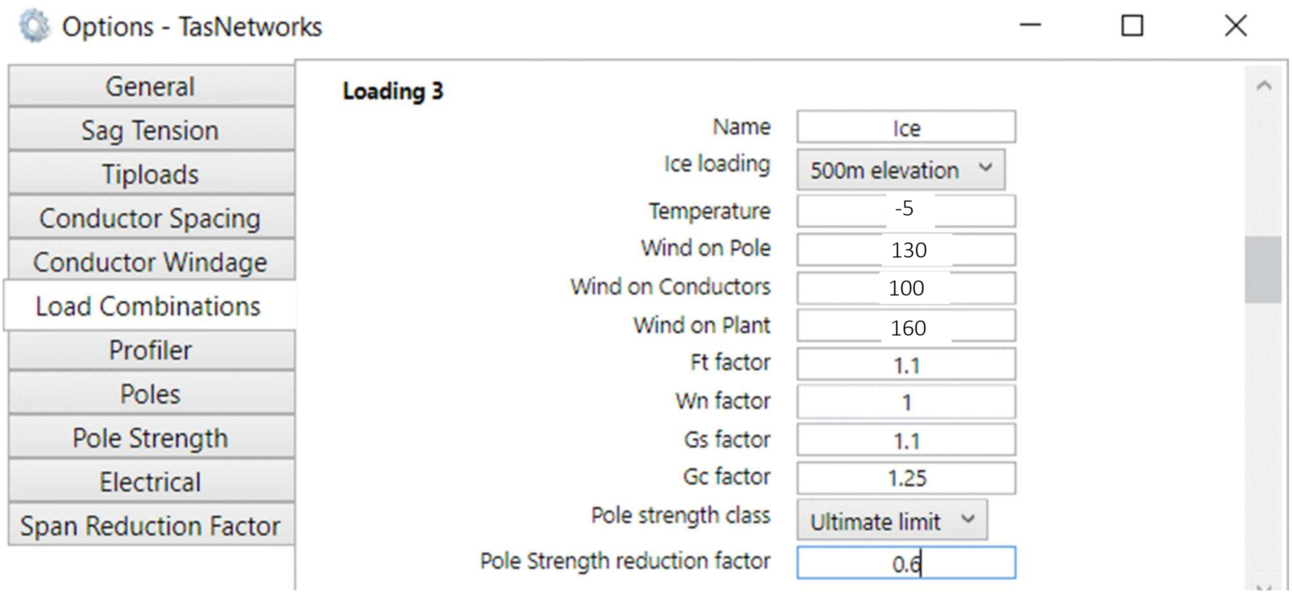
Sag Tension
Tiploads
Conductor Spacing
Conductor Windage
Load Combinations
Profiler
Poles
Pole Strength
Electrical
Span Reduction Factor
Default distance below tip 0.15
Default inter-circuit spacing 1.38
Clearance height 1 5.5
Clearance height 2 6.7
Display span lengths
Default vertical scaling 10
Autosave interval 10
Background colour Black White
Construction rules file
DXF export X scale 1000
DXF export Y scale 100
Use only hot super/cold sub circuits in Measure
When opening v6 file use Table for tension
Add to segment length for materials list Length % of Total
Add to segment length - value
Uplift
Show uplift indicator
Uplift temperature -5
Show uplift on strain poles
Uplift Threshhold 0
Temperatures
Label 1 Hot Bare
Temperature 1 50
Label 2 Hot LVABC
Temperature 2 75
Label 3 Standard
Temperature 3 5
Label 4 Cool
Temperature 4 15
Uplift Cold
-5
Edit circuit colours Edit colours
Print
Save current options
Export options

Conductor Spacing

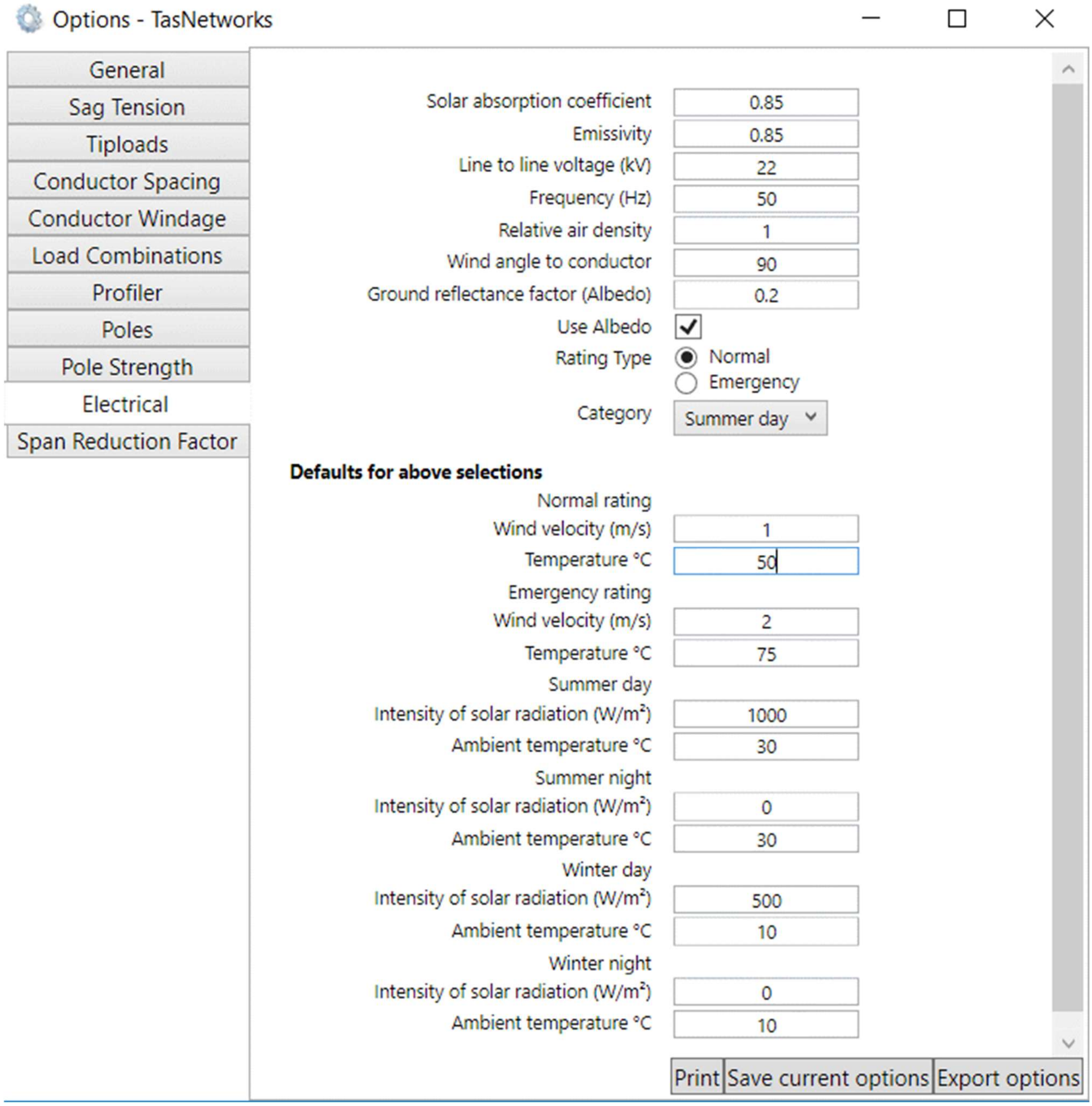


Load Combinations





Electrical
(applies to bare conductors only, not ABC)



Pole Database Set-Up – use data from Section 6 Poles

Conductor Database Set-Up – use data from Section 4 Conductors

Poletop Constructions Database – use data from Construction Manual

12.3 *LVDROP* SET UP

For simple loads, voltage drops be calculated using the formula $V = I Z$, where I is the current in amperes at the time of maximum demand and Z is the impedance of the cable in ohms.

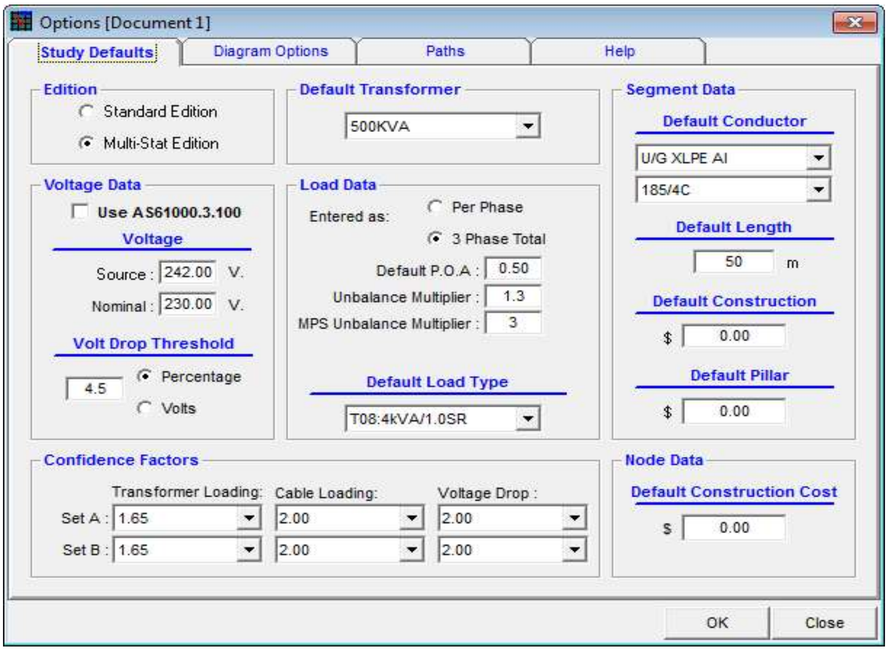
However, for loads that are quite variable, such as housing within a residential street, it is better to analyse the network with software such as *LVDROP*. This allows statistical parameters to be entered for the load: a mean or average value per house at the time of peak demand (or ADMD – After Diversity Maximum Demand), and a standard deviation or measure of the variability of house loads at the time of peak demand. Where there are large houses at one end of a street and townhouses at the other, different load types can be established to model this.

Typical ADMDs are shown in the table below. Note that these values are a guideline only and may vary according to whether electric cooking, water heating, air conditioning and space heating is employed.

Consumer Type	Design ADMD
Townhouses, houses in lower socio-economic areas	3.0kV.A
Houses in average socio-economic areas	4.5kV.A
Prestige housing	6.0kV.A
Light commercial/industrial premises	8.0kV.A

The following settings should be used:

Cable Confidence Factor: 2.0
Voltage Drop Confidence Factor: 2.0
Transformer Confidence Factor: 1.65
Standard Deviation = 1.0 x Mean value (ADMD) for house loads
Standard Deviation = 0 for ‘fixed’ loads that may be switched on at the time of peak demand, e.g. sewer pumps, industrial loads.



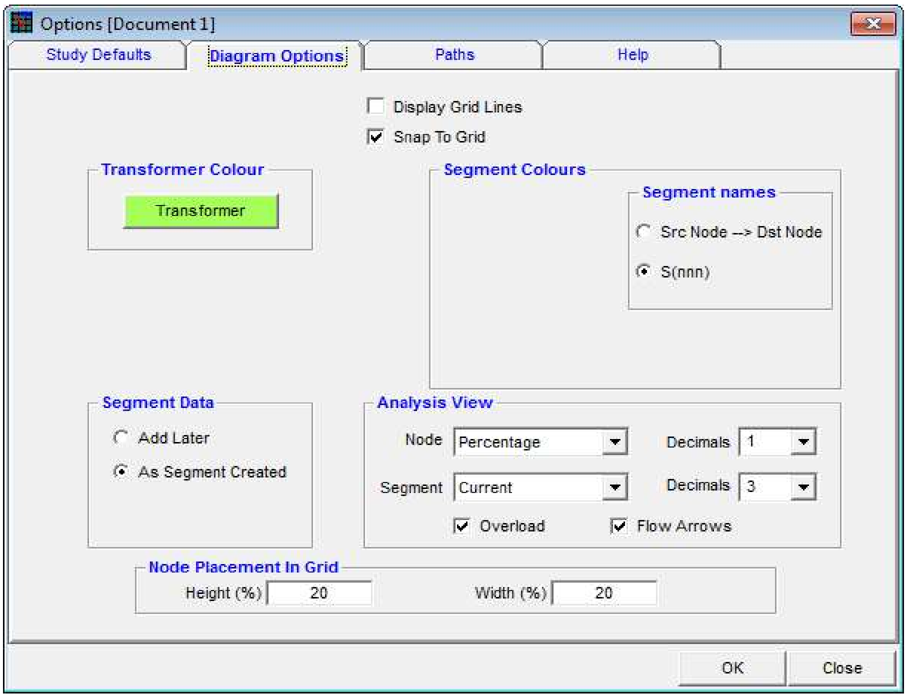

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Diagram Options
Paths
Help
Display Grid Lines
Snap To Grid
Transformer Colour
Transformer
Segment Colours
Segment names
Src Node --> Dst Node
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Segment Data
Add Later
As Segment Created
Analysis View
Node
Percentage
Decimals
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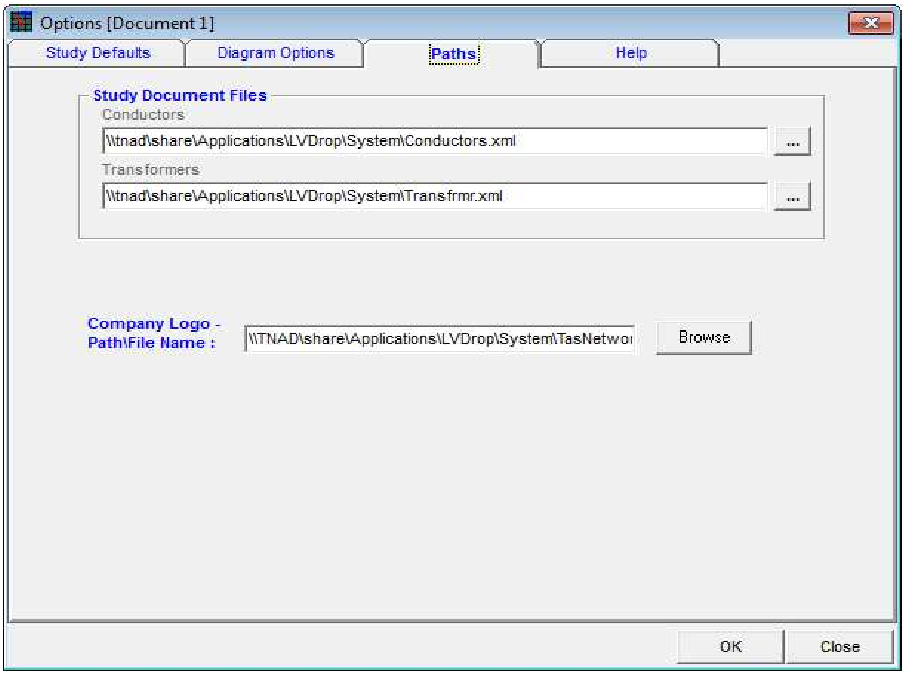
Segment
Current
Decimals
3
Overload
Flow Arrows
Node Placement In Grid
Height (%)
20
Width (%)
20
OK
Close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Transformers
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Company Logo - Path\File Name :
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Browse
OK
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12.4 *POWERLINES PRO* SET UP

Instructions and a template set up for the latest TasNetworks requirements are maintained at the following URL: http://www.powerlinespro.com/tasnetworks.html.

SECTION 13 – POLICY AND PRACTICE

Version: 3.6

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Section 13 – Policy and Practice

13.1 OVERVIEW OF ENVIRONMENTAL CONSIDERATIONS RELATED TO OVERHEAD LINES

Prior to proceeding with a detailed design, an environmental assessment must be carried out, with all required approvals completed prior to commencing on-ground work. TasNetworks maintains and operates an Environmental Management System and designers should refer to the *Environmental Design and Construction Standard* for guidance on these matters. Designers should also have training and competency for the types of work they are carrying out.

Some environmental issues that are of relevance to overhead line designers includes:

Fauna

- Ensure eagle strike risk is considered during design and that appropriate mitigation measures are installed (see section 13.3)
- Identify and report fauna which may interfere with the electricity supply or maintenance work e.g., possums, birds (swans), birds' nests, bee hives, or wasps' nests.
- Avoid and minimise habitat or breeding disturbance during the establishment of new lines and access tracks.
- Consider whether new lines will present a hazard to wildlife, particularly listed threatened species e.g. large birds of prey, migratory bird species, waterfowl, swift parrot and burrowing crayfish.
- Spread of pests in materials taken to/from site, e.g. declared weeds, pests and disease.
- Consider effects of lighting on habitat, e.g. frogs and penguins.

Vegetation

- Consider options to avoid or minimise clearing required for new lines and tracks – by route selection, pole height selection (going over or under canopy), use of ABC type of construction.
- Consider implications for future vegetation trimming and maintenance of clearances including important vegetation as defined under Chapter 8A of the TEC including significant trees.
- Apply arborist principles to manage vegetation clearance zones around TasNetworks' assets.
- Consult ecosystem maps to determine whether a new line or access track will affect listed threatened species or is in the vicinity of protected vegetation.
- Even dead trees and logs can have habitat value.
- Minimise the spread of declared weeds and disease by implementing reasonable and practical control measures (e.g. vehicle/equipment wash-down, and employee hygiene). On rural properties where it is known that a management plan for declared plants exists, take those measures necessary to comply with the requirements of the management plan. Always use certified clean-fill for access tracks and backfill.
- Where revegetation works are required, preference should be given to utilising suitable native plants which are native to the area, and which will not cause any reliability of supply issues in the future, e.g. native grasses and shrubs that will not grow to a height that will interfere with overhead lines.

Land

- Take note of specific approval processes (e.g. Reserve Activity Assessment) that apply to certain reserved land (The Wilderness World Heritage Area, National Parks, Reserves and conservation covenants)
- Where legacy soil contamination is suspected (e.g. history of industrial activity, reclaimed land, fuel stations etc), ensure adequate soil sampling is undertaken prior to construction.
- Think about the work site and whether it is bushfire-prone, flood-prone, exposed to high winds or lightning.
- Consider the location of oil filled assets, particularly in proximity to waterways and other sensitive environments.

- Consider implications for erosion and sediment run off when constructing lines or access tracks (refer to the Forest Practice Code 2020)
- Plan works accounting for seasonal weather conditions, crop planting, increased rainfall, fire danger and the need for hot works.
- For poles in cattle/dairy areas which have evidence of previous creosote treatment, ensure backfill is managed to minimise exposure to grazing cattle.
- Report any visible soil erosion that may compromise the integrity of the electricity infrastructure.
- Minimise disturbance to acid sulphate soils or treat potential acid sulphate soils particularly around concrete and metal structures, including earthing. Acid sulphate soils are common in low-lying coastal and riverine areas. If drained or excavated, exposing the iron sulphides in the organic material in the sediments to oxygen in the air, sulphuric acid is formed and can be harmful to fish or fauna as well as structures.
- Report any oil or SF6 leaks from electrical equipment or plant. Contain and clean up any leak or spill of a hazardous substance or controlled waste.

Air

- Consider implications of construction of lines or access tracks for generating dust.
- Be conscious of works that may generate a lot of noise in sensitive areas.

Waterways

- Ensure works in or impacting on marine or riparian zones, marine parks are conducted in accordance with relevant legislation and policies as these areas are especially sensitive.
- Be especially careful about sediment run-off, fuel/oil/chemical run-off, weed spread and acid-sulphate soil disturbance in the vicinity or waterways or drains leading to waterways.

Electromagnetic Fields

- Refer section 13.6. TasNetworks take a prudent avoidant approach and are conscious of community sensitivity in areas such as near schools or playgrounds.

Community and Heritage

- Consider the impact of ground disturbing works on aboriginal heritage sites and artefacts.
- Consider and assess the impact of work on any listed heritage properties.
- Visual impact – consider effect of works on views. "Stand in the customer’s shoes and think of it as your street".
- Transformers and other large plant need careful positioning.
- Consider the number of wires. Any more than 7 wires in the air and the public are more likely to complain. This also supports replacing open wire LV with LV ABC, where 33kV and 11kV are on the same pole route. In some cases, large cables such as HVABC may be more visually obtrusive than open-wire bare mains.
- Consider disruptions to vehicular traffic and pedestrians.
- Report the unanticipated discovery of any artefacts with cultural significance.
- Consider effects of lighting in residential areas.
- Consider site restoration options.
- Use existing poles rather than replacement: Least change means least risk of adverse community reaction.
- Consider community activities that may be affected by works, e.g. paragliding, aerial crop dusting, mining equipment, large farm machinery, loading cattle, burning off, truck turning areas, refuelling.

13.2 BUSHFIRE MITIGATION MEASURES

Need for Mitigation

Bushfires can cause heavy casualties in terms of life, property and environmental destruction. Information on fire danger areas can be obtained from the Tasmanian fire service. Common causes for starting fires are:

- Conductor clashing due to wind or vegetation, including flying bark
- The operation of EDO fuses
- Wildlife-induced flashovers
- Broken conductors falling to the ground.

Design Options for Fire Mitigation

Design options for use in high-risk bushfire areas include:

- EDO fuses must not be installed in the High Bushfire Loss Consequence Area
- Using ABC
- Fitting mid-span spacers
- Increasing spacing between conductors
- Fitting vibration dampers on more spans
- Fitting conductor covers/sleeves or wild-life-proofing insulation to prevent flashovers
- Using EDO fuses of the spark-free type outside the HBLCA. Check fault level at location to select appropriate type of fuse
- Use of reclosers with more sensitive protection / faster fault clearing
- Undergrounding or routing lines away from sensitive vegetation that cannot readily be trimmed to the full extent desired, e.g. due to heritage, aesthetic reasons, protected vegetation
- Use of enclosed switches.

Admittedly some of these options may be very expensive, but whole-of-life costing may be used for justification of additional costs.

13.3 WILDLIFE ISSUES

When designing power lines, interference from wildlife has to be taken into account. Ground animals, such as possums, climb onto poles. Birds, such as swans, geese, water fowls, raptors, and crows can collide with power lines. On collision, these animals can get electrocuted, and sometimes protection systems will operate to de-energise the line. This can cause interruption of supply to customers.

TasNetworks does not want animals to be electrocuted or injured by its infrastructure. Nor does TasNetworks want supply to its customers to be disrupted. Therefore the system must be designed to eliminate or minimise animal electrocution (or injury) and/or outages.

Possum Guards

Possum guards must be installed on all relevant poles and stays. These are mandatory on poles carrying uninsulated HV conductors and equipment, in order to prevent possums from climbing up the pole. (Refer D-OH1-0727-SD-001.) All stays must also have stay sighters installed above and below the GY2/GY3 insulators (Ref D-OH1-0730-SD-001). The top sighter must be located so that it can rotate freely. Split bolt clamps are used to keep the sighter from moving up or down the stay wire.

Birds

Areas with significant bird life

The presence of large waterways, such as lakes, rivers, estuaries and coastal areas will be an indication of significant birdlife in the area. Bird collisions and electrocutions are more likely to occur where power lines are erected near waterways. Therefore, identifying areas with significant bird life is import for reducing outages and minimising environmental impact. This is especially so for listed threatened species. Known records of threatened species near the new or existing network can be identified using NetMaps, the Natural Values Atlas or LISTmap. Expert advice may also be sought from TasNetworks Environment and Sustainability Team. Generally, residents in the area will be able to provide valuable information. Swans, geese, water fowl, and other large birds commonly collide with conductors.

Identification of High Risk Pole Positions

Certain birds like eagles, hawks, and kites tend to use poles and crossarms to perch and survey the surrounding area to hunt for prey. Poles located on the brow of a hill overlooking wide grassy areas or opposite water are very probable perching sites. Also, poles could be situated in flat open areas where they are the only tall structures. For existing lines, evidence of previous electrocutions in the form of carcasses around the pole base will be an indicator.

Various raptors species behave very differently and so are subject to different risks from the network. Eagles are likely to suffer from mid-span collision while Grey Goshawks prefer to sit on a mid-level perching position such as the lower LV circuit, transformer cross-arms, or even on stand-off insulator brackets. This is probably because they prefer locations which offer some protection from larger birds. Additionally, they are much more likely to be found in urban areas when compared to eagles. This means that the tools used to mitigate assets for eagle and Goshawks are different.

E.g. Wedge-tailed eagles are more likely to be involved in a mid-span collision in a rural area and so benefit more from the installation of bird diverters. Grey Goshawks are more likely to be electrocuted in a fringe-urban area while perching on a lower pole cross-arm by uninsulated conductor bridgings.

Design Options for Wildlife

- Design the line so that areas with significant bird life are avoided where possible.
- Use FRP cross-arms (if available) to reduce the likelihood of phase-to-earth electrocution.
- Use triangular design configuration (Ref D-OHC-C002-SD-001 or D-OHC-C071-SD-001) for greater conductor separation (this will prevent conductor shorting).
- Use insulator pin raisers or taller insulator pins (Ref D-OHC-C001-SD-001) to increase the height of insulators on intermediate HV pole top arrangements. This will reduce the probability of shorting between live conductors and crossarms (not for eagles).
- Cover the HV conductor on both sides of the insulator. This is to prevent shorting between the live conductor and the crossarm.
- Install bird perches. These will be preferred by eagles over cross-arms or pole tops.
- Use suspended conductor construction with underslung conductors at strain positions (Ref D-OHC-C008-SD-001). This is to improve the clearance to the LV below. The HV conductor may need to be covered with insulated sleeving.
- Consider HV ABC.
- Consider underground for particularly high risk sections of line.
- Use bird diverters to make conductors more visible to birds.

Note: All transformer and switchgear bushings shall be covered with appropriate bushing covers (e.g. D-OHC-F017-SD-001) and transformer leads shall be PVC insulated to 1kV. (Ref D-OHC-F001-SD-001)

Design Requirements for Raptors

The below flow chart communicates the requirements for bird mitigation based on the Eagle Strike Risk (ESR) layer in NetMaps. This layer was designed to automatically combine the risk factors for eagle mid-span collisions.

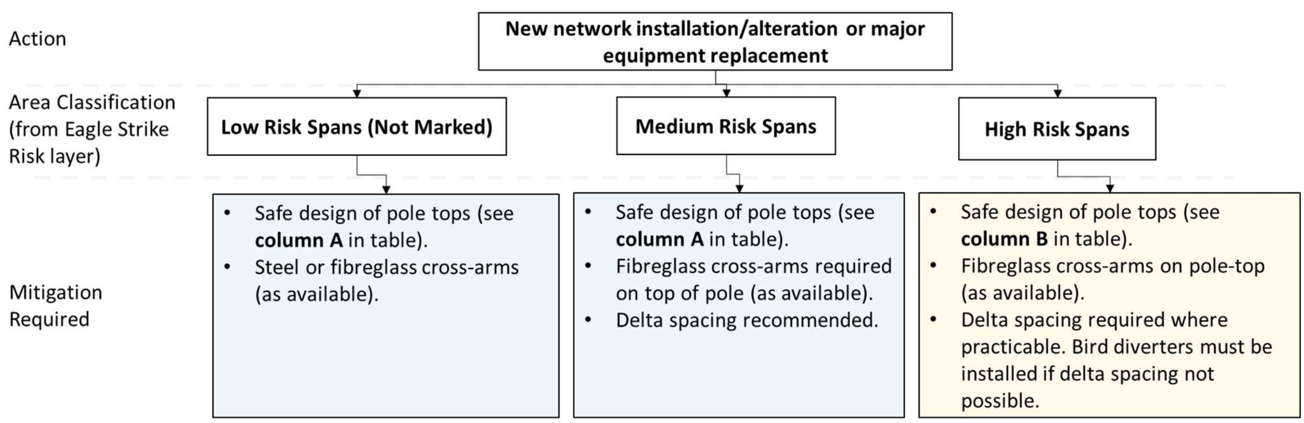


Figure 1: How to determine if an asset requires raptor mitigation.

Table 1: Safe pole-top design requirements for wildlife.

Pole-top Dressing	**Column A**	**Column B**
All poles where practicable	N/A	Delta conductor spacing design with FRP cross-arms
Conductor tee-off poles	Insulate bridges	Insulate bridges
Complex pole (eg. With a transformer or ABS on top)	Insulate droppers and bridges	Insulate droppers and bridges
Strain configuration poles NOTE: Underslinging should only be done on poles were no LV is present AND there is a low chance of LV being installed.	Underslung jumper wires or insulate overslung wires if not possible	Underslung jumper wires or insulate overslung wires if not possible
Intermediate stobie/metal/concrete poles and structures – conductive poles	N/A	Insulate conductors on HV
Conductor transposition pole	Insulate conductors	Insulate conductors

For more detail, please see TasNetworks document: "*TasNetworks Raptor Mitigation Field Scoping Guide*".

13.4 AERIAL MARKERS

General Requirements

Australian Standard 3891 Part 1 specifies the requirements for aircraft warning markers on certain overhead cables, and their supporting structures, for the purpose of warning aircraft pilots of the presence of a cable or structure. Cables and supporting structures require markers where:

1. Cable height is in excess of 90m above any road, railway or navigable waterway.

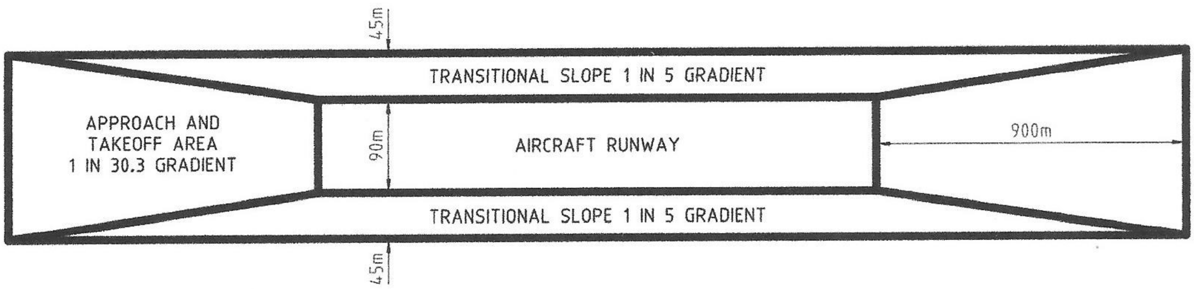
2. Cable height is in excess of 90m continuously for 50m or more above ground or water surface.

3. Cables shall be indicated with 600mm spherical markers of alternating colours, one of which shall be white, and the other yellow.
   (A minimum of three markers is required and the interval between the markers shall be 25-30m.)

4. Cable height in excess of 150m shall be marked with at least three high intensity obstacle lights, one of which shall be placed in the middle section.
   (The intervals between the obstacle lights shall not exceed 150m.)

5. Cable height in excess of 90m and forming part of a span between supporting structures in excess of 1500m, shall be marked with at least three high intensity obstacle lights. One of the obstacle lights shall be placed in the middle section.

6. Cables in proximity of aerodromes (designated by the Civil Aviation Authority) shall be subject to requirements specified by surveyors from the Civil Aviation Authority. Specifically, markers shall be placed on cables in proximity to authorised landing/alighting areas which penetrate the transitional slope (20%) or approach/take-off slope (3.3%) as shown the diagram below. The top 6m of the supporting structure shall be painted by alternating white with yellow bands not less than 2m in width.



Notes:

a. Cable height is the vertical distance taken at 5°C under still air conditions at any point along the length of a cable span from the highest conductor to the ground, or the ambient level of vegetation, or highest expected water level immediately below it.
b. In the case where the current in the cable is not sufficient to power the light throughout all dark periods, reflectors shall be used on the spherical markers.
c. Where practicable, markers shall be mounted on the highest cable in the span.
d. The Civil Aviation Authority shall be consulted for requirements for the marking of cables in proximity to licensed or government aerodromes.
e. Advice should be sought from the Civil Aviation Authority prior to the construction of obstacle lights to avoid confusion with any nearby or aircraft navigation obstacle avoidance lights.

Further Specific Requirements

Low Level Flying

Typical low-level flying operations are agricultural, mustering, media and ballooning.

Cable markers shall be:

- Either:
  Spherical with a minimum diameter of 300mm; or
  Cylindrical with a minimum diameter of 180mm, and minimum length of 300mm.
- Spaced to remain visible and allow the pilot to assess the cable direction at all times during the approach flight path.
- Coloured alternatively white and yellow (as specified above which provides contrast when viewed in different directions and conditions).

Note that markers may slightly increase the amount of sag in a span.

Areas Requiring Marking

Generally areas requiring markers are those nominated previously in "General Requirements" or at the request of property owners, or aerial operators involved in low level flying.

Additionally, aerial markers will be required in areas where:

- Aviation sports activities (such as hang gliding, paragliding, or ballooning) commonly occur
- Over water where high boat masts may come into contact with aerial cables
- Near mines or other work zones where high machinery regularly operates and
- Over roadways where there is a possibility of commercial vehicles with high loads impacting low slung cables.

Areas Exempt from Requirements for Markers

- Areas designated by the Civil Aviation Authority as a remote area
- Areas not within 40km of authorised landing areas (as designated by the Civil Aviation Authority)
- Areas not within 20km of any railway line currently in use, any major road classified as a national highway, or any navigable waterway
- Any cable running generally parallel to, and within 100m of, a marked cable.

GUIDELINES FOR USE OF SUSPENDED WARNING MARKERS

These guidelines are based on the use of a Suspended Warning Marker that has a weight of 0.9kg and suspends underneath conductors for a length of 510mm.

1. Conductor must visually be in good condition with no broken strands, excessive number of joints or serious corrosion that materially affects conductor strengths.
2. Rail crossing or navigable waterway crossing spans should not be fitted with these markers without obtaining relevant approvals.
3. Not to be used on copper mains that are 7/0.064” (7/1.75) or old PVC insulated services.
4. When the markers are installed, there must be the same number of markers on each wire.
5. Spacing of markers to generally to be no more than 30m, but if the spacing is reduced the markers must all have the same spacing.
6. When checking ground clearance or intercircuit clearance, allow for:
    a. length of suspended marker, plus
    b. 100mm additional sag for each marker installed (except for stay wires).
7. In general, on multi-circuit lines, the markers can only be installed on the lowest circuit except where there are sizable clearances between circuits. Intercircuit clearance shall be checked with the top circuit at maximum design temperature and lower circuit is at 15°C. If insufficient clearance is available and upper circuit marking is required, then a marker ball is to be used rather than a suspension marker.

13.5 ATTACHMENT OF SIGNS AND BANNERS TO POLES

Galvanised Steel Street Light Poles

Banners are not allowed on galvanised steel street light poles because of the additional forces imposed.

Street lighting poles are designed to carry luminaires only and there is no spare capacity for additional fixtures. Banners can set up vibrations which can result in metal fatigue. Should there be any corrosion at the base of the pole, additional forces may shorten the remaining life.

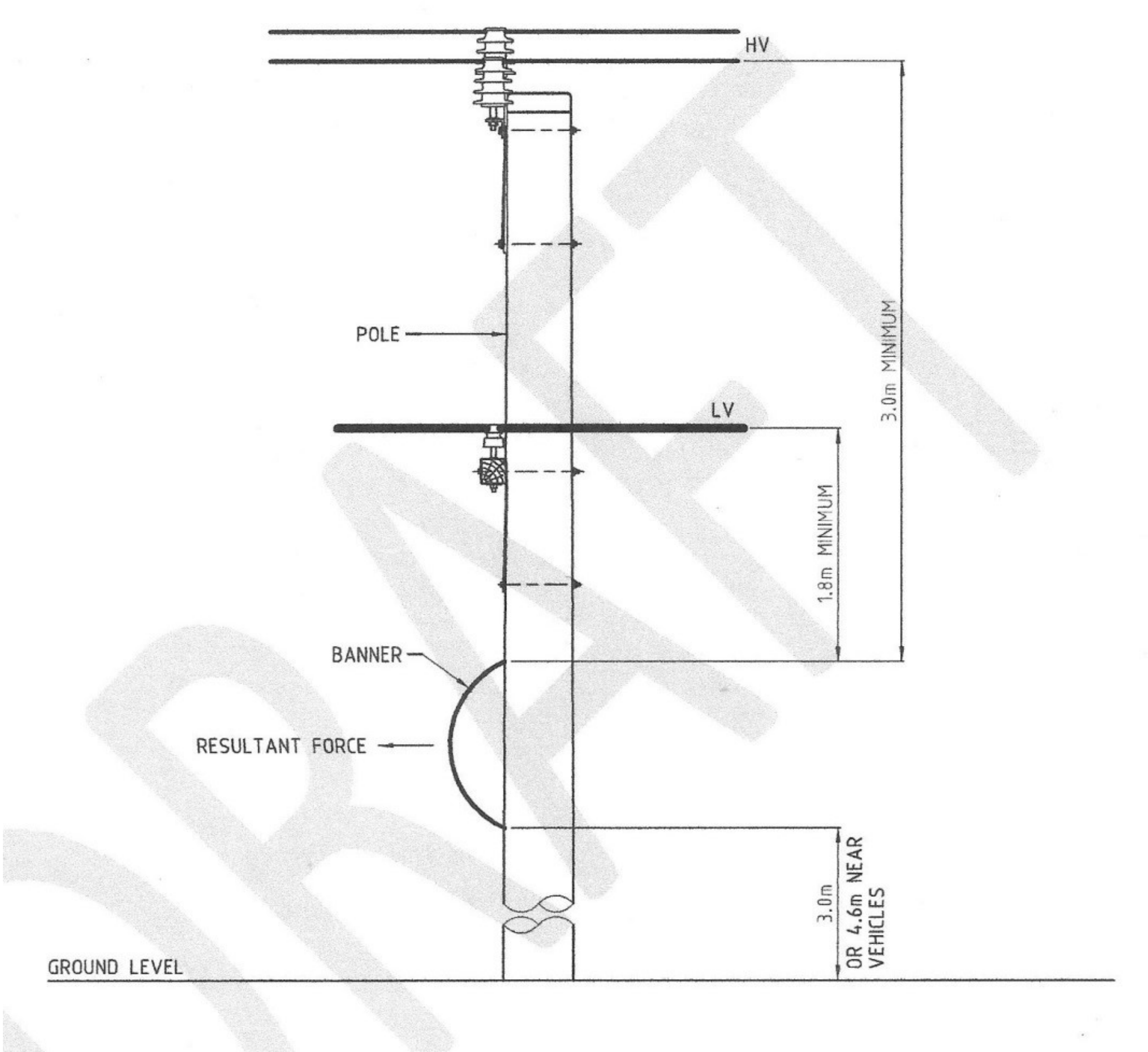
The only exceptions are the purpose designed poles erected along the main arterial route adjacent to Constitution Dock in Hobart. These poles are owned by the Hobart City Council.

Banners on Wood Poles

Banners are allowed on wood poles with the following restrictions:

1. they are to be kept to a minimum size and shall not exceed 1.7m^2 in area;
2. they shall not be strung between two poles;
3. they will not obscure numbers nor interfere with access to TasNetworks equipment;
4. where possible, banners should conform with the curvature of the poles so that projections are minimised;
5. metal banners should be designed to minimise the possibility of loosening due to wind, vibration, or shrinkage of timber;
6. the minimum clearance from the ground to the bottom of the banner is to be 3.0 metres;
7. this minimum clearance is to be increased to 5.6 metres if the banner projects over a roadway or if there is a likelihood of vehicles passing in close proximity to the pole and banner;
8. the minimum clearance from the top of the banner and low voltage conductors, or street light switchwire, is to be 1.8 metres;
9. the minimum clearance from the top of the banner and high voltage conductors is to be 3.0 metres;
10. no banners are to be positioned on any pole that has an underground cable, transformer, recloser, or switch installed on it;
11. no holes are to be drilled, or fasteners driven into, the pole - rather, the banners are to be fastened by a banding system;
12. the banners shall only be allowed to remain on the pole for a period not greater than eight weeks;
13. the erection of the banner shall not constitute a climbing aid - i.e. any framework or structure associated with the banner shall not give assistance to an individual attempting to illegally climb TasNetworks poles;
14. the erection of the banner shall be such that the resultant force due to wind shall be parallel to the main conductors erected on the pole;
15. the free moving length of any banner shall not be any longer than 1.0 metre and shall not be capable of coming into contact with, or near contact with, the overhead wires or cables;
16. TasNetworks shall not be liable for any claims arising from the installation or continued presence of a banner on TasNetworks poles; and
17. permission to erect a particular banner on a TasNetworks pole shall be at the discretion of the local TasNetworks representative.

Provided that all these requirements are met, the work shall be carried out to the satisfaction of the TasNetworks representative. No work is to proceed without the express permission of the local TasNetworks representative.


HV
POLE
LV
3.0m MINIMUM
1.8m MINIMUM
BANNER
RESULTANT FORCE
3.0m OR 4.6m NEAR VEHICLES
GROUND LEVEL

13.6 ELECTROMAGNETIC FIELD MITIGATION

Distribution Line Siting

Electric and magnetic fields (EMFs) are created by all electrical equipment, including domestic appliances, industrial equipment and electricity supply infrastructure, and concerns about possible health effects have led to extensive research on the subject. However, the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) advises: "The scientific evidence does not firmly establish that exposure to 50Hz electric and magnetic fields found around the home, the office or near power lines is a hazard to human health. Current science would suggest that if any risk exists, it is small.". Nonetheless, Energy Networks Australia and TasNetworks follow the principle of prudent avoidance, which was described by Sir Harry Gibbs in the following terms: "…. [doing] whatever can be done without undue inconvenience and at modest expense to avert the possible risk …" Prudent avoidance does not mean there is an established risk that needs to be avoided. It means that if there is uncertainty, then there are certain types of avoidance (no cost / very low cost measures) that could be prudent.

Distribution power lines need to be located:

- on the opposite side of the road from areas such as schools, kindergartens, child-care centres, and other places where adults and children congregate;
- away from the walls of multi-storey buildings and other areas where adults and children congregate; and
- on the side of the road bordered by open spaces (if possible).

Substations need be located at the electrical centre of their low voltage network, i.e. so that current flows in all directions needs to be balanced, and in a location that minimises sustained exposure of the public to associated fields.

Community consultation with consequent information sharing is of great benefit when deciding where to site distribution lines. This is particularly relevant where HV lines over buildings are under consideration.

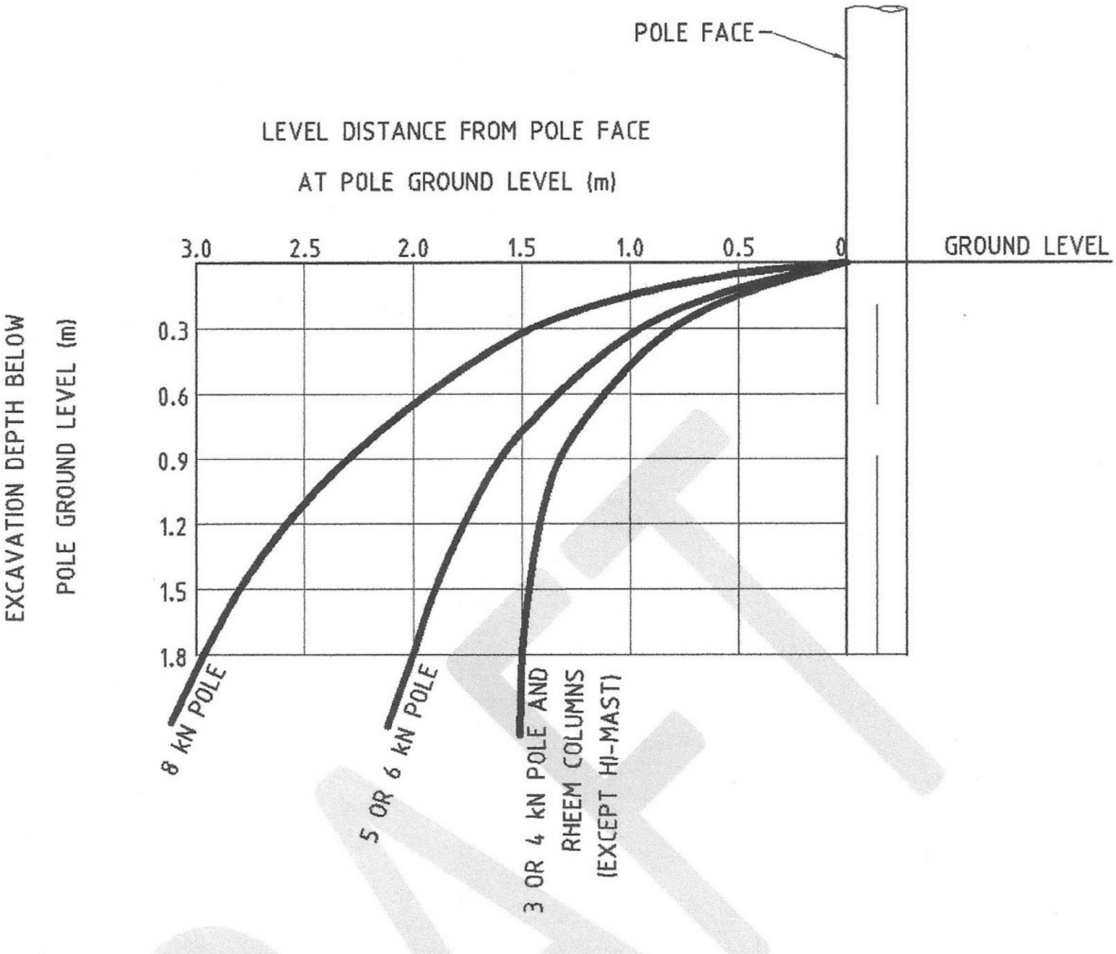
Distribution Line Design

Design options which may be considered, subject to economic viability, could include:

- the use of aerial bundled conductor (ABC) to provide more effective field cancellation;
- the use of constructions with more effective field cancellation between phases, e.g. delta or triangular type rather than flat constructions; use of opposite phasing arrangements (RWB/BWR) on double circuit vertical lines;
- use of increased height to increase distance from the public (although sometimes greater height is interpreted as greater danger by the public);
- the use of offset construction to increase horizontal separation from parties likely to be affected;
- the use of underground cable in place of overhead conductors where at all possible (subject to budgetary constraints), which does more to appease public perceptions than necessary address field intensity;
- the balancing of load across all phases to reduce neutral currents;
- the use of insulated twisted service cable instead of open wire services to provide more effective field cancellation;
- Where new or reworked sub-transmission facilities are going to be co-located on the same structure as existing distribution circuits, the phasing of the new work needs to be applied in such a way as to reduce overall electro-magnetic fields.

13.7 TEMPORARY EXCAVATION NEAR POLES

Excavation near overhead service poles requires a great deal of care. The diagram below indicates the excavation versus distance from the pole face at ground level for poles with different loadings. Note that this is a general guide only. For poor soils, *civil engineer signoff is required*.



Notes

1. The depth/distance curves apply to 3, 4, 5, 6, & 8 kN unstayed poles of 9m to 12m length, in any direction from the pole face for a short term of not more than one week. The excavation must be done in fine weather (not wet or windy) and must be monitored daily.
2. Any excavation that encroaches deeper than the limiting curves or is immediately adjacent to the pole (e.g. cable pole) will reduce the pole footing strength - an engineering assessment will be required. Additionally, this situation may require the fitting of temporary stays. Shallow excavations for pole testing and earth installation are allowed provided the hole is dug, backfilled, and rammed on the same day.
3. Excavations in the same plane as the resultant tip load direction are more critical than those to the side.
4. Because of the variation in cohesiveness of soils, this information should be accepted as a field reference guide for average undistributed clay soils. This guide should not be used for loose sandy soil or made up soil.

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