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Technical Note - TN 059: 2016

Issued date: 20 December 2016

Effective date: 20 December 2016

Subject: Update to T HR EL 10001 ST *HV Aerial Line Standards for Design and Construction*

This technical note is issued by the Asset Standards Authority (ASA) to notify the amendments to T HR EL 10001 ST *HV Aerial Line Standards for Design and Construction,* version 1.0. The relevant sections of the standard that are amended are stated in this technical note along with the content that replaces the existing text.

The summary of amendments includes the following:

- minimum height of first pole step
- strength reduction factor for foundations of timber support poles and timber stay poles

1. Section 9.5 Pole steps

Replace the contents of Section 9.5 Pole steps with the following text:

Pole steps in accordance with drawing EL0017974 shall be provided for all wood poles. The pole steps shall be installed 125 mm ± 20 mm into the timber of the pole radially to the pole axis. Holes for pole steps shall be bored a minimum depth of 175 mm.

For steel poles, the design of pole steps and their attachment shall be compatible with the maintenance arrangement and practices of the AEO maintaining the HV aerial line.

Pole steps shall be installed at 450 mm intervals on two sides of the pole that are ideally displaced by 120° along the pole circumference. The nominal distance between pole steps on each side is 900 mm. The pole steps shall be positioned such that any obstruction to climbing is minimised.

The first pole step shall be installed at a minimum height of 5.5 m from ground level.

2. Section 10 Foundation for wood poles

Replace the contents of Section 10 with the following text:

Poles shall be concreted in the holes up to 500 mm below ground level. The concrete shall have a thickness of at least 100 mm radially and at the bottom of the pole, and completely fill the void between the pole and the undisturbed soil. Above the concrete the hole shall be backfilled with clean fill and well rammed. Concrete footings shall be designed in accordance with AS 3600 *Concrete structures*. The exposure classification shall be A1. The minimum concrete strength shall be 20 MPa at 28 days.

Any water accumulated in the hole shall be removed before standing the pole.

To facilitate pole base maintenance, the ground around the pole and within 300 mm from the edge of the pole shall be able to be readily excavated to a depth of 450 mm with hand tools.

Foundations shall be designed to match the capacities of pole. Minimum pole embedment depths as shown in Appendix C may be used for the installation of wood poles, provided that the following conditions are met:

- pole is located in ground with slope less than 2.5H:1 V
- pole is located at more than 4 m from the edge of any embankment
- the soil is cohesive with a minimum unsaturated shear strength of 50 kPa and soil density of 18.5 kN/m^3 (stiff soil), or non-cohesive soil with an angle of friction of 35° minimum (dense to very dense fine and silty sand or clayey sandy gravel)
- foundation is designed to yield before structure failure, and with a strength reduction factor of 0.8, when the structure is loaded to its maximum capacity

For all other installation conditions, the pole foundation shall be designed by a civil engineer with appropriate design authority.

Refer to drawings EL0162213, EL0149232 and EL0162262 for previous practices used for wood poles.

3. Section 18.1.1 Stay pole

Replace the contents of Section 18.1.1 with the following text:

Refer to EP 10 01 00 07 SP *Timber Poles* for specifications and dimensions of stay poles.

Stay poles shall otherwise comply with the requirements of Section 9.3.

Refer to drawings EL0497822 and EL0497823 for stay pole arrangements.

Foundations for stay poles shall be constructed in accordance with the timber support poles, as set out in Section 10.

Minimum pole embedment depths as shown in Appendix D may be used for the installation of timber stay poles, provided that the following conditions are met:

- installation and soil conditions are within the limit conditions specified for timber support poles in Section 10
- maximum load along direction of guy wires is 60 kN; refer to drawings EL0497822 and EL0497823
- the angle of the guy wire to the horizontal is between 40° and 60°

For all other installation conditions, the stay pole foundation shall be designed by a civil engineer with appropriate design authority.

4. Appendix C Embedment depths of timber support poles

Replace the contents of Appendix C with the following:

The minimum embedment depths of timber support poles with installation and soil conditions given in Section 10 are provided in Table 7.

Table 7 – Embedment depths of timber support poles with normal ground and soil

Pole designation	Pole length (m)	Height above ground (m)	Ground line diameter (mm) Strength group S1	Ground line diameter (mm) Strength group S2	Minimum embedment depth (see notes)	Design capacity for maximum wind (kNm)
8.0/8	8	5.88	278	300	2.12	84.19
8.0/12	8	5.54	314	339	2.46	122.08
9.5/8	9.5	7.20	303	327	2.30	108.72
9.5/12	9.5	6.87	339	366	2.63	153.29
11.0/8	11.0	8.60	318	343	2.40	126.28
11.0/12	11.0	8.23	359	388	2.77	182.23
11.0/15	11.0	8.03	382	413	2.97	219.37
12.5/8	12.5	9.99	333	359	2.51	145.56
12.5/12	12.5	9.59	379	409	2.91	214.50
12.5/15	12.5	9.39	402	434	3.11	255.82
14.0/8	14.0	11.34	353	381	2.66	173.38
14.0/12	14.0	11.03	390	421	2.97	233.45
14.0/15	14.0	10.74	422	456	3.26	296.04
15.5/8	15.5	12.77	364	393	2.73	189.72
15.5/12	15.5	12.38	410	442	3.12	271.21
15.5/15	15.5	12.14	438	473	3.36	329.68

Pole designation	Pole length (m)	Height above ground (m)	Ground line diameter (mm) Strength group S1	Ground line diameter (mm) Strength group S2	Minimum embedment depth (see notes)	Design capacity for maximum wind (kNm)
17.0/8	17.0	14.12	384	414	2.88	222.67
17.0/12	17.0	13.73	430	464	3.27	312.79
17.0/15	17.0	13.49	458	494	3.51	376.95
18.5/8	18.5	15.55	394	425	2.95	240.21
18.5/12	18.5	15.16	440	475	3.34	334.79
18.5/15	18.5	14.88	472	509	3.62	413.78
20.0/8	20.0	16.93	409	441	3.07	269.35
20.0/12	20.0	16.58	451	487	3.42	359.88
20.0/15	20.0	16.27	488	527	3.73	455.50
21.5/8	21.5	18.32	425	458	3.18	300.80
21.5/12	21.5	17.93	471	508	3.57	409.82
21.5/15	21.5	17.66	503	543	3.84	499.94
23.0/8	23.0	19.70	440	474	3.30	334.54
23.0/12	23.0	19.27	491	530	3.73	464.13
23.0/15	23.0	19.04	518	559	3.96	547.05

Note: Minimum embedment depths are calculated with the ESAA BH Pile program.

5. Appendix D Embedment depths of timber stay poles

Replace the contents of Appendix D with the following:

The minimum embedment depths of timber stay poles with installation and soil conditions given in Section 18.1.1 are provided in Table 8.

Table 8 – Embedment depths of timber stay poles with normal ground/soil

Pole designation	Pole length (m)	Height above ground (m)	Ground line diameter (mm) Strength group S1	Ground line diameter (mm) Strength group S2	Minimum embedment depth (see notes) (m)	Design capacity for maximum wind (kNm)
6G 350	6.0	3.21	334	361	2.79	141.85
6G 400	6.0	3.29	391	420	2.71	146.50
6G 450	6.0	3.35	442	478	2.65	150.25
7.5G 400	7.5	4.44	384	413	3.06	207.19
7.5G 450	7.5	4.51	435	471	2.99	211.82
7.5G 500	7.5	4.58	492	530	2.92	216.49
9G 425	9.0	5.68	404	438	3.32	273.07
9G 475	9.0	5.76	460	496	3.24	278.84
9G 525	9.0	5.82	511	554	3.18	283.78
10.5G 425	10.5	6.90	398	432	3.60	338.41
10.5G 475	10.5	6.98	455	491	3.52	345.23
10.5G 525	10.5	7.05	506	549	3.45	351.13

Note: Minimum embedment depths are calculated with the ESAA BH Pile program.

Authorisation:

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T HR EL 10001 ST

Standard

HV Aerial Line Standards for Design and Construction

Version 1.0

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Standard governance

Owner: Lead Electrical Engineer, Asset Standards Authority

Authoriser: Chief Engineer Rail, Asset Standards Authority

Approver: Director, Asset Standards Authority on behalf of the ASA Configuration Control Board

Document history

Version	Summary of Changes
1.0	First issue.

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Preface

The Asset Standards Authority (ASA) is an independent unit within Transport for NSW (TfNSW) and is the network design and standards authority for defined NSW transport assets.

The ASA is responsible for developing engineering governance frameworks to support industry delivery in the assurance of design, safety, integrity, construction, and commissioning of transport assets for the whole asset life cycle. In order to achieve this, the ASA effectively discharges obligations as the authority for various technical, process, and planning matters across the asset life cycle.

The ASA collaborates with industry using stakeholder engagement activities to assist in achieving its mission. These activities help align the ASA to broader government expectations of making it clearer, simpler, and more attractive to do business within the NSW transport industry, allowing the supply chain to deliver safe, efficient, and competent transport services.

The ASA develops, maintains, controls, and publishes a suite of standards and other documentation for transport assets of TfNSW. Further, the ASA ensures that these standards are performance-based to create opportunities for innovation and improve access to a broader competitive supply chain.

This standard supersedes RailCorp standard EP 10 01 00 06 SP *HV Aerial Line Standards for Design and Construction*, Version 4.0.

The changes to previous content include:

- updates to reflect organisation changes and resulting changes in responsibilities
- conversion of the standard to ASA numbering, format and style
- clarification on requirements for length of cable sections within a high voltage feeder
- specification of design loading conditions for TfNSW high voltage aerial lines
- provision of embedment depths of timber support and stay poles under normal ground and soil conditions
- minor amendments and clarification to content

Table of contents

1. Introduction

Power supply to traction and other substations, railway stations, signalling systems, as well as other elements of the TfNSW heavy rail network is primarily provided by the RailCorp distribution system. The RailCorp distribution system consists of both high voltage (HV) cables and aerial lines with nominal voltages of between 11 kV and 132 kV. A small number of feeders with a nominal voltage of 2 kV are still present in the existing network; however, these feeders are gradually being phased out.

2. Purpose

The purpose of this document is to set out the requirements for the following:

- the design and construction of new high voltage aerial lines
- the rehabilitation of existing HV aerial line infrastructure

This will ensure that aerial lines are suitable for their intended purpose.

2.1. Scope

This document covers the requirements for HV aerial lines that form part of the RailCorp distribution system.

Pole mounted substations and switches are not part of the HV aerial line system. The requirements for such equipment are not part of the scope of this document. However, the loads due to such equipment shall be considered in the structural design of the poles. The design of the HV aerial line shall ensure that all relevant clearance requirements are met.

2.2. Application

This standard is intended to be used by competent personnel engaged in the provision of services relating to rail infrastructure. Compliance with the requirements in this standard will not, by itself, be sufficient to ensure that satisfactory outcomes will be produced. Personnel providing services based on the standard need to bring appropriate expertise to the matters under consideration. In addition to the requirements of this standard, asset decisions shall take into account the lifecycle cost considerations specified in T MU AM 01001 ST *Life Cycle Costing.*

If, when using the standard, it is considered that the intent of stated requirements is not clear, a clarification should be sought from the ASA Lead Electrical Engineer.

This standard is applicable for all new HV aerial line installations.

Where existing HV aerial lines are to be modified, the design and construction of the modification shall be such that the resultant configuration shall comply with this document. Where it is not practicable to do so, the designer shall list all noncompliance and identify the associated hazards with a hazard log. The designer shall propose a design approach to mitigate the risks to operation and maintenance, as well as other risks, associated with the noncompliance. The mitigation measures shall be accepted by the relevant AEO prior to the commencement of detailed design, and be in accordance with the AEO's judgement of significance (JOS) processes for HV aerial lines. Refer to T MU MD 00009 ST *AEO Authorisation Requirements*. Where the AEO has not established a JOS process for HV aerial lines that has been accepted by the ASA Lead Electrical Engineer, the proposed design shall be documented via a standards concession.

Where a new HV aerial line installation or modification is constructed and energised in stages, the above requirements are applicable to the configuration at each stage of construction.

3. Reference documents

The following documents are cited in the text. For dated references, only the cited edition applies. For undated references, the latest edition of the referenced document applies.

Australian standards

AS 1154.1 Insulator and conductor fittings for overhead power lines – Part 1: Performance, material, general requirements and dimensions

AS 1154.3 Insulator and conductor fittings for overhead power lines – Part 3: Performance and general requirements for helical fittings

AS 3600 Concrete structures

AS 3818.1 Timber – Heavy structural products – Visually graded – Part 1: General requirements

AS 3818.4 Timber – Heavy structural products – Visually graded – Part 4: Cross-arms for overhead lines

AS 3818.11 Timber – Heavy structural products – Visually graded – Part 11: Utility poles

AS 3891.1 Air navigation – Cables and their supporting structures – Marking and safety requirements – Part 1: Permanent marking of overhead cables and their supporting structures for other than planned low-level flying

AS 4100 Steel structures

AS 4435.1 Insulators – Composite for overhead power lines – Voltages greater than 1000 V ac – Part 1: Definitions, test methods and acceptance criteria for string insulator units

AS 4435.4 Insulators – Composite for overhead power lines – Voltages greater than 1000 V ac – Part 4: Definitions, test methods, acceptance criteria for post insulator units

AS 4899 Pin insulators – Porcelain and glass for overhead power lines – Voltages greater than 1000 V ac

AS 5604 Timber – Natural durability ratings

AS 6947 Crossings of waterways by electricity infrastructure

AS 60305 Insulators for overhead lines with a nominal voltage above 1000V – Ceramic or glass insulator units for ac systems – Characteristics of insulator units of the cap and pin type

AS/NZS 2878 Timber – Classification into strength groups

AS/NZS 2947.1 Insulators – Porcelain and glass for overhead power lines – Voltages greater than 1000 V ac – Part 1: Test methods – Insulator units

AS/NZS 2947.4 Insulators – Porcelain and glass for overhead power lines – Voltages greater than 1000 V ac – Part 4: Test methods – Insulator strings and insulator sets

AS/NZS 4435.2 Insulators – Composite for overhead power lines – Voltages greater than 1000 V ac – Part 2: Standard strength classes and end fittings for string insulator units

AS/NZS 4677 Steel utility service poles

AS/NZS 4680 Hot-dip galvanized (zinc) coatings on fabricated ferrous articles

AS/NZS 4792 Hot-dip galvanized (zinc) coatings on ferrous hollow sections, applied by a continuous or a specialised process

AS/NZS 7000 Overhead line design – Detailed procedures

HB 331 Overhead line design

Transport for NSW standards

EP 01 00 00 01 SP 33 kV ac Indoor Switchgear – Non-withdrawable

EP 10 00 00 04 SP Transmission Line Easement Conditions

EP 10 01 00 05 SP Requirements for Electric Aerials Crossing RailCorp Infrastructure

EP 10 01 00 07 SP Timber poles

EP 21 00 00 01 SP Insulation Coordination and Surge Arrester Selection

EP 95 00 30 05 SP RailCorp Network Management Plan Chapter 4 – Bush Fire Risk Management

ESC 215 Transit Space

ESC 540 Service Installations within the Rail Corridor

T HR CI 12200 ST Access Roads

T HR EL 00004 ST Buildings and Structures under Overhead Lines

T HR EL 08004 ST Overhead Wiring Fittings and Materials

T HR EL 10002 ST HV Aerial Lines – Standard Conductors and Current Ratings

T HR EL 10003 ST Wood Pole Serviceability

TMD 0001 CAD and Drafting Manual - All Design Areas – Sections 1 and 2

TMD 0001 CAD and Drafting Manual – Electrical Design – Section 4

T MU AM 01008 ST Technical Maintenance Plans and Coding System

T MU MD 00009 ST AEO Authorisation Requirements

TN 003: 2013 Change Authorisation Process for Proposed Operating Diagrams

TN 016: 2015 Overbridges and footbridges – Earthing and bonding requirements

TS 10765 Concessions to ASA Requirements

Transport for NSW standard drawings

The following two documents, published on the ASA website, contain listings of all drawings referenced in this standard:

HV Aerial Line Arrangements

HV Aerial Line Fittings

RailSafe documents

SMS-06-GD-0268 Working around Electrical Equipment

PR-D-78701 Personnel Certifications – Electrical

Other reference documents

NSW Maritime, Boaters' guide to electricity cable crossings of NSW navigable waters

NSW Department of Water and Energy February 2009, Code of Practice for Electricity Transmission and Distribution Asset Management

ENA Doc 015-2006 National guidelines for prevention of unauthorised access to electricity infrastructure

ENA Doc 023-2009 ENA guidelines for safe vegetation management work near live overhead lines

ISSC 3 Guideline for Managing Vegetation near Power Lines

ISSC 20 Guideline for the Management of Activities within Electricity Easements and Close to Electricity Infrastructure

4. Terms and definitions

The following terms and definitions apply in this document:

AAC all aluminium conductor

ABC aerial bundled cable

AEO Authorised Engineering Organisation

ASA Asset Standards Authority

BIL basic insulation level

CBL calculated breaking load

ENA Energy Networks Association

ESAA Electricity Supply Association of Australia

GIS geographic information system

JOS judgement of significance

rail infrastructure means the facilities that are necessary to enable a railway to operate and includes—

(a) railway tracks and associated railway track structures; and

(b) service roads, signalling systems, communications systems, rolling stock control systems, train control systems and data management systems; and

(c) notices and signs; and

(d) electrical power supply and electric traction systems; and

(e) associated buildings, workshops, depots and yards; and

(f) plant, machinery and equipment,

but does not include—

(g) rolling stock; or

(h) any facility, or facility of a class, that is prescribed by the national regulations not to be rail infrastructure

SWER single wire earth return

TfNSW Transport for New South Wales

UGOH underground to overhead

5. General requirements

The design and construction of HV aerial lines shall comply with the requirements of the NSW Department of Water and Energy (now Resources and Energy division of NSW Trade and Investment) document, *Code of Practice for Electricity Transmission and Distribution Asset Management;* AS/NZS 7000 *Overhead line design – Detailed procedures,* and this document.

Refer to HB 331 *Overhead line design* for guidelines to the application of AS/NZS 7000.

Single wire earth return (SWER) systems shall not be used.

The general design parameters listed in Table 1 shall be used for HV aerial lines.

Table 1 – General design parameters

Design aspect	Design parameters
Provision for live line working	Not required. However, where multiple circuits are supported on the same structure, adequate clearances shall be provided to allow for working on the lower circuit with the upper circuit live. See Section 7 for further information.
Design life	50 years
Security level (in accordance with AS/NZS 7000)	Level III
Maximum conductor operating temperature	70 °C
Reliability	Refer to EP 21 00 00 01 SP for required outage rates.
Insulation coordination / BIL	Refer to EP 21 00 00 01 SP for requirements

Where modification is to be made to a section of an existing HV aerial line, a design life of less than 50 years may be used in accordance with the provisions in Section 2.2. In determining the proposed design life the designer shall consider the condition of the entire line and any plans for upgrading the line in future.

5.1. Environmental considerations

Design and construction of HV aerial lines shall ensure that the environmental requirements of TfNSW are complied with for the full asset life cycle. Refer to the environmental management system documents published on the RailSafe website[1] for further information.

The impact from birds and other wild life shall be considered in the design of HV aerial line routes and pole top arrangements.

1 https://railsafe.org.au/ems-documents

6. Configuration of feeder route

A HV feeder may consist of aerial lines, cables, or a combination of both. The decision to adopt an aerial or cable route shall be based on technical feasibility and risks, and whole of life costs. The decision for the chosen configuration and associated supporting evidence shall be documented for each project.

6.1. Feeder route consisting of both cable and aerial line

Where a high voltage feeder consists of a combination of aerial lines and cables, the following issues shall be addressed in the design of such hybrid feeders:

- reliability of feeder due to the number of underground to overhead (UGOH) transitions
- feeder fault finding
- re-closure procedures – consideration shall be made on whether the feeder is to be classified as a predominantly aerial feeder or a predominantly cable feeder
- design and maintenance of earthing system
- management of buried assets

The considerations for the classification of the feeder as a predominantly aerial feeder or a predominantly cable feeder shall include:

- ease of fault finding due to the location of the feeder route
- number of cable sections that are longer than 500 m within the feeder
- lightning outage rate
- protection arrangement for the feeder
- importance of the feeder, such as a feeder supplying electricity to a railway tunnel
- availability of backup to the system when the feeder is unavailable

6.2. Lengths of cable and aerial sections within a hybrid feeder

The configuration of a hybrid feeder shall satisfy the provisions set out in Section 6.2.1 through to Section 6.2.4.

6.2.1. Length of aerial sections

Each aerial section, between two cable terminations or between a cable termination and the aerial line termination at a substation, shall have at least four spans and shall not be less than 500 m. This requirement does not apply to tee offs to poles with pole mounted substations.

6.2.2. Length of cable sections within an 11 kV hybrid feeder

There is no restriction on the length of cable sections within an 11 kV hybrid feeder.

6.2.3. Length of cable sections within a 33 kV hybrid feeder

The lengths of cable sections within a 33 kV hybrid feeder shall comply with the following requirements:

- the length of cable between two aerial line sections shall not be less than 500 m
- the length of cable between an aerial line section and the cable termination at an indoor substation switchgear shall either be less than 100 m or be more than 500 m
- the length of cable between an aerial line section and the cable termination at an outdoor substation switchgear shall not be less than 500 m

6.2.4. Length of cable sections within a 66 kV hybrid feeder

The lengths of cable sections within a 66 kV hybrid feeder shall comply with the following requirements:

- the length of cable between two aerial line sections shall not be less than 500 m
- the length of cable between an aerial line section and the cable termination at an indoor substation switchgear shall either be less than 100 m or more than 500 m
- the length of cable between an aerial line section and the cable termination at an outdoor substation switchgear shall not be less than 500 m
- cables shall be terminated at a traction substation as far as practicable to facilitate cable testing and maintenance

  Where it is not practicable to do so, the cable screens shall have a continuous connection to the earth mat of a traction substation. The connection arrangements shall be in accordance with the ASA requirements specified for the switchgear. See EP 01 00 00 01 SP *33 kV AC Indoor Switchgear – Non-withdrawable* for reference.

6.3. Locations of underground to overhead (UGOH) transitions

UGOH poles shall be located within the rail corridor as far as practicable. Where it is not practicable to do so, a secure exclusion zone shall be provided around the UGOH pole to manage risks of unauthorised access and electrical shock. Existing and possible future hazards in the vicinity shall be identified and suitable mitigation measures provided.

Examples of such hazards include:

- swimming pools
- gas pipelines
- locations frequented by members of the public, such as schools and bus shelters

Refer to ENA Doc 015-2006 *National guidelines for prevention of unauthorised access to electricity infrastructure* for guidelines for the prevention of unauthorised access.

6.4. Request for concession

A request for concession shall be submitted to the ASA as per TS 10765 *Concessions to ASA Requirements* where the proposed length of cable or aerial section does not meet the conditions detailed in Section 6.2. The following issues shall be addressed in the request:

- issues with overvoltage due to harmonics, network loading conditions and network configuration
- issues associated with having both cable and aerial sections in a feeder, as listed in Section 6.1

7. Multiple HV circuits on poles

The RailCorp distribution system is generally designed to give 'N-1' redundancy. As such HV aerial lines with a voltage of 33 kV or higher shall not be supported on the same pole.

An 11 kV aerial line may be supported under another aerial line with a voltage of 33 kV or higher on the same pole, provided that the separation between the circuits allow for the maintenance of the 11 kV aerial line while the upper circuit is live. The minimum separation at the structure between the 11 kV circuit and the 33 kV or 66 kV above is 1.8 m (0.8 m working zone per AS/NZS 7000 + 1.0 m safe approach distance per SMS-06-GD-0268 *Working around Electrical Equipment)* under all wind and temperature conditions.

HV conductors of external parties shall not be supported on TfNSW HV aerial line support structures.

8. HV aerial line route

To minimise interface issues and risks associated with external parties, it is preferred that HV aerial line routes be located within the rail corridor.

HV aerial line routes within the rail corridor shall comply with the requirements of ESC 540 *Service Installations within the Rail Corridor*.

Where it is necessary to locate the route outside of the rail corridor, arrangements shall be made for relevant agreements with external authorities and for the acquisition of easements.

Refer to AS/NZS 7000 for typical easement widths.

Where support structures are to be located on or adjacent to roadways, particular attention should be paid by the designer to the risk of vehicular impact. Support structures shall be located to have this risk minimised.

8.1. Maintenance and construction access

Adequate and safe access shall be provided for persons and plant for the construction and maintenance of the HV aerial line. As far as practicable, support structures shall be located so that the structure and conductor support arrangements may be accessed by elevated work platforms.

Easements may have to be arranged and access roads may have to be constructed to comply with this requirement. Access roads shall comply with the requirements of T HR CI 12200 ST *Access Roads*. Refer to EP 10 00 00 04 SP *Transmission Line Easement Conditions* for requirements in easements.

8.2. Vegetation clearance

Clearance to vegetation shall comply with the requirements of ISSC 3 *Guideline for Managing Vegetation near Power Lines* and ENA document 023-2009 ENA *guidelines for safe vegetation management work near live overhead lines*.

8.3. Buildings and structures under HV aerial lines

Bare 2 kV or 11 kV aerial lines shall not pass over buildings or extensions from buildings. Where it is not practicable to avoid such situations, screened aerial bundled cables (ABC) may be used over buildings.

Bare 33 kV or 66 kV aerial lines shall not pass over buildings and extensions from buildings.

Concessions will only be considered when all of the following are clearly demonstrated in the request for concession:

- there is no practicable alternative
- the building is not normally occupied
- the building does not have a water service connected
- all practicable measures have been adopted to reduce the likelihood of the line falling and the subsequent risk to persons in or around the building

Signalling location cases are not considered to be 'buildings' for the purpose of this requirement.

Small freestanding bus shelters may be placed under HV bare aerial lines if there is no practicable alternative and appropriate risk mitigations are put in place. Bus shelters that are interconnected to larger structures are not permitted under HV bare aerial lines.

Refer to TN 016: 2015 *Overbridges and footbridges – Earthing and bonding requirements* for earthing and bonding requirements at overbridges and footbridges with high voltage bare aerial conductors located above.

Refer to T HR EL 00004 ST *Buildings and Structures Under Overhead Lines* for other requirements of buildings and structures under HV aerial lines.

8.4. Crossing of rail infrastructure

Crossing of TfNSW heavy rail infrastructure shall comply with the requirements of EP 10 01 00 05 SP *Requirements for Electric Aerials Crossing RailCorp Infrastructure*.

Crossing of TfNSW heavy rail main line tracks shall be avoided as far as practicable. Crossing shall not be over three or more main line tracks.

8.5. Crossing of waterways

Crossing of waterways shall comply with the requirements of AS 6947 *Crossings of waterways by electricity infrastructure* and NSW Maritime’s *Boaters' guide to electricity cable crossings of NSW navigable waters*.

8.6. Bush fire risks

New HV aerial line routes shall not be located in bush fire prone areas. Where a design investigation concludes that there is no practicable alternative, the designer shall apply for a concession. The following supporting documents shall be provided with the request for concession:

- an options study demonstrating that all other routes are not practicable
- vegetation management plan for the aerial line route
- provisions in the design and specification of components to mitigate the risk of fire

Modifications to existing HV aerial line routes within bush fire prone areas shall be in accordance with EP 95 00 30 05 SP *RailCorp Network Management Plan Chapter 4 – Bush Fire Risk Management.*

8.7. Areas subject to flooding

New HV aerial line routes shall not be located in areas prone to flooding as far as practicable. Where it is not practicable to avoid such areas, the designer shall demonstrate that the additional risks on design life, constructability, reliability and maintainability of the aerial line are adequately mitigated in the design.

Additionally, the design of the structure footing shall be performed by a civil engineer with appropriate design authority.

9. Support structures

Support structure types shall be wood poles or steel structures. Other structure types are not approved. Specific requirements for support structures regarding location, identification signs, pole types, pole steps, and loading conditions are provided in the following sections.

9.1. Location requirements for support structures

The minimum horizontal dimension between the face of the structure and the design centreline of the track shall comply with the requirements of ESC 215 *Transit Space*.

Structures shall be located to minimise the risk due to impact from vehicles or other mechanical plant.

9.2. Support structure identification signs

Support structures shall have identification signs showing the HV aerial line feeder number and structure identification number. A structure supporting multiple feeders shall have the feeder number signs displayed and arranged in the same order as the feeders are supported on the structure.

A structure shall only have one structure number. The structure number shall be associated with the feeder with the highest voltage attached to the structure.

Structure identification signs shall comply with drawing EL0001095.

Identification signs shall be mounted on structures at a height of approximately 2 m above ground level, and shall be attached to the structure by:

- suitable clouts for wood poles
- glued to steel poles with a suitable neutral cure silicone sealant
- signs shall be shaped to the structure surface profile prior to gluing

9.3. Wood poles

Wood poles shall be fully de-sapped, select grade and without full-length preservative treatment, in accordance with AS 3818.11 *Timber – Heavy structural products – Visually graded – Part 11: Utility poles* and EP 10 01 00 07 SP *Timber poles*.

Wood poles shall be of a hardwood timber species of strength group S1 or S2 in accordance with AS/NZS 2878 *Timber – Classification into strength groups,* and natural durability class 1 or 2 in accordance with AS 5604 *Timber – Natural durability ratings.*

Poles with a length exceeding 18.5 m shall not be used in designs without the prior agreement of the AEO maintaining the HV aerial line.

New poles shall have nominal pole strength ratings of 8 kN or more. Poles supporting new UGOH arrangements shall have a minimum nominal strength rating of 12 kN.

Where modifications are to be made to an HV aerial line, the residual strength of existing poles shall be determined by pole base examinations. Consideration shall also be made of other pole degradation factors. See T HR EL 10003 ST *Wood Pole Serviceability* for further information.

Poles shall be marked and branded in accordance with AS 3818.1 *Timber – Heavy structural products – Visually graded – Part 1: General requirements*, AS 3818.11 and EP 10 01 00 07 SP.

9.3.1. Pole cap

The head of poles shall be fitted with pole caps in accordance with drawing EL0012653.

9.4. Steel poles

Steel poles shall not be installed within the rail corridor when an overhead earthwire is attached to the pole.

Steel poles shall comply with AS/NZS 4677 *Steel utility service poles.*

Steel poles shall be galvanised to AS/NZS 4680 *Hot-dip galvanized (zinc) coatings on fabricated ferrous articles* and AS/NZS 4792 *Hot-dip galvanized (zinc) coatings on ferrous hollow sections, applied by a continuous or a specialised process.*

9.5. Pole steps

Pole steps in accordance with drawing EL 0017974 shall be provided for all wood poles. The pole steps shall be installed 125 mm +/- 20 mm into the timber of the pole radially to the pole axis. Holes for pole steps shall be bored a minimum of 175 mm deep.

For steel poles, the design of pole steps and their attachment shall be compatible with the maintenance arrangement and practices of the AEO maintaining the HV aerial line.

Pole steps shall be installed at 450 mm intervals on two sides of the pole that are ideally displaced by 120° along the pole circumference. The nominal distance between pole steps on each side is 900 mm.

The first pole step shall be installed at a minimum height of 3 m from ground level.

9.6. Design loading conditions for support structures

The following loading conditions shall be used for the design of support structures. Refer to AS/NZS 7000 for values not specified in this section.

9.6.1. Maximum wind and maximum weight

The design loading conditions for poles at maximum wind and maximum weight are provided in Table 2 below:

Table 2 - Design loading conditions – maximum wind and weight

Parameter	Value	Notes
Strength reduction factor for wood poles (see note)	0.4	Based on: • Capacity factor – 0.9 • Pole degradation factor (k_d) – 0.5 for durability class 1 and 2 • All other 'k' factors listed in AS/NZS 7000 Appendix F – 1.0 • Factor to allow for wind loads on crossarms, insulators and fittings – 0.9
Wind load on poles	1110 Pa design wind pressure	Nil
Drag coefficient for wood poles	1.3	Nil
Wind loads on crossarms, insulators and fittings	Generally ignored	Accounted for by applying a factor of 0.9 in the strength reduction factor for poles
Wind load on conductors	15 °C at 900 Pa	Assume wind direction is perpendicular to conductors
Vertical dead loads from non-conductor loads	Generally ignored, except where there is significant attachment to the pole such as a large transformer	Nil

Note: The value of the strength reduction factor may be varied if a design life shorter than 50 years is applicable to the project in accordance with the provisions in Section 5.

9.6.2. Everyday condition – sustained loads

The design loading conditions for poles for everyday conditions are provided in Table 3 below:

Table 3 - Design loading conditions – everyday conditions

Parameter	Value	Notes
Strength reduction factor for wood poles (see note)	0.26	Based on: • Capacity factor – 0.9 • Pole degradation factor (k_d) – 0.5 for durability class 1 and 2 • Duration of load factor for strength (k_1) – 0.57 • All other 'k' factors listed in AS/NZS 7000 Appendix F – 1.0
Conductor loads	5 °C at 0 Pa	Nil
Vertical dead loads from non-conductor loads	Generally ignored, except where there is significant attachment to the pole such as a large transformer	Nil

Note: The value of the strength reduction factor may be varied if a design life shorter than 50 years is applicable to the project in accordance with the provisions in Section 5.

9.6.3. Serviceability limits – deflection

The maximum deflection at pole top shall not exceed 3% of the length of the pole above ground under the loading conditions specified in Section 9.6.2.

10. Foundations for wood poles

Poles are to be concreted in the holes to a level 500 mm below ground level. The concrete shall have a thickness of at least 100 mm radially and at the bottom of the pole, and completely fill the void between the pole and the undisturbed soil. Above the concrete the hole shall be backfilled with clean fill and well rammed. Concrete footings shall be designed in accordance with AS 3600 *Concrete structures*. The exposure classification shall be A1. The minimum concrete strength shall be 20 MPa at 28 days.

Any water accumulated in the hole shall be removed before standing the pole.

To facilitate pole base maintenance, the ground around the pole and within 300 mm from the edge of the pole shall be able to be readily excavated to a depth of 450 mm with hand tools.

Foundations shall be designed to match the capacities of poles. Minimum pole embedment depths as shown in Appendix C may be used for the installation of wood poles, provided that the following conditions are met:

- pole is located in ground with slope less than 2.5H:1V
- pole is located at more than 4 m from the edge of any embankment
- the soil is cohesive with a minimum unsaturated shear strength of 50 kPa and soil density of 18.5 kN/m3 (stiff soil), or non-cohesive soil with an angle of friction of 35 degrees minimum (dense to very dense fine and silty sand or clayey sandy gravel)

For all other installation conditions, the pole foundation shall be designed by a civil engineer with appropriate design authority.

Refer to drawings EL0162213, EL0149232 and EL0162262 for previous practices used for wood poles.

11. Foundations for steel poles

Foundations for steel poles shall be designed by a civil engineer with appropriate design authority.

12. Underground services search

An underground services search shall be conducted during design and confirmed prior to construction to ensure that poles and foundations are clear of all underground services. Where underground services are present in the vicinity of the foundation, appropriate control measures shall be implemented to protect against damage to such services.

13. Pole top

The pole top is designed to provide appropriate support of the conductors as well as providing adequate clearances between conductors and obstructions.

Standard pole top arrangement drawings are listed in the ASA website. It is the responsibility of the designer to ensure that pole top arrangements in the standard drawings are compliant with this document and suitable for site and project conditions.

Where pin type insulators are used, all wood and metal interface areas shall be painted with a conductive paint.

In addition to the requirements of AS/NZS 7000, the minimum clearances shown in Table 4 shall be complied with for wood pole supports under the following conditions:

- conductor temperature 70 °C and 0 Pa wind
- conductor temperature 50 °C and 500 Pa wind

Table 4 - Minimum conductor clearances to crossarms, pole steps, pole or strut

Nominal voltage (kV)	Minimum clearance for wood pole supports (m)
132	1.52
66	0.69
33	0.40
11	0.20

13.1. Crossarm types

Crossarms shall be of solid timber or galvanised steel. Other types of crossarms are currently not approved.

Refer to the standard pole top arrangement drawings listed on the ASA website for dimensions of standard crossarms.

13.2. Crossarm position

When not shown on the pole top arrangement, the top crossarm shall be positioned 300 mm from the top of the pole.

Crossarms shall be fitted to the side of the pole nearest to the start of the aerial line as indicated by the pole numbering. The only exceptions are where the aerial line crosses a railway or another aerial line. In such cases, crossarms shall be fitted on the side remote from the crossing span.

13.3. Crossarm attachment to wood poles

The pole is to be notched 35 mm +/- 5 mm for the attachment of crossarms.

Crossarms are to be attached to poles by pole bands. See drawing EL0020464 for further details.

13.4. Timber crossarms

Grade 1 natural sawn tallowwood crossarms as per AS 3818.4 *Timber – Heavy structural products – Visually graded – Part 4: Cross-arms for overhead lines* and AS 3818.1 is preferred.

Acceptable alternatives are as follows:

- Grade 1 natural sawn crossarms in accordance with AS 3818.4
- hardwood species of strength group S1 in accordance with AS/NZS 2878
- natural durability Class 1 in accordance with AS 5604

Crossarms shall be protected from end splitting and checking. Complete the following measures within 48 hours of sawing:

- apply 'Caltex Timber Sealer' or equivalent approved by the relevant AEO
- install gang nails with a minimum thickness of 1.2 mm covering at least 50% of the end grain
- paint the top surface of the crossarm with one coat of Dulux acrylic one step prime paint or equivalent approved by the relevant AEO, and two coats of Dulux Weather Shield Acrylic paint, colour gray green or pale eucalypt, or equivalent approved by the relevant AEO

13.5. Steel crossarms

Steel crossarms shall comply with AS 4100 *Steel structures*, and galvanised to AS/NZS 4680 or AS/NZS 4792 as appropriate.

14. Conductors

See T HR EL 10002 ST *HV Aerial Lines – Standard Conductors and Current Ratings* for the range of standard conductors and the nominal current ratings.

The maximum design conductor operating temperature is 70 °C.

14.1. Configuration with copper and aluminium conductors

Copper conductors shall not be located above aluminium conductors. This requirement is applicable to multiple circuits on a pole and to the installation of overhead earthwires.

14.2. Clearance for conductors

The following documents shall be referred to for conductor clearance requirements:

- AS/NZS 7000
- AS 6947
- EP 10 01 00 05 SP
- ENA Doc 023-2009

- ISSC 3 *Guideline for Managing Vegetarian near Power Lines*
- ISSC 20 *Guideline for the Management of Activities within Electricity Easements and Close to Electricity Infrastructure*

Ground clearance requirements shall be satisfied with a conductor temperature of 70 °C and 0 Pa wind. Designers shall consider the need to allow for possible changes to ground levels.

Horizontal clearance requirements shall be satisfied with a conductor temperature of 50 °C and 500 Pa wind. The horizontal clearances of conductors to the boundaries of the rail corridor, boundary fences and easements calculated under such conditions shall comply with the structure clearance requirements of AS/NZS 7000.

14.3. Conductor support arrangements

Refer to pole top arrangement drawings listed on the ASA website.

Helically formed armour rod with elastomer insert shall be used at support arrangements for aluminium conductors in tension. See drawing EL0017064 for more information.

14.4. Conductor sag and tension

All aluminium conductors (AAC) without vibration dampers are to be tensioned to drawings EL0008743-9 and EL0019132.

AAC conductors with vibration dampers are to be tensioned to drawings EL0016102-9.

Copper conductors without vibration dampers are to be tensioned to drawings EL0016093 to EL0016101.

Apart from 'slack tension' spans, variations to the standard design conductor sag and tension shall not be made without the agreement of the AEO maintaining the HV aerial line. In particular, the same design conductor sag and tension should be used for all aerial sections of a HV feeder.

Refer to layout drawings for design conductor tensions for existing installations. Consult the AEO maintaining the HV aerial line if such information is not shown on layout drawings.

New conductors shall be pre-tensioned to 35% calculated breaking load (CBL) for one hour, and then sagged for a temperature of 10 °C below the ambient temperature.

Refer to AS/NZS 7000 for methods for measurement of conductor temperatures and tensions. Due to its many practicable disadvantages, the dynamometer method shall not be used.

15. Overhead earthwire

Overhead earthwire is not required for 11 kV aerial lines.

Overhead earthwire shall be installed for the full length of the aerial feeder for voltages of 33 kV and above.

For modifications to existing installations, the extent of overhead earthwire coverage may be reduced with justification by a cost benefit analysis. The resultant configuration shall provide for the following as a minimum:

- a minimum of 800 m of overhead earthwire adjacent to the termination of an HV aerial line at a system substation
- a minimum of 800 m of overhead earthwire from an UGOH arrangement
- all new poles for aerial lines with a nominal voltage of 33 kV and above shall be designed to be suitable for overhead earthwire installation

See T MU AM 01008 ST *Technical Maintenance Plans and Coding System* for the definition of system substation.

15.1. Overhead earthwire conductors

Overhead earthwire conductors shall be chosen from the range of standard conductors in T HR EL 10002 ST. The minimum wire diameter of the conductor strands shall be 2.5 mm.

15.2. Shielding angle

The shielding angle shall not exceed the following:

- 30° at 0 Pa wind with a conductor temperature of 5 °C
- 40° at 500 Pa wind with a conductor temperature of 15 °C

Refer to drawing EL0013170-2 for information on previous practices.

15.3. Support arrangements

Overhead earthwire may be supported from the pole or from extension brackets mounted on the pole.

Refer to arrangement and fitting drawings listed in the ASA website.

15.4. Earthing of overhead earthwires

Overhead earthwires shall be earthed at each support pole, except at locations nominated by an approved and accepted earthing design. The earthing design shall list all support locations at which the overhead earthwire is not connected to earth, and detail the reasons for such omissions, and the impacts on the electrical infrastructure. All such locations shall be clearly identified on the layout drawings. A cross-reference to the earthing design shall also be provided on the layout drawings.

The down earth lead shall be spaced from the surface of the pole with a nominal distance of 275 mm by pole stand-off supports (as shown in drawing EL 0015788). The vertical distance between a pole stand-off support and any crossarm or insulator support shall not be less than 400 mm.

A cable guard shall be provided for the down earth lead up to a minimum height of 2.4 m from ground. See drawing EL 0284008 for further detail.

At joint use poles the down earth lead shall be insulated or segregated from other utilities equipment and earthing systems to provide a minimum 2.0 m clearance between exposed earthing systems.

Refer to drawings EL0017446-8 for typical arrangements for the down earth lead, and drawing EL0284008 for details of connection to pole earth electrodes.

16. Insulators

Only insulators that have been type approved by ASA shall be used in the RailCorp Distribution System.

Currently type approved insulators are listed in Appendix A. Where an existing insulator is to be replaced by another insulator type, all design parameters at the pole top shall be checked and confirmed prior to the replacement.

16.1. Suspension and termination arrangements

Porcelain and glass insulator strings and insulator units shall comply with the following standards:

- AS/NZS 2947.1 *Insulators – Porcelain and glass for overhead power lines – Voltages greater than 1000 V ac – Part 1: Test methods – Insulator units*
- AS/NZS 2947.4 *Insulators – Porcelain and glass for overhead power lines – Voltages greater than 1000 V ac – Part 4: Test methods – Insulator strings and insulator sets*
- AS 60305 *Insulators for overhead lines with a nominal voltage above 1000V – Ceramic or glass insulator units for ac systems – Characteristics of insulator units of the cap and pin type*

Glass insulator units (fitting 453/15) shall also comply with drawing EL0009366. The composition of glass insulator strings used with wood pole supports is given in Table 5. Project specific designs are required for applications with steel pole supports.

Composite insulators shall have silicone rubber housing and comply with the following Australian standards:

- AS 4435.1 Insulators – *Composite for overhead power lines – Voltages greater than 1000 V ac – Part 1: Definitions, test methods and acceptance criteria for string insulator units*
- AS/NZS 4435.2 *Insulators – Composite for overhead power lines – Voltages greater than 1000 V ac – Part 2: Standard strength classes and end fittings for string insulator units*

Couplings shall be of the tongue and clevis type complying with AS 1154.1 *Insulator and conductor fittings for overhead power lines – Part 1: Performance, material, general requirements and dimensions.*

Table 5 - Composition of glass insulator strings used with wood pole supports

Voltage (kV)	Arrangement	No of units in insulator string (see note)
11	Termination	2
11	Suspension	1
33	Termination	3
33	Suspension	3
66	Termination (without overhead earthwire)	6
66	Termination (with overhead earthwire)	5
66	Suspension (line deviation > 30 ^{o} without overhead earthwire)	6
66	Suspension (line deviation > 30 ^{o} with overhead earthwire)	5
66	Suspension (line deviation ≤ 30 ^{o} without overhead earthwire)	5
66	Suspension (line deviation ≤ 30 ^{o} with overhead earthwire)	4
132	Termination	10
132	Suspension	Not used

Note: See EP 10 01 00 05 SP for insulation requirements for spans crossing railway tracks.

16.2. Pin insulator arrangements

Pin insulators shall be SLP/11/180 per AS 4899 *Pin insulators – Porcelain and glass for overhead power lines – Voltages greater than 1000 V ac.*

Pins for timber crossarms shall be type A/130/7 per AS 4899 and comply with drawing EL0017195.

Pins for steel crossarms shall be type A/130/7 per AS 4899 and modified in accordance with drawing EL0017195.

Conductors may be attached by helical fittings complying with AS 1154.3 *Insulator and conductor fittings for overhead power lines – Part 3: Performance and general requirements for helical fittings;* or, for copper conductors only, by binding arrangement in accordance with drawing EL0038125. Helically formed armour rod with elastomer insert shall be used for aluminium conductors.

16.3. Line post insulator arrangements

Porcelain line post insulators shall comply with AS/NZS 2947.1.

Composite line post insulators shall comply with AS 4435.4 *Insulators – Composite for overhead power lines – Voltages greater than 1000 V ac – Part 4: Definitions, test methods, acceptance criteria for post insulator units.*

Refer to the arrangement drawings listed in the ASA website for application.

16.4. Guy insulators

Provisions for guy insulators are provided in Section 18.1.3.

17. Conductor fittings and accessories

All conductor fittings and accessories shall be compatible with the conductor and installed in accordance with the manufacturer's instructions.

17.1. Full tension line splices

Full tension line splices shall be either compression joints complying with AS 1154.1 or helical preformed splices to AS 1154.3. The type test requirements shall include the electrical heat cycle test and short time current test.

Helical preformed splices shall not be used with conductors with seven strands or less.

Full tension line splices shall not be installed:

- within 1.2 m of a conductor support location
- in spans crossing railway tracks, navigable waters, major roads, other aerial lines, structures or over buildings

17.2. Non-tension splices

Non-tension conductor splices shall comply with AS 1154.1. The type test requirements shall include the electrical heat cycle test and short time current test.

Conductor clamps to drawings EL0017671 and EL0017672, or non-tension compression joints may be used.

17.3. Anchor fittings

Anchor fittings shall be helical preformed fittings complying with AS 1154.1 and AS 1154.3. The electrical heat cycle test is not required.

17.4. Vibration dampers

Vibration dampers shall be Stockbridge type complying with AS 1154.1.

Spiral vibration dampers shall not be used.

Where used, the specification of the vibration damper and the locations at which the vibration damper are to be installed shall be detailed by the designer on layout drawings.

17.5. Aircraft warning markers

Refer to AS 3891.1 *Air navigation – Cables and their supporting structures – Marking and safety requirements – Part 1: Permanent marking of overhead cables and their supporting structures for other than planned low-level flying* for requirements for aircraft warning markers.

Where required, the locations at which aircraft warning markers are to be installed shall be detailed by the designer on layout drawings.

17.6. Bird diverters

Bird diverters are to be installed when required as a measure for mitigating the risk of conductor strike by birds.

Bird diverters shall comply with AS 1154.1.

18. Guy arrangements

Guy arrangements are used when the permissible design load limits of poles are exceeded. The guy arrangement shall be designed to take the full applied load rather than just the portion by which the load exceeds the pole capacity.

18.1. Guy arrangements for timber poles

Timber poles may be guyed using stay poles or ground anchors.

Guying to another aerial line support pole is acceptable. However, back to back horizontal guy wires between poles shall not be used except for temporary support of damaged poles.

18.1.1. Stay pole

Refer to EP 10 01 00 07 SP for specifications and dimensions of stay poles.

Stay poles shall otherwise comply with the requirements of Section 9.3.

Refer to drawings EL0497822-3 for stay pole arrangements.

Foundations for stay poles shall be constructed as per timber support poles, as set out in Section 10. Minimum pole embedment depths as shown in Appendix D may be used for the installation of timber stay poles, provided that the following conditions are met:

- pole locations and soil conditions are within the limit conditions specified for timber support poles in Section 10
- maximum load along direction of guy wires is 60 kN. See drawings EL0497822-3
- the angle of the guy wire to the horizontal is between 40 degrees and 60 degrees

For all other installation conditions, the stay pole foundation shall be designed by a civil engineer with appropriate design authority.

18.1.2. Ground anchor

Refer to drawings EL0497824-5 for guy arrangements using ground anchors.

All driven ground anchors shall be type approved by ASA, and shall be proof loaded to three times the maximum load shown on the relevant arrangement drawings. A proof loading certificate shall be provided for each installation by the installer.

Sight guards shall be provided on all ground anchor installations to mitigate the risk of mechanical impact damage.

18.1.3. Guy insulator

Guy insulators shall be provided for all guy arrangements. Refer to drawings EL0497822–5 for arrangements, and Appendix A for ASA type approved guy insulators.

18.1.4. Earth connection

Guy wires and rods below the guy insulator shall be effectively earthed to achieve a resistance to earth of 10 ohm or less.

Refer to drawings EL0497822-5 for earthing arrangements.

18.2. Guy arrangements for steel poles

Guy arrangements for steel poles shall be designed on a job by job basis.

19. Earthing

An earthing design shall be done for the HV aerial line installation and associated equipment for each project as part of the earthing design for the overall project.

Connection to earth shall be made to:

- overhead earthwire at each support structure (see Section 15.4 for further information)
- cable screens and the base of surge arresters at UGOH arrangements
- cable screens, catenary wire, and the base of surge arresters at the pole for the transition of 11 kV ABC to bare aerial conductors
- 11 kV ABC catenary wire for tension arrangements, such as arrangement 11/48 (drawing number EL0002979), where an earth down lead is installed
- guy wires and rods below the guy insulators
- steel poles

20. Signs

Signs shall be installed as per the following requirements:

- drawing EL0001096 for access road direction signs which are to be installed at appropriate locations to identify the correct route to gain access to an aerial line feeder
- Section 9.2 for feeder and support structure identification

- Section 9.3 and Section 9.4 for markings required for support structures
- *Boaters' guide to electricity cable crossings of NSW navigable waters* and AS 6947 for crossings of navigable waters

21. Survey

Survey requirements for each project shall be specified by the designer, but shall include all the details required on layouts and profile drawings as listed in Section 22.2 and Section 22.3. Where there is an existing HV aerial line, the survey shall include the following:

- ambient temperature
- conductor support heights at each pole
- height of each conductor at mid-span
- photograph(s) of the pole top arrangement at each pole facing the direction of increasing pole numbers

22. Design documentation

Typical design documents required for each stage of design include:

- concept design
  - proposed HV system and reticulation diagrams
  - conductors specification
  - concept solutions on the optimal feeder route
  - scope of modifications to existing HV feeders
  - requirements for easements and approvals by external bodies
  - interface issues
- preliminary design
  - preliminary layout and profile drawings
  - preliminary risk analysis
  - requirements for concessions to ASA requirements
  - requirements for type approvals
  - proposed easements and associated approval requirements
  - scope of interface activities
  - appropriate environmental reports for the feeder route

- final design
  - final risk analysis
  - final environmental reports
  - layout drawings
  - profile drawings
  - temperature / tension or sag charts / tables
  - details of easements and approvals
  - details of modifications to existing HV feeders and supporting structures
  - approved concessions to ASA requirements
  - approved ASA type approval certificates
  - details of interface requirements
  - supporting calculations for strength of poles and crossarms, clearances, and overhead earthwire shielding angles

The actual design documentation required for each design stage of a project shall be determined by the designer and agreed by the relevant AEO at the beginning of the design process.

22.1. Proposed HV system and reticulation diagrams

Proposed HV system and reticulation diagrams shall be prepared for every project, and each stage of the project.

The proposed diagrams shall be based on relevant diagrams of the existing network and show:

- proposed changes to existing feeders
- proposed changes in connectivity to the RailCorp distribution system
- lengths of proposed aerial and cable sections of each HV feeder

Proposed HV system and reticulation diagrams shall be approved by all relevant stakeholders in accordance with ASA technical note TN 003: 2013 *Change Authorisation Process for Proposed Operating Diagrams*. Examples of such proposed diagrams are available on the Sydney Trains electrical operating diagrams (EOD) site.

22.2. Layout drawings

HV aerial line layouts shall be based on detailed route survey and shall comply with the following documents:

- TMD 0001 *CAD and Drafting Manual - All Design Areas – Section 1 and Section 2*
- TMD 0001 *CAD and Drafting Manual – Electrical Design – Section 4*

Layouts shall be drawn on A1 size drawings with a scale of 1:500. Where practicable, it is preferable to have details of overhead wiring and HV feeders shown in combined layout drawings.

The following information shall be shown on layout drawings as a minimum:

- conductor specification and tensioning data. This information is generally shown in the first sheet of a drawings set
- reference to other relevant design documents, including profile drawings, survey files, design software used, earthing design,
- details associated with each support pole (refer to Appendix B for further information):
  - pole number
  - pole length / strength / rake
  - pole top arrangement
  - pole location, given in coordinates
  - angle of deviation at the pole
  - non-standard sinking depth, if applicable
  - non-standard earthing arrangement (see Section 15.4)
  - reference to non-standard foundation design, if applicable
- sketches of any non-standard pole top arrangements showing alterations to standard arrangements. Such sketches shall be located as close to the applicable poles as practicable
- span lengths
- locations of guy poles or anchors, and applicable guy arrangements in accordance with the designations detailed in Appendix B
- a virtual span table on each sheet detailing the virtual spans applicable to the spans on that sheet
- TfNSW rail infrastructure property boundaries and actual fence lines

- details of easements and easement boundaries
- locations of signs, vibration dampers and aircraft warning markers
- other relevant details located within a corridor containing the centreline of the HV aerial line route, including:
    - railway tracks and stations
    - buildings and structures
    - roads and kerb lines
    - other aerial services
    - other 'obstructions' (for example trees and light posts) to the HV aerial line

The width of the corridor containing the above details shall not be less than 8 m or the minimum easement corridor width as shown in Figure 3.11 of AS/NZS 7000: 2010.

22.3. Profile drawings

HV aerial line profiles shall be based on detailed route survey and shall comply with Section 1, Section 2 and Section 4 of TMD 0001. Profiles shall be drawn on A1 size drawings with a horizontal scale of 1:500 and a vertical scale of 1:100.

The following information shall be shown on profile drawings as a minimum:

- reference to other relevant design documents, for example layout drawings and survey files
- overhead earthwire conductor profile at 40°C, phase conductor profiles at 70°C, and associated ground clearance envelope
- profile of ground line below the conductors
- details associated with each support pole (refer to Appendix B for further information):
    - pole number
    - pole length / strength / rake
    - pole top arrangement
    - pole location, given in coordinates
    - heights of pole top, crossarms / post insulator supports
    - angle of deviation at the pole
    - non-standard sinking depth, if applicable
    - non-standard earthing arrangement (see Section 15.4)
    - reference to non-standard foundation design, if applicable

- span lengths
- locations and heights of 'obstructions' located within the corridor containing the centreline of the HV aerial line route as defined in Section 22.2, including:
    - railway tracks and stations
    - buildings and structures
    - roads and kerb lines
    - other aerial services
    - other 'obstructions' to the HV aerial line, for example trees and light posts

Where an HV aerial line crosses other aerial services, separate profiles shall be drawn of the crossing spans to show the minimum clearance between the conductors based on the worst combination of loading and ambient conditions. The conditions shall be indicated on the profile drawings.

22.4. Temperature and tension tables or charts

Temperature and tension tables or charts, such as sag tables, shall be provided for stringing of all conductors including overhead earthwires. Temperatures shall be given in increments of not more than 5 °C, and shall cover the full range of ambient conditions at the site.

22.5. Access road maps

Where access roads have been constructed for the purpose of accessing the HV aerial line route, maps showing their locations and routes shall be provided.

22.6. Non-standard arrangement drawings

Where the designer proposes to use an arrangement that is not covered by any Transport standard arrangement drawings, the proposed arrangement shall be detailed in a drawing complying with Section 1, Section 2 and Section 4 of TMD 0001.

All materials required for the arrangement shall be detailed and specified on the drawing.

22.7. Supporting calculations

Supporting calculations shall be provided by the designer to demonstrate:

- adequacy of specified pole strengths
- adequacy of pole foundations
- adequacy of strength of specified crossarms

- correct overhead earthwire shielding angles
- provision of adequate clearances

23. Construction staff

All HV aerial line construction staff shall be suitably accredited in accordance with the competency system and the safety management system of the relevant AEO and RailSafe document, *Personnel Certifications – Electrical* (PR-D-78701).

24. Materials requirements

The supply, testing and acceptance of HV aerial line materials shall comply with the quality assurance requirements stipulated in T HR EL 08004 ST *Overhead Wiring Fittings and Materials.*

Materials shall not be handled in a manner that may cause damage to the materials.

Poles shall not be dropped to the ground from jinkers.

Insulator shall be inspected for damage and cleaned with a dry clean cloth prior to installation.

25. Inspection and tests

The following inspection and tests shall be undertaken prior to the commissioning of new or modified HV aerial lines.

25.1. Visual inspection

A visual inspection shall be undertaken and shall include the following as a minimum:

- general condition of the aerial line route and installation
- visible signs of component damage and / or defects due to workmanship
- confirmation that the aerial line installation is in accordance with the approved and accepted design and relevant standards
- confirmation that all required clearances have been checked and recorded

25.2. Phase identification check

An identification check shall be carried out to confirm that 'A' phase at start is 'A' phase at the end of the aerial line, and likewise for 'B' and 'C' phases.

25.3. Electrical continuity

Electrical continuity shall be tested by measuring the loop resistance from one end over the full length of the aerial section for each pair of conductors, including the overhead earthwire. The test shall be conducted with an injection current of 10 A dc. This test is passed if:

- the measured value is not greater than 105% of the calculated value at the temperature at which the test is conducted
- the measured values for each phase conductor do not vary by more than 2% from those of the other phase conductors

25.4. Insulation resistance

The test shall be conducted with a 5 kV dc insulation resistance tester and with all feeder cables, surge arresters and earths disconnected.

The measured value under dry weather conditions shall not be less than 1 MΩ per kilometre for each phase conductor

25.5. Electrical phase check

An electrical phase check shall be carried out against a known supply to check that the aerial line has the correct phase relation to the system.

26. Data set associated with HV aerial lines

The following data shall be maintained for all HV aerial line assets.

- as-built design documentation
- geographic information system (GIS)
- asset information

This data shall be the property of TfNSW and shall be maintained by the AEO responsible for maintaining the aerial lines.

26.1. As-built design documentation

As-built design documentation shall be provided by the AEO responsible for the construction of the HV aerial line within 30 days of each stage of commissioning.

All as-built design documents shall be accepted by the design acceptance authority of the AEO responsible for design of the HV aerial lines and lodged with the TfNSW Central Plan Room. As-built design documents shall include:

- all 'for construction' design documents listed in Section 22 and updated to as-built status
- survey files
- information for updating the TfNSW feeder data book:
    - extent, length and conductor details of each section of relevant HV feeders
    - extent, lengths and conductor details of overhead earthwires
- information for updating asset information system of the AEO maintaining the HV aerial lines, in a format specified by the relevant AEO
- digital colour photographs of the following:
    - the pole top arrangement at each pole facing the direction of increasing pole numbers
    - locations with critical clearance constraints or other 'obstructions'

26.2. Geographic information system (GIS)

HV feeder data on the GIS of the AEO maintaining the HV aerial lines shall be updated based on the accepted as-built layouts and profile drawings.

26.3. Other asset information

Relevant information in the asset information system of the AEO maintaining the HV aerial lines, including:

- identification and number of HV feeders
- identification number and year of installation of each supporting structure
- for wood poles, timber species of each pole

Appendix A Type approved insulators for HV aerial lines

Refer to Table 6 for details of ASA type approved insulators for HV aerial lines.

Table 6 - Type approved insulators for HV aerial lines

Insulator description	Fitting number	Drawing number	Application	Type approved insulators	Sydney Trains stock code
70 kN Ø 255 mm toughened glass disc	453/15	EL0009366	Units in suspension or termination insulator strings	Morlynn CT100/146	001059351
11 kV porcelain pin insulator	T1/11	EL0017195 (Item 1)	11 kV pin insulator arrangement	Morlynn P11	001058668
33 kV porcelain line post insulator	T1/24	N/A	Support of bridge conductor from crossarm for 33 kV 'anchor & bridge' arrangements	Morlynn H11461	001879311
33 kV porcelain line post insulator	Nil	EL0005694	33 kV line post insulator arrangement	Morlynn H11286	Nil
33 kV silicone composite station post insulator	Nil	EL0455661 (Item 28)	33 kV UGOH arrangement	K-Line KL35SPT2M12NO	002071736
66 kV cycloaliphatic station post insulator	Nil	EL0052208 (Item 28)	66 kV UGOH arrangement	EMC Pacific SP1690-12-24	Nil
66 kV composite string insulator	Nil	N/A	66 kV suspension and termination arrangements; use of this insulator is subject to approval on a case by case basis.	K-Line KL69HCT16	Nil
120 kN composite string insulator	453/16	EL0216729	Guy insulator	K-Line KL46Hey10	001873447

N/A means not applicable

Appendix B Pole and pole top arrangements on layout and profile drawings

Details of pole and pole top arrangements shall be designated on layout and profile drawings in accordance with the example given in Figure 1.

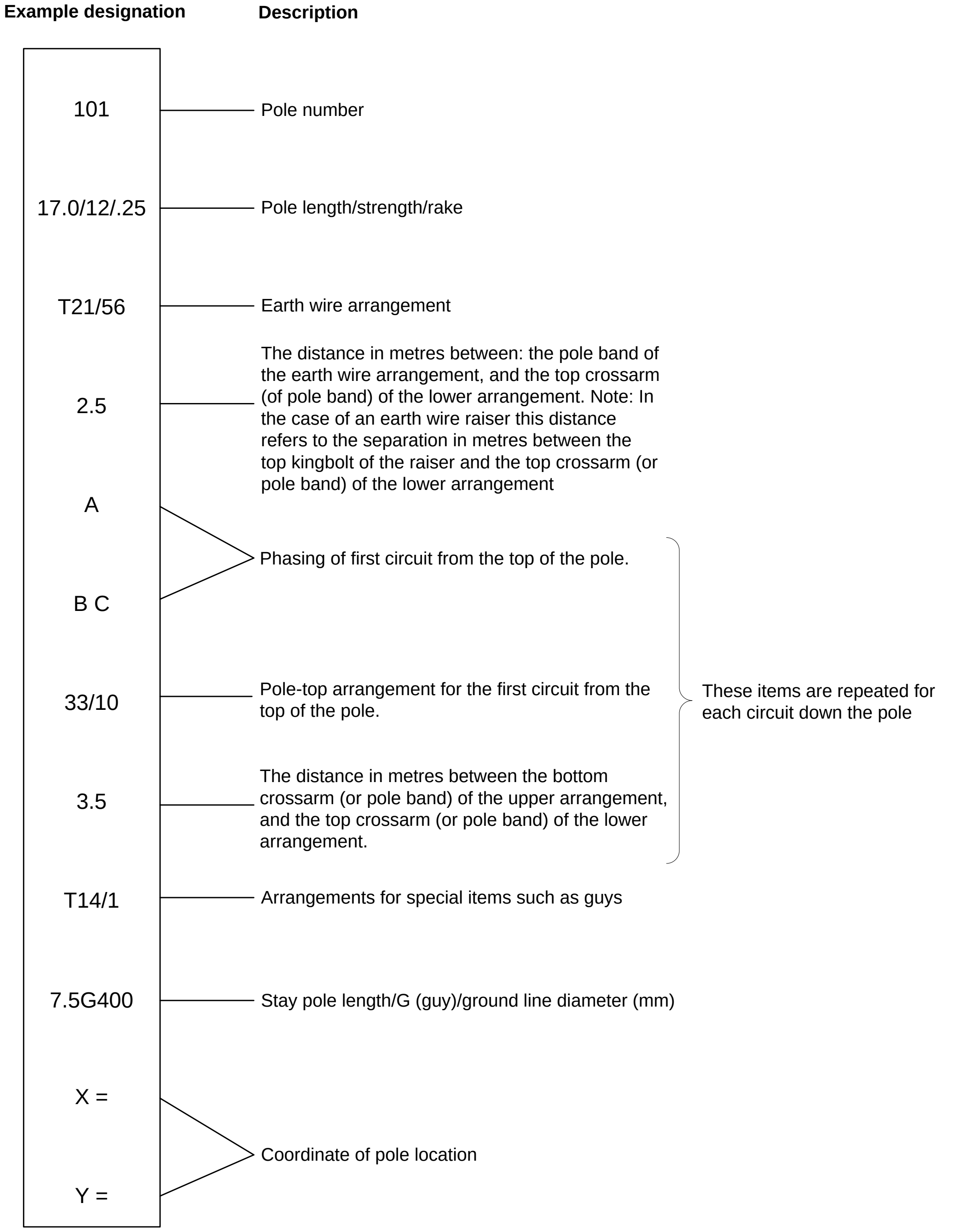

Figure 1 – Designation of pole and pole top arrangements

Where the conductor phasing is unknown and conductor identification is required numbers may be used, for example '1', '2', and '3' may be used instead of 'A', 'B' and 'C'.

Appendix C Embedment depths of timber support pole

The minimum embedment depths of timber support poles with normal ground and soil conditions are provided in Table 7.

Table 7 - Embedment depths of timber support poles with normal ground and soil

Pole Designation	Pole length (m)	Height above ground (m)	Ground line diameter (mm) Strength group S1	Ground line diameter (mm) Strength group S2	Minimum embedment depth (see notes)	Design capacity for maximum wind (kNm)
8.0/8	8	5.56	275	297	2.44	81.31
8.0/12	8	5.16	311	336	2.84	117.67
9.5/8	9.5	6.87	299	323	2.63	105.18
9.5/12	9.5	6.48	335	362	3.02	148.03
11.0/8	11.0	8.24	314	339	2.76	122.04
11.0/12	11.0	7.83	355	384	3.17	176.14
11.0/15	11.0	7.57	378	409	3.43	211.59
12.5/8	12.5	9.63	330	356	2.87	140.87
12.5/12	12.5	9.17	375	405	3.33	207.42
12.5/15	12.5	8.92	398	430	3.58	247.02
14.0/8	14.0	10.96	350	378	3.04	167.79
14.0/12	14.0	10.60	386	417	3.40	225.85
14.0/15	14.0	10.25	418	452	3.75	285.78
15.5/8	15.5	12.38	360	389	3.12	183.68
15.5/12	15.5	11.92	406	438	3.58	262.23
15.5/15	15.5	11.62	433	468	3.88	318.14
17.0/8	17.0	13.70	380	410	3.30	215.48
17.0/12	17.0	13.25	426	460	3.75	302.52
17.0/15	17.0	12.95	453	489	4.05	363.85
18.5/8	18.5	15.13	390	421	3.37	232.59
18.5/12	18.5	14.68	435	470	3.82	323.91
18.5/15	18.5	14.34	467	504	4.16	399.70
20.0/8	20.0	16.48	405	437	3.52	260.48
20.0/12	20.0	16.09	446	482	3.91	348.16
20.0/15	20.0	15.70	482	521	4.30	439.75
21.5/8	21.5	17.86	420	453	3.64	291.15
21.5/12	21.5	17.41	466	503	4.09	396.37

Pole Designation	Pole length (m)	Height above ground (m)	Ground line diameter (mm) Strength group S1	Ground line diameter (mm) Strength group S2	Minimum embedment depth (see notes)	Design capacity for maximum wind (kNm)
21.5/15	21.5	17.08	497	537	4.42	482.97
23.0/8	23.0	19.23	435	469	3.77	323.91
23.0/12	23.0	18.73	485	524	4.27	448.84
23.0/15	23.0	18.44	512	553	4.56	528.31

Notes:

See Section 10 for limits of installation conditions applicable to the specified minimum embedment depths

Minimum embedment depths are calculated with the ESAA BH Pile program.

Appendix D Embedment depth of timber stay poles

The minimum embedment depths of timber stay poles with normal ground and soil conditions are provided in Table 8.

Table 8 - Embedment depths of timber stay poles with normal ground/soil

Pole Designation	Pole length (m)	Height above ground (m)	Ground line diameter (mm) Strength group S1	Ground line diameter (mm) Strength group S2	Minimum embedment depth (see notes) (m)	Design capacity for maximum wind (kNm)
6G 350	6.0	2.79	326	353	3.21	120.14
6G 400	6.0	2.89	381	412	3.11	125.70
6G 450	6.0	2.97	435	470	3.03	130.24
7.5G 400	7.5	3.96	372	403	3.54	181.60
7.5G 450	7.5	4.06	427	462	3.44	187.56
7.5G 500	7.5	4.15	482	521	3.35	193.09
9G 425	9.0	5.15	394	427	3.85	244.81
9G 475	9.0	5.25	449	486	3.75	251.35
9G 525	9.0	5.34	504	545	3.66	257.39
10.5G 425	10.5	6.30	387	420	4.20	305.94
10.5G 475	10.5	6.41	442	479	4.09	313.66
10.5G 525	10.5	6.51	497	538	3.99	320.87

Notes:

See Section 18.1.1 for limits of installation conditions applicable to the specified minimum embedment depths

Minimum embedment depths are calculated with the ESAA BH Pile program.