ElectraNet

Transmission Line General Requirements Including Typical Overhead Line Structures

Document Number: 1-03-FR-09

VERSON 1.1 July 2024

This functional requirements document is in line with the organisation's:

- **1-03-ACS-01 Transmission Line Conductors**
- **1-03-ACS-02 Transmission Line Insulators**
- **1-03-ACS-03 Transmission Line Earthing.**

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1. Purpose

This document details the general requirements for transmission lines and overhead line supports.

2. Scope

This specification is applicable to the transmission lines connected to ElectraNet's South Australian transmission network.

3. Terms and acronyms and initialisms

3.1 Terms

No.	Term	Definition
1	Armour rod	Is a helical fitting that is fitted to conductors to protect the conductor from damage. Armour rods are intended to be installed suspension points.
2	Clevis	Is a fitting free to rotate around an axis and attached to the steelwork of a support.
3	Conductor	Any bare conductor which is placed above ground, in the open air and is suspended between two or more supports.
4	Dead-end tension joint	Is a joint inserted at the end of a conductor for attachment to an insulator tension set, designed to carry the full current and to provide mechanical termination of the conductor.
5	Earth wire	Earth wire (overhead), is a stranded conductor connected to earth at some, or all supports, which is suspended usually but not necessarily above the line conductors to provide a degree of protection against lightning strikes.
6	Earthing electrode	Is an uninsulated conductor installed vertically that is in contact with the earth (or an intermediate material) intended for the conduction and dissipation of current.
7	Expansion chamber	Is a designated area or section within a transmission cable system where HV power cables can expand and contract with temperature variations, preventing mechanical stress and potential damage.
8	Grazer	Is a software application utilised by ElectraNet that provides a graphical interface to access data from various systems that is related to ElectraNet's transmission and telecommunications network.
9	Horizontal-V	Is a suspension structure insulation configuration that consists of an upper long rod and a lower post insulator that are attached to 2 vertically separated points of a structure extending to a single conductor attachment point, resembling the letter 'V' when viewed horizontally.
10	Joint bay	Is a designated area or section within a transmission cable system where HV power cable joints are housed and managed.
11	Link box	Is an enclosure for the connecting links used for earthing or cross-bonding of the metallic sheaths of high voltage cables.
12	Long rod	Is a rigid insulator intended to be subjected to tensile loads, comprising an insulating part having an approximately circular cylindrical shank, with or without sheds, and external or internal fixing devices attached to each end.

No.	Term	Definition
13	Lug (terminal)	Is a type of terminal used to connect a cable or stranded conductor to other electrical equipment.
14	Mid-span tension joint	Is a joint inserted between two lengths of a conductor to provide electrical and mechanical continuity of the conductor. Mid-span tension joints are installed between supports.
15	OPGW joint box	Is an enclosure that houses OPGW optical fibre splices or terminations.
16	Palm terminal	Is a type of terminal that incorporates a flat 'palm' surface for making connections.
17	PD sensor	Is a specialised device used to detect and measure partial discharge in electrical insulation.
18	Pile foundation	Is a long slender foundation installed without excavation.
19	Pole	Is a type of overhead line support, it consists of a vertical single member support.
20	Post insulator	Is an insulator intended to give rigid support to a live part which is to be insulated from earth or from another live part. *Informative 1: A post insulator may be an assembly of a number of post insulator units.* *Informative 2: Post insulators for substations are also known as station post insulators.*
21	Protective spark gap	Is a surge protective device which consists of an open air-gap between one or more energized electrodes in series, and an electrode connected with earth. *Informative: It is distinguished between:* ▪ *rod spark gap, made of two rods set in line opposite to each other* ▪ *horn spark gap, made of two or more upright vertical rods splaying out at the top to facilitate arc extinction.*
22	Rock anchor	Is a type of foundation where a high-strength steel rod or cable that is inserted into a drilled hole in the rock and anchored with grout or resin.
23	Sag link	Is a link that forms part of a strain insulator assembly, A sag link is adjustable in length.
24	Sealing end	Is a termination providing a seal to the end of the cable from the external environment and maintaining the pressure, if any, of the cable system.
25	Socket clevis	Also known as socket tongue, is a type of clevis that is a component in an insulator set that connects the insulator to the conductor clamp. It consists of a U-shaped clevis with a pin and a socket that fits over the ball end of the insulator.
26	Spacer	Is a device which keeps the sub-conductors of a bundle in a given geometrical configuration.
27	Stayed support	Is a support whose stability is ensured by stays.
28	Stobie pole	Is a type of pole made of 2 steel I-beams, joined by tie-bolts, and held apart by a slab of concrete.
29	Stub (of a support)	Is an element used to connect the leg of a support with the foundation.

No.	Term	Definition
30	Support (structure)	Is the general term for different structure types that support the conductors of overhead lines.
31	Suspension insulator set	Is an assembly of components that forms the attachment point of an energised conductor to a support.
32	Tension insulator set	Is an assembly of components that forms the attachment point of an energised conductor to a tension support.
33	Tension support	Is a support to which the conductors or bundles are attached through tension insulator sets.
34	Terminal support	Is a support designed to terminate the line tension of conductors on one side.
35	Transmission cable	Is an HV power cables used for the transmission or distribution of electrical energy.
36	Tower	Is a type of overhead line support. A tower is a freestanding vertical framework normally made from galvanised steel.
37	Vibration damper	Is a generic term for a device attached to a conductor or an earth wire in order to suppress or minimise vibrations due to wind.

3.2 Acronyms and initialisms

No.	Acronym or initialism	Definition
1	NER	National Electricity Rules, are rules made under the national electricity law and govern the operation of the national electricity market.
2	AAAC	All Aluminium Alloy Conductor, is a is a type of stranded conductor that has a larger mechanical resistance than AAC and better corrosion resistance that ACSR. All the wires are made from aluminium alloy.
3	AAC	All Aluminium Conductor, is a is a type of lightweight, easy to handle stranded cable used for overhead power lines. All the wires are made from aluminium.
4	ACSR	Aluminium Conductor Steel-Reinforced, is a type of high-capacity, high-strength stranded conductor used for overhead power lines. The outer wires are made from aluminium and the inner wires are made from steel.
5	ACSR/AC	Aluminium Conductor Steel-Reinforced/Aluminium Clad, is a type of ACSR where the steel wires have an aluminium coating.
6	ACSR/GZ	Aluminium Conductor Steel-Reinforced/Galvanised, is a type of ACSR where the steel wires are galvanised.
7	ACWM	Aircraft Collision Warning Marker, is a high-visibility marker fitted to overhead lines to increase their visibility for pilots performing low-level aviation.
8	ACWM-B	Aircraft Warning Collision Marker Ball, is a type of Aerial Collision Warning Marker (ACWM) that is fitted to overhead line conductors or earth wire.
9	CMS	Condition Monitoring Sensor, is a sensor that is fitted to provide information that can be used to monitoring a parameter of condition of a piece of equipment.
10	DTS	Distributed Temperature Sensor, is an optoelectronic device which measures temperatures by means of optical fibres functioning as linear sensors.

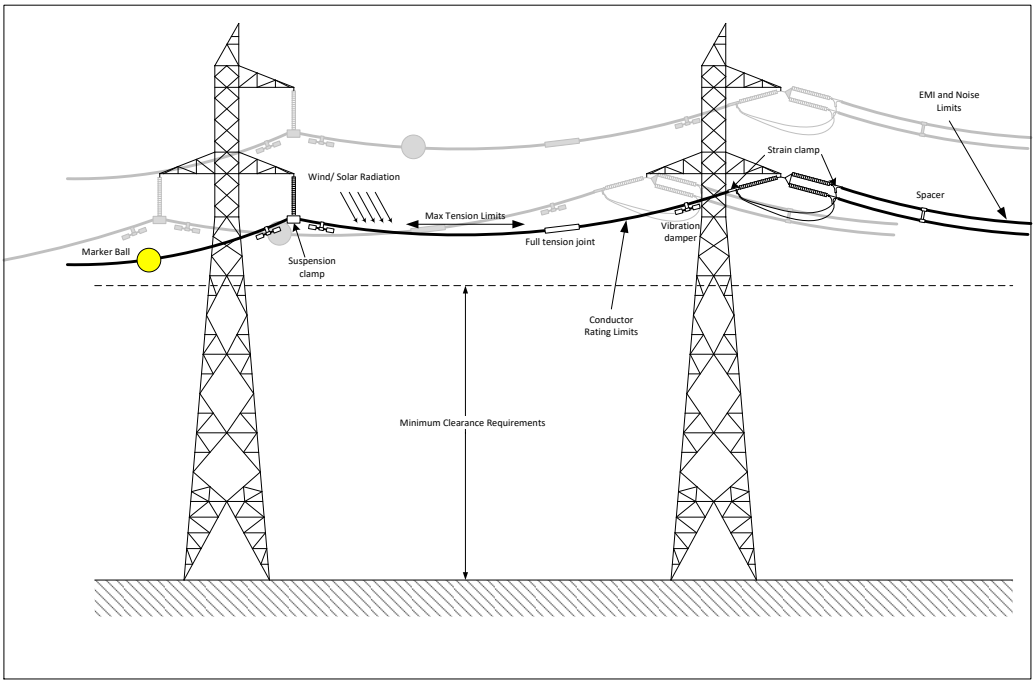
No.	Acronym or initialism	Definition
11	OPGW	Optical Ground Wire, an earth wire containing optical telecommunications fibres.
12	PG clamp	Parallel Groove clamp, is a type of electrical connector used to join 2 parallel conductors. It consists of a metal body with grooves that align the conductors side by side, and bolts or screws to clamp them together.
13	PVC	Polyvinyl Chloride, is a synthetic polymer of plastic. PVC comes is a rigid form or it can be It can be made softer and more flexible by the addition of plasticisers.
14	SC/GZ	Steel Conductor/Galvanised, is a stranded conductor made from galvanised steel wires.

4. Transmission line requirements

4.1 Introduction

The term Transmission Lines broadly refers to overhead transmission lines and underground cables. The key function of a transmission line is to transfer bulk power between generation sources and load centres. ElectraNet owns, manages, and operates transmission lines at 66, 132, 275, 330 kV. Transmission Lines are made up of various components, namely poles, lattice structures, conductors, cables, insulators, foundations, and earthing systems. These components are described in more detail in this document.

Figure 1: Typical transmission line



4.2 Transmission lines components

4.2.1 Transmission line supports

1. The primary functions of transmission line supports are to provide mechanical support to conductors. This is achieved by maintaining mechanical integrity without permanent structural deformation under ultimate load conditions whilst preserving structure geometry to retain operational electrical clearances under prescribed serviceability and ultimate load conditions.
2. Secondary functions of transmission line supports are to:
   a. ensure safety of people and the environment
   b. maintain structure geometry to preserve maintenance-safe approach distances for serviceability and ultimate load conditions
   c. provide an electrical path to earth for fault currents
   d. provide a whole-of-life cost-effective service.
3. Support types include free-standing and guyed:
   a. towers/poles

b. steel tubular poles
c. stobie poles
d. concrete poles.

4. Refer to Appendix C for a diagram of typical overhead transmission line structures.
5. Typical foundations of transmission line structures are:
   a. bored piers
   b. mass concrete
   c. driven/cast in-situ piles
   d. soil/rock anchors
   e. special foundations (e.g. raft foundations).

4.2.2 Transmission line conductors

1. The primary function of transmission line conductor systems is to transfer electrical power between designated locations, within prescribed performance, operating and environmental conditions.
2. Secondary functions of transmission line conductors are to:
   a. maintain electrical safety and minimise adverse effects on the environment
   b. provide a whole-of-life cost-effective service.

4.2.3 Transmission line insulators

1. Transmission line insulation has 2 primary functions:
   a. To insulate energised components from earthed structures at rated operating voltages and specified switching and lightning impulses.
   b. To support the conductor system up to ultimate mechanical load limits and transfer the mechanical loads to structure.
2. Transmission line insulator sets have 4 primary functions:
   a. To support the insulator system up to electrical load limits.
   b. To support the insulator system up to ultimate mechanical load limits.
   c. To provide effective attachment interface between conductor and insulators to securely transfer loads to the structure.
   d. To provide a whole-of-life cost effective service.

4.2.4 Transmission line earthing

1. The primary functional requirement of a transmission line earthing system is to:
   a. provide an electrical path for lightning and fault currents to earth, to ensure safety of people, assets, and the environment.
   b. ensure that faults are cleared within the NER time limits, transmission line components are not damaged, and the network performance (due to lightning) is within agreed NER limits.
   c. provide an earth (i.e. zero) potential reference to ground under normal circuit conditions for the dissipation of leakage currents.

2. Secondary functional requirements of a transmission earthing system for its design life are to:
    a. maintain electrical safety and minimise adverse effects on the environment.
    b. provide an effective technical solution.
    c. provide a whole-of-life cost-effective service.
3. Transmission line earthing relates to:
    a. Aerial earthing – this sub-system includes earth wire and OPGW and its various supporting hardware and fittings (tension insulator sets, suspension insulator sets, protective spark gap insulators, vibration dampers, joints, and ACWM-B).
    b. Ground level earthing – this sub-system includes earthing electrodes, earthing connections, PVC insulated cable, copper strap), lugs, fasteners, and clamps. This earthing sub-system forms a dedicated electrical connection between the structure and the soil surrounding it. This is in addition to the electrical connection provided by the embedded structure/foundation and soil.
    c. Communication hardware – this sub-system includes the interface fibre hardware for OPGW assets. This includes OPGW joint boxes, etc.

4.2.5 Transmission cables

1. The primary functions of transmission cables is to transfer electrical power between designated locations, within prescribed performance, operating and environmental conditions and to insulate energised components from earthed structures at rated operating voltages and specified switching and lightning impulses.
2. Secondary functions of transmission cables are to:
    a. maintain electrical safety and minimise adverse effects on the environment
    b. provide electrical insulation
    c. provide a whole-of-life cost-effective service.
3. Transmission cable components are:
    a. cable and accessories including joints, sealing ends, link boxes, PD sensors
    b. CMS/DTS
    c. cable trench, joint bays, link box equipment pits, support structures, expansion chambers.

City West Substation

Appendices

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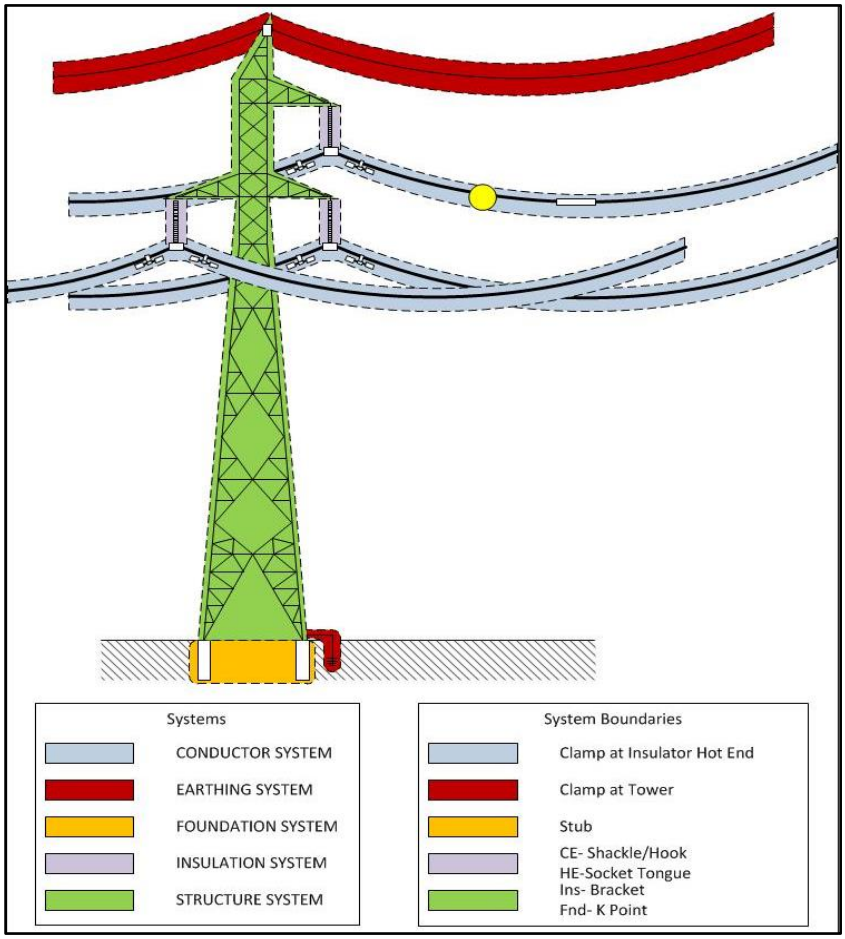
Appendix A System boundaries

A.1. General system boundary

The system boundary is depicted in Figure 2.

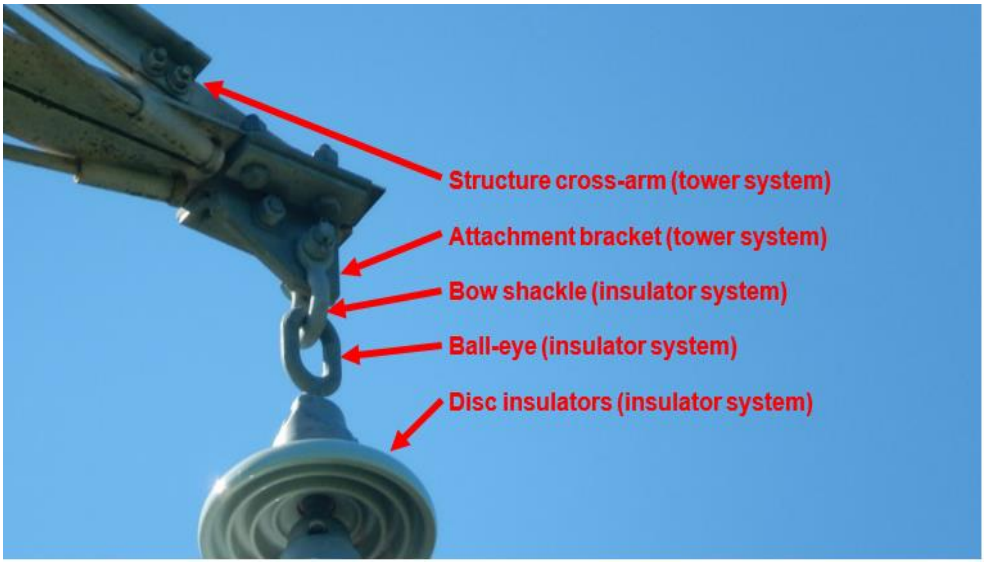
Figure 2: Transmission lines functional systems



A.2. Structure insulator and earthing system boundary

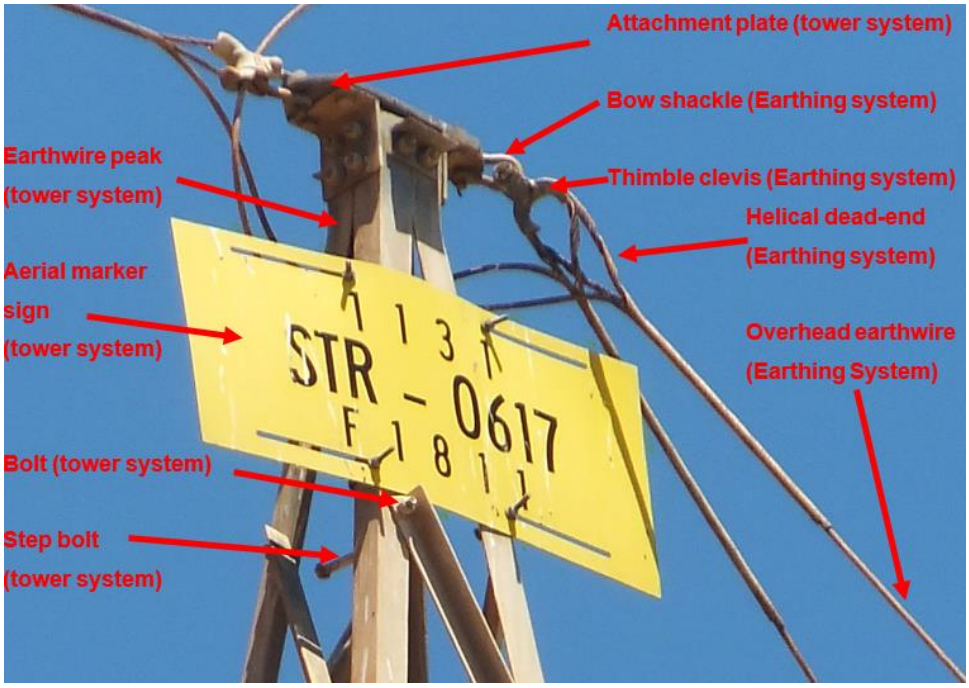
1. The structure and insulator systems boundary is defined as the attachment bracket/plate intrinsically connected to the structure (i.e. welded or bolted connection). See Figure 3.

Figure 3: Structure system boundaries with insulator systems



2. The structure and aerial earthing systems boundary is defined as the attachment bracket/plate intrinsically connected to the structure (i.e. welded or bolted connection) shown in Figure 4.
3. The structure/earthing system boundary at ground level is the connecting bolt fastening the earth bond lead to the structure.

Figure 4: Structure system boundaries with aerial earthing systems



A.3. Structure/Foundation System Boundary

1. The structure and foundation system boundaries are:
    a. free-standing lattice support: stub connection
    b. stayed support: base-plate and stay assembly attachment to connecting eye of the buried anchor tie rod
    c. pole with base-plate and anchor-bolt connection: base-plate
    d. embedded pole: pole member contained within footing.
2. Transmission line support structure sub-elements comprise of:
    a. structural members – includes primary members such as tower/pole leg and bracing sections, steel tube pole section, stobie pole composite material sections (steel/concrete) or reinforced concrete pole sections.
    b. fasteners – includes plates, bolts, nuts and washers.
    c. stay arrangements – includes stay wires and associated fittings.
    d. auxiliary members – includes anti climbing device, fall arrest system, climbing aids and structure ID and danger warning plate signage.
3. The foundation system is comprised of 2 sub-elements:
    a. Structural footing sub-element that transfer load actions to the geotechnical foundation sub-element. Components comprise reinforced concrete footings, steel/concrete or other pile types, rock/soil anchors, and include structure/footing interface components (lattice tower stubs, anchor bolts and related plates, nuts and washers).
    b. Geotechnical foundation sub-element consists of the soil/rock medium (including engineered backfill) that interact with the ‘footing’ to resist load actions.

Appendix B Transmission lines functional locations

Table 1: Conductor system

Location	All ElectraNet owned transmission feeders
Asset	Transmission lines Conductors: 1. ACSR/AC or ACSR/GZ 2. AAAC 3. AAC. Transmission lines conductor hardware and attachments: 1. armour rods 2. vibration dampers 3. spacers 4. ACWMs 5. mid-span tension joint 6. suspension insulator sets. Full tension conductor attachments: 1. bolted 2. bolted dead-end tension joint 3. compression dead-end tension joint. Non-tension conductor attachments: 1. palm terminals 2. lugs 3. PG clamps.
Exclusion	1. Earth wire/OPGW and attachment fittings 2. Insulators and insulator fittings 3. Hardware.

Table 2: Insulation system

Location	All ElectraNet owned transmission feeders
Asset	Transmission lines Insulators by function and attachment type: 1. suspension insulator set 2. tension insulator set 3. post. Transmission lines Insulators by materials and make: 1. porcelain disc insulators 2. glass disc insulators 3. porcelain long rod and post insulators 4. non ceramic long rod and post insulators including horizontal-v. Hardware/attachment for insulators: 1. hooks 2. shackles 3. sag links 4. clevis/socket clevis 5. sockets/tongues/socket tongues.
Exclusion	Conductors and attachments on them.

Table 3: Earthing system

Item	Requirement
Component	1. Bare conductor for earth wire applications (ACSR/GZ, SC/GZ, or OPGW) 2. Full tension earth wire/OPGW attachment components 3. Non-tension earth wire/OPGW attachment components 4. Conductor hardware 5. Earthing connections 6. Earthing components 7. Embedded foundation.
Exclusion	Communication hardware.

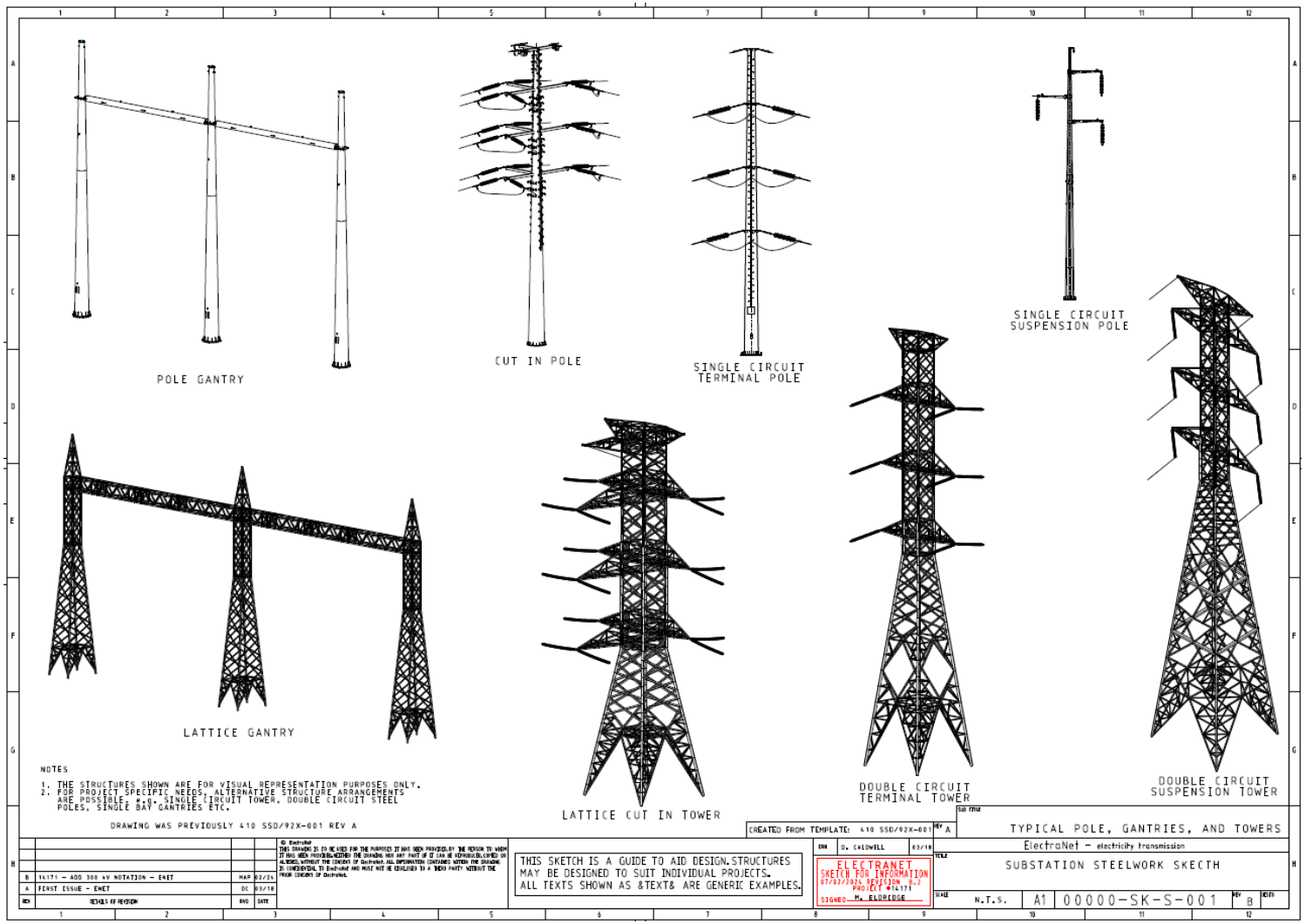
Table 4: Structure location classifications for earthing

Item	Requirement
Environment area A	Structures located in built up areas or any locations where the public, including unsupervised children, may be present. This includes structures in the following locations: 1. land allocated for educational use 2. land allocated for recreational use 3. in a public thoroughfare (declared road, walkway, track) within 100 m of any of the above-named locations 4. public lands within a city or town e.g. road reserves, green belts, or other easy access areas 5. within private property where a residence or recreational area is within 100 m of the structure 6. where there is evidence of persons frequenting the area or evidence that a structure is being, or has been climbed by unauthorised persons 7. Torrens Island except for structures located in substations or switchyards 8. Northern Power Station and the surrounding areas north and east of the power station where there is easy access by the public 9. the environment area for each structure is shown in the line schedules which are accessed via Grazer.
Environment area B	1. Structures which are located within 5 km of a town and within 100 m of a road, public thoroughfare (declared road, walkway, track) or private access track to a private residence. 2. The environment area for each structure is shown in the Line Schedules which are accessed via Grazer.
Environment area C	1. Transmission line structures located inside substations or in areas not defined in Areas A and B above. 2. The Environment Area for each structure is shown in the line schedules which are accessed via Grazer.

Appendix C Typical overhead structures

1. Figure 5 illustrates the typical structures used in overhead line design.
2. Structures must be designed in accordance with AS/NZS 7000.

Figure 5: Typical overhead line structures



References

Standards

No.	Name	Title
1	AS/NZS 7000	Overhead Line Design

ElectraNet documents

No.	Name	Title
1	1-03-ACS-01	Transmission Line Conductors Asset Class Strategy
2	1-03-ACS-02	Transmission Lines Insulators Asset Class Strategy
3	1-03-ACS-03	Transmission Line Earthing Asset Class Strategy

ElectraNet drawings

No.	Name	Rev	Title	Subtitle
1	00000-SK-S-001	B	SUBSTATION STEELWORK SKETCH	TYPICAL POLE, GANTRIES, AND TOWERS

ElectraNet