OVERHEAD DISTRIBUTION LINE DESIGN MANUAL

THIS DOCUMENT PROVIDES GUIDELINES ON THE MINIMUM REQUIREMENTS FOR DESIGN OF EVOENERGY OVERHEAD DISTRIBUTION LINES (11KV, 22KV AND 400V)

This Design Manual sets out the requirements and must be applied to the design of an overhead distribution line in the ACT. It relates to the information necessary to assess various aspects of the development and its suitability for connection to Evoenergy's electricity system.

CONTENTS

1. SCOPE AND PURPOSE

1.1 Scope

The scope of this document is to provide guidelines on the minimum requirements for design of Evoenergy overhead distribution lines (11kV, 22kV and 400V). Content of this document is based on AS/NZS 7000 and SA/SNZ HB331, which is a handbook to provide guidance for the application of AS7000.

This document covers the following aspects:

- Design criteria for overhead lines
- Standard construction practices
- Application of Australian standards and guidelines.

As design calculations will primarily be performed using software, the manual will provide guidance for setting input parameters on software for line design, rather than detail by-hand calculations. However, this document is a comprehensive design manual providing all necessary design data, requirements, worked examples and engineering notes.

This manual provides the standard approach to overhead line design for the Evoenergy distribution network. If the standard design guidelines are not suitable for any situation, the designers may choose to depart from these standard design guidelines and develop a solution based on appropriate engineering analysis. Approval by the Asset Owner is required for departures from this overhead design manual.

For switching requirements and design, the designer should consult with the Overhead Asset Manager, System Control Manager and Asset Planning section for guidance on network requirement before making a decision.

The strict application and compliance of AS/NZS 7000 to the overhead network is limited to new overhead lines and existing assets that require life extension or maintenance tasks to be conducted.

1.2 Purpose

The guideline is intended to:

- Promote standardisation and a uniform design philosophy.
- Be practical and ensure earthing is cost effective to design, install, supervise and maintain.
- Provide a convenient reference for design parameters, standards, and policy.
- Support designers with limited 'first-principles' line engineering expertise.
- Support training of new designers (not as complete training material, but as an underpinning reference).
- Support any future auditing of designs submitted by external design consultants.

1.3 Software

It is recommended to use the latest version of the Poles & Wires software for distribution line design.

2. REFERENCES AND STANDARDS

2.1 Australian Standards

DOCUMENT NUMBER	DOCUMENT TITLE
AS 1154.1	Insulator and conductor fittings for overhead power line
AS 1154.2	Insulator And Conductor Fittings for Overhead Power Lines - Dimensions
AS 1154.3	Insulator And Conductor Fittings for Overhead Power Lines - Performance and General Requirements for Helical Fittings
AS 1726 – 1993	Geotechnical site investigations
AS 2067	Substations and High Voltage Installations Exceeding 1 KV A.C.
AS 2947-2009	Crossing of waterways by electricity infrastructure.
AS 3609	Insulators - Porcelain Stay Type - Voltages Greater Than 1000 V AC
AS 3891.1-2008	Air navigation - Cables and their supporting structures - Marking and safety requirements - Permanent marking of overhead cables and their supporting structures for other than planned low-level flying
AS 3891.2-2008	Air navigation - Cables and their supporting structures - Marking and safety requirements - Marking of overhead cables for planned low-level flying operations.
AS 62217	Polymeric Insulators for Indoor and Outdoor Use with A Nominal Voltage > 1000 V - General Definitions, Test Methods and Acceptance Criteria
AS 62271	High-voltage switchgear and control gear
AS/NZS 2947.2	Insulators - Porcelain and Glass for Overhead Power Lines - Voltages Greater Than 1000 V AC. - Characteristics
AS/NZS 7000	Overhead Line Design
SA/SNZ HB331	Overhead Line Design handbook

2.2 Acts, Codes of Practice, and other documents

DOCUMENT OWNER	DOCUMENT TITLE
Work Health and Safety Act 2011 (ACT)	Section 22 - Duties of persons conducting businesses or undertakings that design plant, substances or structures
Work Health and Safety Regulation 2011 (ACT)	Part 4.1 Noise - Section 59 Duties of designers, manufacturers, importers and suppliers of plant; and Part 4.2 Hazardous manual tasks – Section 61 Duties of designers, manufacturers, importers and suppliers of plant or structures
ACT Work Health and Safety	Safe Design of Structures Code of Practice
National Construction Code	National Construction Code Volume One
National Construction Code	National Construction Code Volume two
Transport Canberra and City Services	Standard Specification for Urban Infrastructure Works

ESAA	NENS 04 – 2003National guidelines for safe approach distances to electrical and mechanical apparatus
ACT Government	Design Standards for Urban Infrastructure Series
ACT Government	SL2001-28, Utility Networks (Public Safety) Regulation 2001
ACT Government	A2000-65, Utilities Act 2000

2.3 Evoenergy documents

DOCUMENT NUMBER	DOCUMENT TITLE
PO07201	Chamber Type Substation Design and Construction Standard
PO07395	Technical Specification - Cables and Conductors
PO07127	Distribution Earthing Design and Construction Manual
PO07173	Evoenergy Distribution Service and Installation Rules
PO07454	Electrical Data Manual
PO07110	A Guide to Development of Network Design & Documentation
PO070523	Standard Supply Voltage for LV System
PO07106	Technical Specification - Composite Power Pole
PO07451	Technical Specification - Pole Mounted Transformers
PO06103	Manage Environmental Interactions

2.4 Evoenergy drawings index

Following is a list of important Current Standard Construction Drawings and Electrical Drawings.

- Drawing numerical series: Electrical/ Cad drawings
- Drawing D104 series: OH Parts including poles
- Drawing D201 series: OH HV Complete Assemblies
- Drawing D202 series: OH LV Complete Assemblies
- Drawing D203 series: OH Pole Substation Complete Assemblies
- Drawing D204 series: OH Conductors and Accessories including Sub and Interface Assemblies
- Drawing D30x series: UG/OH Underground/Overhead HV and LV Assemblies

NO.	DRAWING NUMBER	TITLE
		DRAWING NUMERICAL SERIES: ELECTRICAL/ CAD DRAWINGS
1.	3810-001	CRITERIA FOR THE USE OF SPIRAL VIBRATION DAMPERS
2.	3811-004	MINIMUM CLEARANCES INSULATED & BARE OVERHEAD CONDUCTORS
3.	3811-014	VEGETATION CLEARANCE REQUIREMENTS FOR EVOENERGY ZONE SUBSTATIONS IN ACT AND NSW
4.	3811-015	VEGETATION CLEARANCE REQUIREMENTS FOR EVOENERGY GROUND ASSETS IN ACT AND NSW
5.	3811-016	VEGETATION CLEARANCE REQUIREMENTS FOR EVOENERGY HIGH VOLTAGE UNDERGROUND AND OVERHEAD NETWORK ASSETS IN ACT
6.	3811-017	VEGETATION CLEARANCE REQUIREMENTS FOR EVOENERGY LOW VOLTAGE UNDERGROUND AND OVERHEAD NETWORK ASSETS IN ACT

NO.	DRAWING NUMBER	TITLE
7.	3811-018	VEGETATION CLEARANCE REQUIREMENTS FOR UG & OH TRANSMISSION LINE ASSETS IN ACT
8.	3811-019	FALL IN HAZARDOUS VEGETATION IN ACT & NSW
9.	3811-020	VEGETATION CLEARANCE REQUIREMENTS FOR EVOENERGY HIGH VOLTAGE UG & OH NETWORK ASSETS IN NSW
10.	3811-021	VEGETATION CLEARANCE REQUIREMENTS FOR EVOENERGY LOW VOLTAGE UG & OH NETWORK ASSETS IN NSW
11.	3812-001	CRITERIA FOR THE USE OF LV SPREADERS
12.	3832-018	SEPARATION AND COVER REQUIREMENTS FOR CABLES AND PLANT
13.	3832-020	CLEARANCE REQUIREMENT FOR SWIMMING POOL FROM ELECTRICAL INFRASTRUCTURE
14.	390-017	LINE CONFIGURATION NAMING STANDARD
15.	390-018	CLEARANCE REQUIREMENTS BETWEEN ACTEWAGL INFRASTRUCTURE AND TELECOMMUNICATION CARRIERS CABLE INSTALLATION
16.	390-022	THIRD PARTY MICROCELL AND ANTENNA REQUIREMENTS RADIO FREQUENCY HAZARDS MINIMUM CLEARANCE TO GROUND
17.	390-023	THIRD PARTY MICROCELL AND ANTENNA REQUIREMENTS BARE OVERHEAD MAINS MINIMUM CLEARANCE REQUIREMENTS
18.	390-024	THIRD PARTY MICROCELL AND ANTENNA REQUIREMENTS LV ABC CONSTRUCTION REQUIRED MINIMUM CLEARANCES
19.	390-025	THIRD PARTY MICROCELL AND ANTENNA REQUIREMENTS ISOLATION SWITCH MOUNTING CONSIDERATIONS FIXED TO EVOENERGY STRUCTURES
20.	192-43-45	17m, 18.5m, 20m 21.4m INTERMEDIATE REINFORCED SPUN CONCRETE POLE FOR SINGLE CONDUCTOR LINES CASTING REQUIREMENTS
21.	391-740-06	SPACER PLATES FOR 22kv LINE POST INSULATORS
22.	391-740-16	CASTING REQUIREMENTS 12.5m 8kN TYPE 1 THREE PIECE COMPOSITE FIBRE POLE HIGH VOLTAGE
23.	391-743-05	SPUN REINFORCED / STRESSED CONCRETE POLE EARTHING DETAILS
24.	392-36-01	HAND TIE DETAILS FOR HV OVERHEAD CONDUCTORS
25.	392-36-02	HIGH VOLTAGE OVERHEAD CONDUCTOR TOP TIE APPLICATION
26.	392-36-04	HAND TIE DETAILS FOR LV OVERHEAD CONDUCTORS AND HV OVERHEAD BRIDGING CONDUCTORS
27.	392-41-050	INTELLIRUPTER TRIAL POLE CASTING DETAILS
28.	392-41-051	INTELLIRUPTER TRIAL INFIELD INSTALLATION BILL OF MATERIALS
29.	392-41-20	AIR NAVIGATION OVERCROSSING MARKER ASSEMBLY
30.	392-41-36	11/22kV COMPOSITE FIBRE CROSSARM ASSEMBLIES FOR CONCRETE POLES
31.	392-41-40	22kV OVERHEAD INSULATOR ASSEMBLY DETAILS INLINE INSULATOR ASSEMBLIES FOR CROSSARM APPLICATIONS
32.	392-41-41	22kV OVERHEAD INSULATOR ASSEMBLY DETAILS STRAIN INSULATOR ASSEMBLIES FOR CROSSARM APPLICATIONS
33.	392-41-42	22kV OVERHEAD INSULATOR ASSEMBLY DETAILS INLINE INSULATOR ASSEMBLIES FOR POLE TOP APPLICATIONS
34.	392-41-43	22kV OVERHEAD INSULATOR ASSEMBLY DETAILS STRAIN INSULATOR ASSEMBLIES FOR CONCRETE POLE TOP APPLICATIONS
35.	392-41-44	22kV OVERHEAD INSULATOR ASSEMBLY DETAILS STRAIN/PIN INSULATOR ASSEMBLIES FOR WOOD POLE TOP APPLICATIONS

NO.	DRAWING NUMBER	TITLE
36.	392-41-45	22kV OVERHEAD INSULATOR ASSEMBLY DETAILS STRAIN INSULATOR ASSEMBLIES FOR WOOD POLE TOP APPLICATIONS
37.	392-41-47	2 UNIT 11kV POLE MOUNTED REGULATOR WITH POLE MOUNTED CONTROL CONSTRUCTION DETAIL
38.	392-43-06	PLANT POSITIONING GUIDELINES POLE TOP CONSTRUCTION
39.	392-43-07	MINIMUM BRIDGING SEPARATIONS POLE TOP CONSTRUCTION
40.	393-002	STANDARD ALIGNMENTS AND RESERVATIONS OVERHEAD MAINS
		DRAWING D104 SERIES: OH PARTS
41.	D104-0001	PARTS, OH INFRASTRUCTURE, POLE, 9.5m, 8/16kN, TYPE 1, REINFORCED CONCRETE
42.	D104-0002	PARTS, OH INFRASTRUCTURE, POLE, 11m, 8/16kN, TYPE 1, REINFORCED CONCRETE
43.	D104-0023	PARTS, OH INFRASTRUCTURE, POLE, 9.5m, 8/32kN, TYPE 1B, FIBRE REINFORCED POLYMER, COMPOSITE, TWO PIECE, UTILITY POLE
44.	D104-0101	PARTS, OH INFRASTRUCTURE, POLE, 12.5m, 8/16kN, TYPE 3, REINFORCED CONCRETE
45.	D104-0128	PARTS, OH INFRASTRUCTURE, POLE, 12.5m, 8/16kN, TYPE 4, REINFORCED CONCRETE
46.	D104-0134	PARTS, OH INFRASTRUCTURE POLE, 9.5m, 12/24kN, TYPE 1, REINFORCED CONCRETE
47.	D104-0136	PARTS, OH INFRASTRUCTURE, POLE, 12.5m, 12/24kN, TYPE 4, REINFORCED CONCRETE
48.	D104-0137	PARTS, OH INFRASTRUCTURE, POLE, 14m, 8/16kN, TYPE 4S, REINFORCED CONCRETE
49.	D104-0138	PARTS, OH INFRASTRUCTURE, POLE, 15.5m, 8/16kN, TYPE 4S, REINFORCED CONCRETE
50.	D104-0143	PARTS, OH INFRASTRUCTURE, POLE, 12.5m, 8/16kN, TYPE 3C, FIBRE REINFORCED CEMENT
51.	D104-0144	PARTS, OH INFRASTRUCTURE, POLE, 12.5m, 8/16kN, TYPE 4C, FIBRE REINFORCED CEMENT
		DRAWING D201 SERIES: OH HV COMPLETE ASSEMBLIES
52.	D201-0021	OVERHEAD, HIGH VOLTAGE, CA, SWITCHING, 11kV GAS SWITCH, DOUBLE STRAIN ON A 12.5m CONCRETE POLE
53.	D201-0026	OVERHEAD, HIGH VOLTAGE, CA, POLES, 11kV INLINE ON A 12.5m CONCRETE POLE
54.	D201-0027	OVERHEAD, HIGH VOLTAGE, CA, POLES, 11kV DOUBLE STRAIN ON A 12.5m CONCRETE POLE
55.	D201-0028	OVERHEAD, HIGH VOLTAGE, CA, POLES, 11kV TERMINATION ON A 12.5m CONCRETE POLE
56.	D201-0029	OVERHEAD, HIGH VOLTAGE, CA, POLES, 11kV DOUBLE TERMINATION ON A 12.5m CONCRETE POLE
57.	D201-0030	OVERHEAD, HIGH VOLTAGE, CA, POLES, 11kV INLINE-TERMINATION ON A 12.5m CONCRETE POLE
58.	D201-0031	OVERHEAD, HIGH VOLTAGE, CA, POLES, 11kV DOUBLE STRAIN - TERMINATION ON A 12.5m CONCRETE POLE
59.	D201-0032	OVERHEAD, HIGH VOLTAGE, CA, POLES, 11kV INLINE, 1ph FUSED TERMINATION ON A 12.5m CONCRETE POLE
60.	D201-0033	OVERHEAD, HIGH VOLTAGE, CA, POLES, 11kV INLINE, 3ph FUSED TERMINATION ON A 12.5m CONCRETE POLE
61.	D201-0035	OVERHEAD, HIGH VOLTAGE, CA, SWITCHING, 11kV AIR BREAK SWITCH ON A 12.5m CONCRETE POLE
62.	D201-0040	OVERHEAD, HIGH VOLTAGE, CA, SWITCHING, 11kV RECLOSER WITHOUT INLINE ISOLATING LINKS, ON A 12.5m CONCRETE POLE - SHEET 1/2

NO.	DRAWING NUMBER	TITLE
63.	D201-0041	OVERHEAD, HIGH VOLTAGE, CA, SWITCHING, 11kV RECLOSER WITHOUT INLINE ISOLATING LINKS, ON A 12.5m CONCRETE POLE - SHEET 2/2
64.	D201-0042	OVERHEAD, HIGH VOLTAGE, CA, SWITCHING, 11kV RECLOSER WITH INLINE ISOLATING LINKS, ON A 12.5m CONCRETE POLE- SHEET 1/2
65.	D201-0043	OVERHEAD, HIGH VOLTAGE, CA, SWITCHING, 11kV RECLOSER WITH INLINE ISOLATING LINKS, ON A 12.5m CONCRETE POLE- SHEET 2/2
66.	D201-0054	OVERHEAD, HIGH VOLTAGE, CA, SWITCHING, 11kV AIR BREAK SWITCH ON A 12.5m FIBRE REINFORCED CEMENT POLE
		DRAWING D202 SERIES: OH LV COMPLETE ASSEMBLIES
67.	D202-0023	OVERHEAD, LOW VOLTAGE, CA, BARE OPEN, INLINE - 9.5m COMPOSITE POLES
68.	D202-0024	OVERHEAD, LOW VOLTAGE, CA, BARE OPEN, LV INLINE - CONCRETE POLE
69.	D202-0025	OVERHEAD, LOW VOLTAGE, CA, BARE OPEN, LV DOUBLE STRAIN - 9.5m COMPOSITE POLES
70.	D202-0026	OVERHEAD, LOW VOLTAGE, CA, BARE OPEN, LV DOUBLE STRAIN - CONCRETE POLE
71.	D202-0027	OVERHEAD, LOW VOLTAGE, CA, BARE OPEN, LV TERMINATION - 9.5m COMPOSITE POLE
72.	D202-0028	OVERHEAD, LOW VOLTAGE, CA, BARE OPEN, LV TERMINATION - CONCRETE POLE
73.	D202-0029	OVERHEAD, LOW VOLTAGE, CA, BARE OPEN, LV DOUBLE TERMINATION - 9.5m COMPOSITE POLE
74.	D202-0030	OVERHEAD, LOW VOLTAGE, CA, BARE OPEN, LV DOUBLE TERMINATION - CONCRETE POLE
75.	D202-0031	OVERHEAD, LOW VOLTAGE, CA, BARE OPEN, INLINE TERMINATION - COMPOSITE POLES
76.	D202-0032	OVERHEAD, LOW VOLTAGE, CA, BARE OPEN, INLINE TERMINATION - CONCRETE POLE
77.	D202-0033	OVERHEAD, LOW VOLTAGE, CA, BARE OPEN, DOUBLE STRAIN WITH LINKS - COMPOSITE POLES
78.	D202-0034	OVERHEAD, LOW VOLTAGE, CA, BARE OPEN, LV DOUBLE STRAIN WITH LINKS - CONCRETE POLE
79.	D202-0036	OVERHEAD, LOW VOLTAGE, CA, AERIAL BUNDLED CABLE, LVABC INLINE - CONCRETE POLE
80.	D202-0037	OVERHEAD, LOW VOLTAGE, CA, AERIAL BUNDLED CABLE, LVABC INLINE ON A 9.5m COMPOSITE POLE
81.	D202-0038	OVERHEAD, LOW VOLTAGE, CA, AERIAL BUNDLED CABLE, LVABC ANGLE - CONCRETE POLE
82.	D202-0039	OVERHEAD, LOW VOLTAGE, CA, AERIAL BUNDLED CABLE, LVABC ANGLE 9.5m COMPOSITE POLE
83.	D202-0040	OVERHEAD, LOW VOLTAGE, CA, AERIAL BUNDLED CABLE, LVABC DOUBLE TERMINATION - CONCRETE POLE
84.	D202-0041	OVERHEAD, LOW VOLTAGE, CA, AERIAL BUNDLED CABLE, LVABC DOUBLE TERMINATION ON A 9.5m COMPOSITE POLE
85.	D202-0042	OVERHEAD, LOW VOLTAGE, CA, AERIAL BUNDLED CABLE, LVABC DOUBLE STRAIN - CONCRETE POLE
86.	D202-0043	OVERHEAD, LOW VOLTAGE, CA, AERIAL BUNDLED CABLE, LVABC DOUBLE STRAIN ON A 9.5m COMPOSITE POLE
87.	D202-0044	OVERHEAD, LOW VOLTAGE, CA, AERIAL BUNDLED CABLE, LVABC TERMINATION - CONCRETE POLE
88.	D202-0045	OVERHEAD, LOW VOLTAGE, CA, AERIAL BUNDLED CABLE, LVABC TERMINATION ON A 9.5m COMPOSITE POLE

NO.	DRAWING NUMBER	TITLE
89.	D202-0046	OVERHEAD, LOW VOLTAGE, CA, AERIAL BUNDLED CABLE, LVABC INLINE-TERMINATION - CONCRETE POLE
90.	D202-0047	OVERHEAD, LOW VOLTAGE, CA, AERIAL BUNDLED CABLE, LVABC INLINE-TERMINATION ON A 9.5m COMPOSITE POLE
91.	D202-0048	OVERHEAD, LOW VOLTAGE, CA, AERIAL BUNDLED CABLE, LVABC LINK - CONCRETE POLE
92.	D202-0049	OVERHEAD, LOW VOLTAGE, CA, AERIAL BUNDLED CABLE, LVABC LINK ON A 9.5m COMPOSITE POLE
		DRAWING D203 SERIES: OH POLE SUBSTATION COMPLETE ASSEMBLIES
93.	D203-0001	OVERHEAD, POLE SUBSTATION, CA, 25kVA1ph POLE MOUNTED TRANSFORMER ON A 12.5m CONCRETE POLE
94.	D203-0002	OVERHEAD, POLE SUBSTATION, CA, 100-500kVA 3ph POLE MOUNTED TRANSFORMERS ON A 12.5m POLE
95.	D203-0020	OVERHEAD, POLE SUBSTATION, CA, 25kVA 3ph POLE MOUNTED TRANSFORMER, ON A 12.5m CONCRETE POLE
		DRAWING D204 SERIES: OH CONDUCTORS AND ACCESSORIES INCLUDING SUB AND INTERFACE ASSEMBLIES
96.	D199-0003	PARTS, INTERFACES IA, STEEL REINFORCED CONCRETE (CONDUCTIVE) POLES
97.	D199-0012	UNDERGROUND, HV, IA, TERMINATIONS, 11kV UNDERGROUND/OVERHEAD (UG/OH) TERMINATION
98.	D199-0025	OVERHEAD INTERFACES, IA, 11kV STANDARD POLE MOUNT DISTRIBUTION TRANSFORMER, FROM AUGUST 2023
99.	D199-0026	OVERHEAD, HIGH VOLTAGE, IA, POLE BANDS TO SUIT, 11kV AIR BREAK SWITCH ACTUATOR
100.	D199-0027	PARTS, INTERFACES IA, FIBRE REINFORCED CEMENT & POLYMER (NON CONDUCTIVE) POLES
101.	D199-0029	OVERHEAD INTERFACES IA, 22kV STANDARD POLE MOUNT DISTRIBUTION TRANSFORMER FROM AUGUST 2023
102.	D204-0001	OVERHEAD, CONDUCTORS AND ACCESSORIES, IA, CONDUCTOR FITTINGS, DEAD ENDS, SPLICES, ARMOR RODS, TIES, SVDS, GUY LOKS, CLEVIS THIMBLES & SPREADER RODS
103.	D204-0002	OVERHEAD, CONDUCTORS AND ACCESSORIES, IA, CONNECTORS AND BRIDGING
104.	D204-0003	OVERHEAD, CONDUCTORS AND ACCESSORIES, SA, NEUTRAL BONDING, CONCRETE POLE NEUTRAL BONDING
105.	D204-0004	OVERHEAD, CONDUCTORS AND ACCESSORIES, SA, EARTHING, EARTH STAKE FOR A CONCRETE POLE
106.	D204-0006	OVERHEAD, CONDUCTORS AND ACCESSORIES, SA, EARTHING, HV DEEP EARTH ELECTRODE FOR A CONCRETE POLE
107.	D204-0007	OVERHEAD, CONDUCTORS AND ACCESSORIES, SA, EARTHING, ADDITIONAL HV DEEP EARTH ELECTRODE FOR A CONCRETE POLE
108.	D204-0008	OVERHEAD, CONDUCTORS AND ACCESSORIES, SA, STAYS, STANDARD STAY ON A CONCRETE OR COMPOSITE POLE (19/2.75 SC)
109.	D204-0009	OVERHEAD, CONDUCTORS AND ACCESSORIES, SA, STAYS, PLATIPUS STAY ON A CONCRETE OR COMPOSITE POLE (7/3.25 SC)
110.	D204-0010	OVERHEAD, CONDUCTORS AND ACCESSORIES, SA, STAYS, AERIAL STAY ON CONCRETE OR COMPOSITE POLE (19/2.75 SC)
111.	D204-0011	OVERHEAD, CONDUCTORS AND ACCESSORIES, SA, STAYS, SIDEWALK STAY ON A CONCRETE OR COMPOSITE POLE (7/3.25 SC)

NO.	DRAWING NUMBER	TITLE
112.	D204-0012	OVERHEAD, CONDUCTORS AND ACCESSORIES, SA, EARTHING, HV AND LV DEEP EARTH ELECTRODES, FOR A POLE SUBSTATION ON A CONCRETE POLE
113.	D204-0013	OVERHEAD, CONDUCTORS AND ACCESSORIES, SA, STAYS, SIDEWALK STAY ON A CONCRETE OR COMPOSITE POLE (19/2.75 SC)
114.	D204-0014	OVERHEAD, CONDUCTORS AND ACCESSORIES, SA, POLE FOUNDATION, CONCRETE, CEMENT POLES
115.	D204-0017	OVERHEAD, CONDUCTORS AND ACCESSORIES, SA, POLE FOUNDATION, 9.5m COMPOSITE POLES
116.	D204-0018	OVERHEAD, CONDUCTORS AND ACCESSORIES, IA, BAND SELECTION TYPE
117.	D204-0020	OVERHEAD, CONDUCTORS AND ACCESSORIES, IA, 11kV STANDARD POLE MOUNT DISTRIBUTION TRANSFORMER, FROM NOVEMBER 2016
118.	D204-0029	OVERHEAD, CONDUCTORS AND ACCESSORIES, SA, EARTHING, BURIED GRADING RING FOR CONDUCTIVE POLE
119.	D204-0030	OVERHEAD, CONDUCTORS AND ACCESSORIES, SA, BUCKLE, STRAP AND PLATE, CABLE MOUNTING ASSEMBLY
120.	D204-0031	OVERHEAD, CONDUCTORS AND ACCESSORIES, SA, STAYS, STANDARD STAY ON A CONCRETE OR COMPOSITE POLE (M12 GALV STEEL ROPE)
121.	D204-0032	OVERHEAD, CONDUCTORS AND ACCESSORIES, SA, STAYS, AERIAL STAY ON CONCRETE OR COMPOSITE POLE (M12 GALV STEEL ROPE)
122.	D204-0033	OVERHEAD, CONDUCTORS AND ACCESSORIES, SA, STAYS, SIDEWALK STAY ON A CONCRETE OR COMPOSITE POLE PLATIPUS FOOTING, (M12 GALV STEEL ROPE)
123.	D204-0034	OVERHEAD, CONDUCTORS AND ACCESSORIES, SA, STAYS, PLATIPUS STAY ON A CONCRETE OR COMPOSITE POLE (M12 GALV STEEL ROPE)
124.	D204-0035	OVERHEAD, CONDUCTORS AND ACCESSORIES, SA, STAYS, SIDEWALK STAY ON A CONCRETE OR COMPOSITE POLE BORED FOOTING, (M12 GALV STEEL ROPE)
		DRAWING D30X SERIES: UNDERGROUND/OVERHEAD
125.	D301-0003	UNDERGROUND, HIGH VOLTAGE, SA, UG/OH, 11kV CABLE UG/OH WITH SURGE DIVERTERS
126.	D301-0004	UNDERGROUND, HIGH VOLTAGE, SA, UG/OH, HARD BOLTED 11kV UG/OH ON A 12.5m CONCRETE POLE
127.	D301-0005	UNDERGROUND, HIGH VOLTAGE, SA, UG/OH, 11kV OH/UG WITH GAS SWITCH ON A 12.5m CONCRETE POLE
128.	D301-0011	UNDERGROUND, HIGH VOLTAGE, SA, UG/OH, 11kV CABLE UG/OH WITH SURGE DIVERTERS ON A 12.5m FIBRE CEMENT POLE
129.	D301-0012	UNDERGROUND, HIGH VOLTAGE, SA, UG/OH, HARD BOLTED 11kV UG/OH ON A 12.5m FIBER CEMENT POLE
130.	D301-0013	UNDERGROUND, HIGH VOLTAGE, SA, UG/OH, 11kV OH/UG WITH GAS SWITCH ON A 12.5m FIBER CEMENT POLE
131.	D302-0005	UNDERGROUND, LOW VOLTAGE, SA, UG/OH, 2 CORE 16mm2 Cu FUSED UG/OH
132.	D302-0006	UNDERGROUND, LOW VOLTAGE, SA, UG/OH, 4 CORE 16mm2 Cu FUSED UG/OH
133.	D302-0007	UNDERGROUND, LOW VOLTAGE, SA, UG/OH, 240mm2LV CABLE HARD BOLTED UG/OH
134.	D302-0008	UNDERGROUND, LOW VOLTAGE, SA, UG/OH, 240mm2 LV CABLE FUSED UG/OH
135.	D302-0009	UNDERGROUND, LOW VOLTAGE, SA, UG/OH, 240mm2 LV CABLE UG/OH WITH LINKS

3. ABBREVIATIONS AND DEFINITIONS

3.1 Acronyms

TERM	DEFINITION
2CTW	2 Wire Twisted (1 phase) service
4CTW	4 Wire Twisted (3 phase) service
4WL	4 Wire Lateral (open wire 3 phase) service
ACT	Australian Capital Territory
AAC	All Aluminium Conductor
AAAC	All Aluminium Alloy Conductor
ACSR	Aluminium Conductor Steel Reinforced
ADSS	All Dielectric Self-supporting (Communications cable—optical fibre)
AHD	Australian Height Datum
Al	Aluminium
BAZ	Bushfire Abatement Zone
BPA	Bushfire Prone Areas
CBL	Calculated Breaking Load. In relation to a conductor, means the calculated minimum breaking load determined in accordance with the relevant Australian/New Zealand Standard.
CSA	Cross-sectional Area
Cu	Copper
CLAH	Current-limiting Arcing Horn, or gapped surge arrester
EMF	Electromagnetic Field
GL	Ground Level
HDC	Hard Drawn Copper
OPGW	Optical Ground Wire—an overhead earth wire with internal optical fibre/s.
SF	Safety Factor, also Strength Factor
SC/GZ	Steel Conductor / Galvanized
UTS	Ultimate Tensile Strength – the maximum mechanical load which may be applied to a conductor, beyond which failure occurs.

3.2 Definitions

TERM	DEFINITION
Action	Force (load) applied to a mechanical system, as well as imposed or constrained deformation or acceleration, e.g., due to earthquakes, temperature or moisture changes.
Aerial Bundled Cable (ABC)	Two or more XLPE insulated aluminium overhead conductors twisted together to form a single bundled assembly.
Alignment	A distance relative to the edge of the footpath (usually the property boundary side) used to describe the position of a pole, cable, or other service.

TERM	DEFINITION
Average Recurrence Interval (ARI)	Or “Return Period”, is the inverse of the annual probability of exceeding wind speed, as applied in AS/NZS 1170.2
Blowout	The horizontal ‘sag’ or deviation of powerline conductors from the centre because of wind forces.
Bridging	Relatively short, flexible or rigid, bare, covered or insulated leads which electrically connect lines at termination or tee-off points or connect electrical lines to electrical apparatus. Also known as ‘droppers’ or ‘jumpers’.
Bushfire Abatement Zone	Under the Emergencies Act, the Commissioner has declared a Bushfire Abatement Zone (BAZ).
Bushfire Prone Areas	The BPA map is a single risk-based map that defines the area of the ACT that has been assessed as being at high risk to life and property due to bushfires.
Cadastral Map	A map or plan showing details of land tenure (e.g., property boundaries or natural features).
Chainage	The distance from a datum along the centreline of a roadway. This term and offset are used to reference points on roadworks plans.
Common MEN System	An earthing system in which the LV MEN system is connected to the HV system earthing. This is used commonly in urban areas where there are numerous interconnected earth rods all meshed together over a wide area and a low resistance to earth can be obtained. See ‘Multiple Earth Neutral’.
Conductor	A wire or other form of conducting material used for carrying current.
Covered Conductor Thick (CCT)	An unscreened overhead conductor around which is applied a specified thickness of insulating material dependant on the working voltage.
Creep (or Inelastic Stretch)	The process where a conductor increases in length over time when under tension in service. This causes an increase in sag in a span.
Customer	A person or organisation that has applied for or receives electrical supply from the electricity network.
Easement	A strip of land registered on the title deed in the office of the Registrar of Titles allowing access or other rights to a public body or party other than the owner of the parcel of land on which the easement exists.
Earthing	The process of connecting components of electricity supply networks to ground to prevent dangerous voltages occurring which may damage equipment or injure individuals coming into contact with them.
Everyday Tension	The sustained load (continuous force) exerted by conductors under no wind conditions.
Feeder	A circuit (normally HV) emanating from a substation for distributing electric power.
FoS	Factor of Safety
Ground Clearance	The vertical distance between the conductor at its lowest point of sag and ground.
High Voltage (HV)	Electrical potential that is in the range of 1kV to 33kV.
King Bolt Spacing	The vertical distance between king bolt attachment points on a support structure e.g., a pole.
Load Case	A compatible set of load arrangements or conditions to be considered in evaluating a structure, e.g., sustained load, maximum wind load, ice load.
Load Factor	A factor in a limit state equation which takes into account the variability and dynamics of a load, as well as the importance of a structure.

TERM	DEFINITION
Low Voltage (LV)	Electrical potential that is in the range of 32V to 1kV.
Mains	Main lines or cables of a network connecting various sites — does not include services to individual consumers.
Maximum Wind Tension	The force applied by conductors to a support structure in an intense wind, generally a 3s gust corresponding to the overhead line design period.
Mean Equivalent Span (MES)	A theoretical span used to represent the behaviour of a number of spans of varying lengths in a strain section of an overhead powerline, also known as Ruling Span.
Multiple Earth Neutral (MEN)	An earthing system connecting the network neutral conductors to the earth electrodes in customers' electrical installations, the electricity authority transformers and earths at multiple locations on the electricity distribution network.
Overhead Mains	Aerial conductors or cables together with associated supports, insulators and apparatus used for the transmission or distribution of electrical energy.
Phasing	The relative positions of phases (A, B, C) in a polyphase power system.
Pole	A structure (wood, concrete, steel, composite fibre) supporting conductors and other equipment forming part of the overhead mains.
Profile	A longitudinal cross section of ground and an existing or proposed powerline used to check clearances and select optimum pole positions.
RL (Reduced Level)	The elevation of a point above an adopted datum.
Ruling Span	Ruling Span – see Mean Equivalent Span
Sag	The vertical distance between a conductor and a line joining the two attachment points. Usually, the term refers to the maximum distance within a span at or near the midpoint.
Service	The electricity authority's conductors connecting individual customer's installation to the electricity network.
Serviceability Limit State	State beyond which specified service criteria for a structure or structural element are no longer met.
Sinking Depth	The depth of a pole below ground—also known as embedment or planting depth.
Span	A section of overhead conductor between two supporting poles or structures. The term may also refer to the horizontal distance between the two pole attachment points.
Span Reduction Factor (SRF)	A reduction applied to design wind pressure on conductors on long spans taking into account that wind gusts tend to be localised in their intensity.
Stay	A steel wire that is used to support a pole when the tip load exceeds the pole capacity. The stay may be anchored in the ground or to another pole. Also known as a 'guy'.
Strain Point	The structure on a pole that supports the tension of a line in both directions, where conductors are terminated, as opposed to an intermediate support. Used to sectionalise a line for electrical isolation or to provide convenient stringing sections. Also known as a 'Shackle Point'.
Strain Section	A section of overhead powerline between fixed strain points or terminations.
Strength Factor, or Strength Reduction Factor	A factor in a limit state equation used to derate the nominal strength of a component to a practical design value, taking into account variability of the material, workmanship, maintenance and other factors.
Sub-circuit	A circuit below another circuit, e.g., LV mains below 11kV.
Super-circuit	A circuit above another circuit, e.g., 11kV mains above LV.

TERM	DEFINITION
Tip Load	The equivalent mechanical load applied to a pole tip by attached conductors or stays, as well as wind on the pole/structure.
Uplift	A vertical upward force applied to a structure by attached conductors—generally not desirable for intermediate (non-strain) structure types.
Ultimate Limit State	State associated with collapse or structural failure. Generally, corresponds with the maximum load-carrying resistance of a structure or component thereof.
Ultimate Strength	The maximum load (nominal or actual) which may be applied to a structural component without inducing failure.
Wayleave	A written authority that the owner/occupier of a property uses to authorise an electricity authority to construct, maintain and clear vegetation for electrical line installations.
Weight Span	The equivalent span that gives the vertical conductor load applied to a support and equals the span between the lowest points on the catenary on either side of that support.
Wind Span	The equivalent span that gives the horizontal lateral component of the conductor load applied to a support and equals one half of the sum of the spans on either side of that support.
Working Strength	A nominal maximum working load obtained by dividing the ultimate strength by a safety factor. This value is not relevant to limit state design, but existing poles may be labelled with a working strength.

4. DESIGN PHILOSOPHIES

4.1 Wind return periods for design working life and security level

A minimum design return period for a line is set by selection of overhead line security class and design working life as per AS/NZS 7000 table 6.1 – "ultimate limit state wind returns periods for design working life and line security levels."

For example, normal distribution lines in Australia are commonly designed for a 50-year life and Level I security, which AS/NZS 7000 specifies as requiring a minimum 50-year return period.

Minimum line security level of "Level I" must be considered for low voltage (400V) and medium voltage (11/22kV) power line designs at Evoenergy.

According to HB 331:2020 table 8.1 - wind pressure for types of equipment for 50-year return period, for wind region A1-A7, and base wind speed of 39m/s, the wind pressure to be considered as 913 Pa.

4.2 Service conditions

The service conditions in the Australian Capital Territory are generally in accordance with normal service conditions specified in AS 62271.1, AS 2067 and climate data online from Bureau of Meteorology, Australia.

The material must be required to operate in service conditions as outlined in the table below.

PARAMETER	REQUIREMENT
Maximum Ambient Air Temperature	45 ^{0}C
Minimum Ambient Air Temperature	-25 ^{0}C
Average Maximum ambient temperature over 24-hour period	35 ^{0}C
Maximum Solar radiation	1.1kWm^{-2} (Equivalent to black body temperature of 80 ^{0}C
Altitude	Less than 1000m above sea level
Pollution level	Class C – Medium
Wind region	A3
Maximum wind speed	34 m/s or 122.4 km/h
Average relative humidity over 24 hrs	not exceeding 95%
Precipitation	Average Annual Rainfall 630mm
Vibration due to causes external to material	Negligible
Environment (AS 7000, Table D1)	Climatic Zone – Temperate Industrial proximity – exposure zone B1

TABLE 1. SERVICE CONDITIONS

4.3 Design life of overhead network

The design life of the Evoenergy overhead power distribution network was determined in consideration to the expected service life of primary construction elements. Each standard approved component has been selected in consideration ACT environmental conditions and Evoenergy network attributes.

The service life of most overhead network components is specified in various technical specifications which are utilised to procure the items. The service life specified is consideration to material availability, the risk of the product failing and the cost of replacement or renovation. Service life of assets maybe reduced where there is necessity to trial or implement novel technologies or materials to lower the risk to Evoenergy team members, the public or to harness other value.

Evoenergy material technical specifications generally request a design life of at least 40 years for the materials or products used on the overhead network.

A design life between 50-80 years is likely achievable in accordance with Appendix D AS7000. It is likely materials which are specified as below will achieve the required design life:

- Hot dipped galvanising of all ferrous metals (excluding stainless steel) with a coating of 200g/m² expected life 12-25 years, 400g/m² expected life 25-50 years.
- Use of concrete poles where possible, with an expected service life 60-80 years.

4.4 Design options analysis and selection

Design options analysis and selection will be guided by the over-arching principle that network designs minimise the installation of new assets. That is:

1. New loads and load increases are to be serviced through existing assets, where practical, to increase the overall network utilisation.

2. The extent of augmentation is to be minimised by switching existing loads to other LV or HV feeders, or substations, where practical, to provide available existing network capacity at the proposed connection points.

3. Current loads are to be understood through measurement of the actual network or through interrogation of an electronic system for fully occupied buildings and neighbourhoods. Additionally, the potential to maximise network usage during the winter period is to be understood and considered when determining available capacity in the existing network.

4. Any de-rating factors (e.g., connectors, LV boards) of LV and HV feeders are to be investigated and upgraded if this provides a low-cost solution in providing the capacity necessary to service a new load or load increase.

5. Neighbouring developments that are included in future load determination, require at a minimum, a request for Preliminary Network Advice; thereby providing the necessary confidence in the future connection of these loads.

6. If network capacity is “reserved” and an alternate project becomes available that could utilise this reserved capacity, the alternate project is to utilise this capacity unless the original project has (a) at a minimum progressed from the PNA to the application stage or (b) if an offer has been accepted and the project developer is constructing the development in accordance with the project milestones provided with the application.

7. When network augmentation is required, whole of life costs are to be considered when determining what assets are to be installed, thereby providing a preference to assets with the least overall whole of life cost. In the absence of a suitable systems integration functionality and a whole of life costs calculator this may be completed based on up-front capital costs only.

8. When a new load can be supplied by more than one connection point or supply point, preference is to be given to the Least Cost Technically Acceptable Solution (LCTAS).

9. The backyard overhead LV network is to be utilised where practical and cost effective, to remove the need to produce a duplicate underground network in the street verge.

4.5 Environmental considerations

Designers must contact the Environment team through environment@evoenergy.com.au for a preliminary environmental assessment or desktop review prior to design finalisation in line with PO06103 Manage environmental interactions. When requesting an assessment, the designer must include a project number or Work order, Block, Section and Suburb Section, Asset ID and detailed information about the project.

An Evoenergy Environment officer will assess the site for cultural sensitivity, significant trees, threatened species of flora and fauna, contaminated sites and any planning or development constraints which may require additional approval or engagement with regulators. This assessment may require additional considerations to be incorporated into the design, depending on the unique characteristics of the proposed works, site constraints and regulatory obligations. Examples of mitigation may include:

- Installation of bird diverters on OH lines near sensitive habitats or development of different pole top structures to reduce nesting potential in nature reserves.
- Revised construction methodologies for working near established trees or within tree protection zones (e.g., hydrovac, matting to reduce soil compaction).

Depending on the project location, work proposed and environment and planning constraints, an environment officer will provide advice to the Designer to incorporate and consider within 3 working days. This advice may result in additional timeframes or consultation required with regulators depending upon the work location and work proposed. Advice may also result in additional timeframes depending on required Development Approvals or Work Approvals which must be facilitated by the Environment team (Network Initiated) or designer (Customer Initiated).

4.5.1 Development approval

Development Approvals may be required for works that are not exempt under the planning and development regulation 2008. If works are network initiated, the Environment Team can facilitate this process, however, if customer initiated, the requirement for a Development Approval will be pushed on to the customer to provide. It is important to ensure that all Evoenergy works have the required approvals prior to construction to ensure Evoenergy satisfies its regulatory obligations.

4.5.2 Works approval

Works Approval is required for any work that is conducted within areas covered by the National Capital Plan and administered by the National Capital Authority (NCA). If works are network initiated, the Environment Team can facilitate this process, however, if customer initiated, the requirement for Works approval will be pushed on to the customer to provide.

Under the national capital plan Evoenergy must plan the installation of electricity infrastructure to minimise visual impact. This is of particular importance along major vistas, corridors, and major open space. Where the installation of overhead conductors is not suited due to the impact to significant vistas the installation of underground reticulation should be considered.

4.5.3 Network resilience

Evoenergy maintains a long-term target in its sustainability strategy that it is resilient to climate change and continue to deliver and maintain a safe, reliable, and affordable electricity network for the ACT.

Efforts should be made where possible during the design process to account for considerations of future network capability and capacity as increased electrical load and electrification continues as the ACT moves towards net-zero by 2045. Examples of this may include considerations of network losses through conductor sizing, transformer sizing or local network configuration.

4.5.4 Supporting resources:

Evoenergy’s Environment Team maintains a Grid page with resources to support designers to consider environmental and planning constraints in their preliminary designs. Resources include information on:

- Planning and Development
- Contaminated Land and VENM
- Oils and Fuel
- Working in Nature Reserves
- Heritage
- Extreme Weather
- Waste Management

Additional resources include mapping services provided by the ACT government through ACTmapi. This service includes mapping information on:

- Bushfire Prone Areas (BPA) and Bushfire Abatement Zones (BPA)
- Flood prone areas

- Aerial Imagery
- Land custodianship
- Heritage and culturally significant areas
- Significant species and vegetation communities
- Soil and hydro geological data
- Development constraints

4.6 Design considerations and load cases

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

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

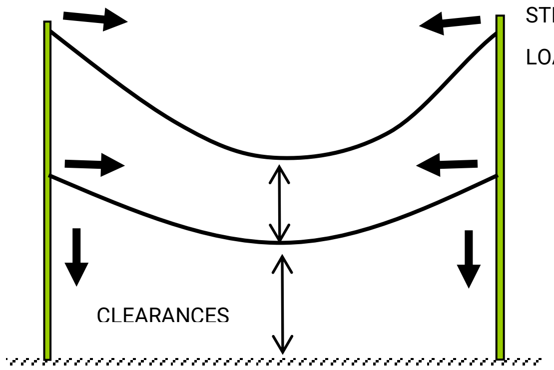


FIGURE 1. DESIGN CONSIDERATIONS AND LOAD CASES

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

4.7 Limit states

The Overhead line design must be based on limit state principal, for serviceability limit state and ultimate strength limit states for the various line components.

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

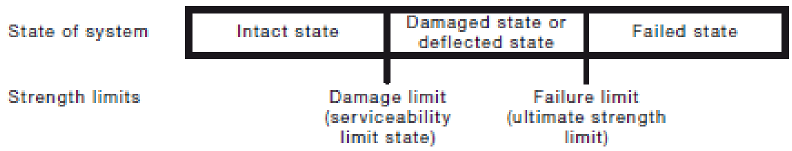


FIGURE 2. LIMIT STATE DESIGN

Limit states online components include but not limited to

- Structure design limit states (i.e., Ultimate strength limit state and Serviceability limit state

- Conductors limit state (i.e., earth wires)
- Insulator limit states
- Electrical structure clearance limit states

AS 7000 Clause 6.3 limit states sets out the approach to be adopted in design. Limit state approach uses a reliability-based approach to match component strengths to the effect of loads calculated based on an acceptably low probability of occurrence, using the below equation.

$$\phi R_n > \text{effect of loads}\left(W_n + \Sigma \gamma_x X\right)$$

where

X	=	applied loads pertinent to each loading condition
γ_x	=	load factors which take into account variability of loads, importance of structure, stringing, maintenance and safety considerations, etc.
W_n	=	wind load based on selected return period wind
ϕ	=	strength factor which takes into account variability of material, workmanship, etc.
R_n	=	nominal strength of the component

EQUATION 1: LIMIT STATES

AS/NZS 7000 also sets out other limit states that designers may need to check where relevant, such as:

- Failure containment (to prevent a cascading failure after one structure fails) or broken wire condition (where one phase conductor breaks on one side of a strain point, so that the loads applied are then out of balance)
- Maintenance and construction loading
- Snow and ice loading
- Seismic loading
- Torsional loading
- Uplift

4.7.1 Component strength factors

AS/NZS7000 clause 6.3.4.2, Table 6.2 provides range of strength reduction factors applicable to different materials and elements of the overhead line.

PART OF OVERHEAD LINE	COMPONENT	LIMIT STATE	STRENGTH FACTOR φ
Wood structures preserved by full length treatment	Pole	Strength	0.60
		Serviceability	0.34
	Crossarm	Strength	0.50
		Serviceability	0.30
Concrete structures	Pole	Strength	0.9
		Serviceability	0.5
Fibre Reinforced Cement (FRC) Structure	Pole	Strength	0.9
		Serviceability	0.5

PART OF OVERHEAD LINE	COMPONENT	LIMIT STATE	STRENGTH FACTOR φ
Fibre Reinforced Polymer (FRP), (Composite) Structure	Pole	Strength	0.75
		Serviceability	0.25
Fibre Reinforced Polymer Structure (Composite)	Crossarm	Strength	0.75
		Serviceability	0.30
Steel structures	Pole / Crossarm	Strength	0.9
Stays	Guy / termination Cable members	Strength	0.70
	Distribution Pole	Strength	0.80
Conductors		Strength	0.90
		Serviceability	0.50
Fittings and pins - forged or fabricated		Strength	0.80
Fasteners	Bolts, nuts, washers	Strength	0.90
Porcelain or glass insulators		Strength	0.80
Synthetic composite suspension or strain insulators		Strength	0.7 (short term ultimate for one minute mechanical strength)
		Serviceability	0.3 to 0.4
Synthetic composite line post insulators		Strength	0.9 (max. design cantilever load)
		Serviceability	0.3 to 0.4
Foundations relying on strength of soil—conventional soil testing		Strength	0.6
Foundations relying on strength of soil—empirical assessment of soil		Strength	0.5

TABLE 2. COMPONENT STRENGTH FACTORS

As per AS 7000 Appendix J, it is recommended that for the serviceable loads, the maximum deflection of the pole is 5% of the pole height above ground.

4.8 Load factors and load cases

LOAD CASE	HORIZONTAL CONDUCTOR FORCES	WIND LOAD ON STRUCTURE	VERTICAL LOADS	
			CONDUCTORS	STRUCTURE
	F_t	W_n	G_c	G_s
No Wind	1.1	_	1.25	1.1
Wind	1.25	1.0	1.25	1.1

TABLE 3. LOAD FACTORS AND LOAD CASES

Notes:

- No Wind is a serviceability limit state. For this condition deflection limit is 5% of pole height above ground.
- Wind is an ultimate strength limit state
- Refer to AS/NZS 7000, Table 7.1 for additional details.

4.9 Design wind pressures

Design wind pressures are provided in the Table below. Wind pressures in the column headed “Normal Design Pressure” are to be used for all new lines except for special rural lines. Wind pressures in the last column, “Special Exposed Rural Design Pressure” are only to be used for new rural lines without shielding, either beside lakes and dams, or run over steep ridges.

In general, span reduction factors are not used within Evoenergy distribution design for the sake of simplicity. However, their use may be warranted for very large spans, say in excess of 210m.

COMPONENT	NORMAL DESIGN PRESSURE	SPECIAL EXPOSED RURAL DESIGN PRESSURE
Conductors	900Pa	1300Pa
Round Poles	1300Pa	1800Pa
Flat Surfaces (Projected Area)	2000Pa	2900Pa

TABLE 4. DESIGN WIND PRESSURES

Notes:

- Wind return period of 50 years has been used based upon AS/NZS 7000, Table 6.1, security level I, 50-year life.
- Normal Design Wind Pressures are based on region A3, terrain category 2 and 10m pole height which gives 140km/h wind speed.
- Special Exposed Rural Design Wind Pressures are based on region A3, terrain category 1 (exposed open terrain with few or no obstructions and water surfaces) and 10m height which gives 168km/h wind speed. These wind pressures are also suitable for exposed hills up to topographic multiplier 1.2.
- The following drag coefficients of the various components have been used: - 1 for conductors, 1.4 for round poles and poles with 8 sides, 2.2 for square sections.

4.10 Design temperatures

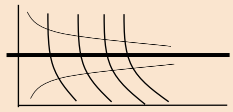
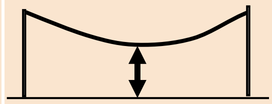
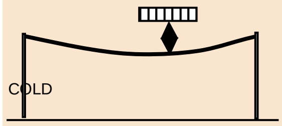
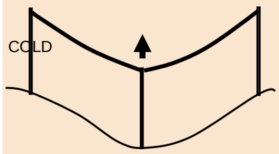
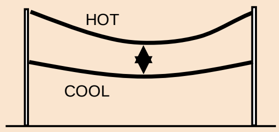
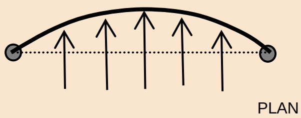
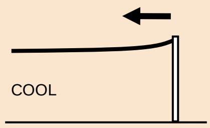
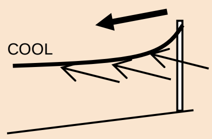
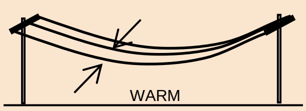
<table>
<tr><th colspan="2">SITUATION</th><th>TEMP</th><th colspan="2">WHEN USED</th></tr>
<tr><td colspan="2">Standard (Reference) Temperature</td><td>15°C</td><td>Reference temperature for conductor stringing tables</td><td></td></tr>
<tr><td>Max. Design Temp. (Hot)</td><td>Standard Bare Mains
(See Note 1)</td><td>75°C</td><td>Checking clearance from ground or
objects below the line</td><td></td></tr>
<tr><td colspan="2">Min. Temp. (Cold)</td><td>-10°C</td><td>Checking clearance from objects above the line</td><td>
</td></tr>
<tr><td colspan="2">Uplift</td><td>-10°C</td><td>Checking for uplift forces, esp. on intermediate structures</td><td>
</td></tr>
<tr><td colspan="2">Subcircuit</td><td>15°C</td><td>Checking intercircuit clearance—hot supercircuit above and cool subcircuit below</td><td>
</td></tr>
<tr><td colspan="2">Blowout</td><td>30°C</td><td>Checking horizontal line displacement
(sideways ‘sag’)
under 500Pa wind force</td><td>
</td></tr>
<tr><td colspan="2">‘No Wind’ Load Condition</td><td>0°C</td><td>Calculating sustained loads</td><td>
</td></tr>
<tr><td colspan="2">‘Wind’ Load Condition</td><td>15°C</td><td>Calculating loads under maximum wind condition</td><td>
</td></tr>
<tr><td colspan="2">Midspan Conductor Clearances</td><td>50°C
Note 2</td><td>Checking interphase conductor spacing to avoid clashing</td><td>
</td></tr>
</table>

TABLE 5. DESIGN TEMPERATURES

Notes:

- Many older lines were designed to lower temperatures, commonly 50°C or 65°C.
- Due to cooling effect.
- Lower temperatures may be required for above 800m altitude where there may be snow and icing.

4.11 Designs for bushfire areas

Design of the overhead network must apply mitigations to minimise the risk of bushfire caused by the distribution network. The Evoenergy network interacts with both bushfire prone and bushfire abatement zones, for the purpose of the application of bushfire risk mitigation, these areas are considered the same.

Mandatory bushfire mitigations include:

- Switchgear with exposed contacts such as air-break switches and bare links must not be installed in bushfire prone areas. Switchgear with contacts enclosed in gas or vacuum such as gas switches and reclosers must be used.
- The use of spiral vibration dampers, armour rods and preformed ties – hand ties must not be used on conductors under tension
- Covered low voltage conductor
- CCT bridging on 11 and 22kV

4.12 Classification of rural and urban

Rural region at Evoenergy will be defined as the union of non-urban zone, region other than act and bushfire abatement zone:

- RURAL = NON-URBAN ZONE Ù REGION OTHER THAN ACT Ù BUSHFIRE ABATEMENT ZONE

Urban region at Evoenergy will be defined as the region other than Rural, that is:

- URBAN = ACT REGION – RURAL

Refer to rural and urban classification guide, PO070509 for more details.

5. SAFETY IN DESIGN

5.1 What is safety in design

Safety in design is a concept which seeks to eliminate or reduce hazards that maybe presented by the structure or system to people, property or the environment throughout the entire life of the object. Safe design begins at the early design stage where the designer considers the purpose of the structure or system. Design considerations will include:

- What the system needs to do and for how long,
- Selection of suitable materials,
- How often will the structure need to be accessed?
- Does the site allow for the safe access of workers and their plant and equipment?
- How will the design interface to the existing network?
- How the system will be built, maintained, operated, removed, recycled or disposed of,
- Law, legislation, or local rules that may apply
- Identify key stakeholders which may include construction staff, local authorities or regulators, property owners, community groups other affected utilities or customers.

Additional information and useful resources in relation safe design maybe found on the Commonwealth Government Safe Work website.

5.2 Legalities and responsibilities relating to safe design

Under part 6.2 of the *Work Health and Safety Regulation 2011* (Cth) requires the designer to develop a written a safety report to that who commissioned the design. Designers must complete the safety in design report which is considered to fulfil the obligations of the designer under clause 6.2 of the Work Health Safety Regulation.

5.2.1 Evoenergy existing practices

Evoenergy currently requires designers to attend sites whilst developing a design. This site visit allows the designer to assess the site and ensure that the proposed design will be fit for purpose. The designer is required to complete a WORQ form for the design which is completed before the design is finalised and approved.

For most tasks this form is considered to fulfil the designer’s responsibility in relation to the development of a written safety in design report.

Where the designer is not utilising approved Evoenergy Standards or where the project is complex in nature the designer may need to conduct investigations and assessments beyond the considerations identified on the form.

5.3 Safe design considerations specific to overhead line design

SA/SNZ HB 331 outlines that designers should consider:

- Which stakeholders need to be engaged? Authorities, contractors, suppliers/ manufacturers, road or rail authorities, landowners, community groups, local authorities, safety regulators or third-party utilities.
- A hazard and risk assessment,
- Specification of materials. Which Standard or Evoenergy specification is required, is the use of standard approved constructions suited?
- Detailed line design
- Ensuring the design meets the requirements of AS/NZS 7000
- Information transfer of relevant information, data and works as executed details.

5.4 Non-standard design

For project specific reasons, designers may consider a non-standard or non-typical design which may include unfamiliar work practice or method of installation, unaccustomed material etc. Designer must review their non-standard or non-typical design with relevant parties as per following table:

TYPES OF NON-STANDARD DESIGNS	LV, HV, TX NEW MATERIAL	LV, HV, TX (EARTHING, CIVILS, ETC) NEW WORK PRACTICE	SCADA / PROTECTION	PV / SOLAR / BATTERY
Asset Standards & Specification	✓	✓		
Work Practices		✓		
PDL Construction	✓	✓		
System Control/ Commissioning			✓	✓
Zones			✓	✓
Network Service	✓			✓
Embedded Generation				✓

TABLE 6. NON-STANDARD DESIGN REVIEW REQUIREMENT

If designer is to implement something different from above mentioned types of non-standard design, then designer is to check with each section supervisor/manager if they would like to assess the non-standard or non-typical design.

5.5 Maximum demand

The maximum demand of a proposed installation must be estimated by the Design Officer after obtaining relevant information from the client in accordance with PO07385 “Maximum Demand Estimates for Residential, Commercial and Industrial Installations”.

For Brownfield developments, it is recommended that at least two methods are used to estimate maximum demand. The choice of methods is subject to availability of data such as: load density and net floor area along with a list of connected loads and corresponding diversity factors.

When a number of consumers are connected to a three-phase electricity supply system, the total loading is normally not the sum of the individual consumer’s maximum loads. In the particular case of URD projects in Greenfield areas, where the dominant types of consumers are domestic residences, load diversity and phase unbalance will affect the overall maximum demand seen by the supply system. The influence of these two effects must be taken into account when estimating the loading on cables and substations. Load diversity occurs because the maximum demand of a given group of consumers occurs at different times of the daily load cycle. For design purposes, the average demand for a very large number of consumers is the After Diversity Maximum Demand (ADMD).

For further details on types of method and ADMD values, refer to PO07385 “Maximum Demand Estimates for Residential, Commercial and Industrial Installations”.

5.6 Use of the ADMS for LV network voltage analysis

Connection of Distributed Energy Resources (DER) to Evoenergy's LV network has now reached levels where it can adversely affect supply power quality if not managed satisfactorily. Of particular concern, for the purposes of this document, is voltage rise conditions due to reverse power flow.

Hence assessment of voltage at the various points of interest (service connection points and points of common coupling) must consider peak power flow in both directions based on the daily load/generation profile. This exercise is best carried out using load flow study software.

Evoenergy uses the load flow module in the ADMS to model and simulate power flow for the purposes of analysing voltage performance in an existing or modified network. The ADMS has provision for specifying different types of loads (e.g., residential, commercial) and embedded generating sources (e.g., Solar PV) to represent operating conditions more closely.

The designer makes the required changes in an offline model (simulation) of the real time network in the ADMS and runs load flow studies on this model to get feeder loading and voltages at nominated nodes or terminals.

Refer to the ADMS user guides for the procedure on simulating a load flow study for new development/connection within the distribution network in Greenfield or Brownfield areas.

As an alternative to using the ADMS other suitable methods may be adopted for analysing the LV network with the approval of relevant stakeholders.

5.7 Voltage drop and rise limits

The design must ensure voltage at the customer's supply connection point is maintained within the range defined by PO070523 "Standard Supply Voltage for LV System", which is +10%, -6%. For a nominal 230V phase to neutral supply system this equates to the range 216V to 253V. Both voltage drop and voltage rise conditions need to be managed to ensure compliance with the above requirement.

To ensure voltage performance is satisfactory, voltage calculations must be done from the distribution transformer LV links to the last customer's point of entry on each LV distribution circuit for peak power flow in both directions. Therefore, two sets of calculations are required, one for voltage drop under peak demand/low generation conditions and one for (possible) voltage rise under low demand/peak generation conditions. For voltage drop the minimum voltage will be at the farthest connected load and for voltage rise the maximum voltage will be at the farthest connected generator. For further details refer to Evoenergy document PO070523 "Standard Supply Voltage for LV System".

The recommended allowance for voltage drops and rise across the various network elements is detailed in Table below.

ELEMENT	VOLTAGE DROP	VOLTAGE RISE
HV Feeder	4.5%	-
Substation	2.5%	-
LV Feeder	4.5%	7%
Service Cable	1.5% for a total voltage drop of (4.5+1.5) = 6% of nominal	3% for a total voltage rise of (7+3) = 10% of nominal

TABLE 7. TABLE - RECOMMENDED MAXIMUM VOLTAGE DROP AND RISE

The values in the table above assume that the tap-changer on the Pole Substation transformer is set at 5% boost and the tap-changers on the Zone Substation transformers are set at 2% boost at high load. A load flow study reflecting power flow and actual transformer tap settings under peak load and generation conditions is required to reliably assess the voltage profile at the various points of relevance.

Voltage levels (drop/rise) are to be assessed using ADMS as per clause 4.3. For Brownfield development the existing low voltage network may need to be investigated and analysed (for voltage levels, existing loading, any solar PV resources causing reverse the power flow etc.) at the preliminary design stage.

5.8 Ferroresonance

Ferroresonance is a phenomenon which may occur when a capacitance is either in series or in parallel with a nonlinear inductance. It can cause over voltages and over currents that can pose a risk to transmission and distribution equipment and to operational personnel.

In power distribution systems, the most common place to find ferroresonance is when a three-phase distribution transformer is energised through an underground cable. Under no load, or very light load conditions, the cable parameters (length, type) may result in the capacitance being sufficient to create ferroresonance under single phase switching conditions. Single phase switching conditions occur when operating single phase HV switches or HV drop-out fuse units.

Whilst there are other methods of controlling ferroresonance, the use of ganged 3-phase HV switching is one of the most effective and commonly used methods of avoiding it. This is why 3-phase HV switching is the standard adopted by Evoenergy. For further detail refer to Evoenergy document PO07177 – “Ferroresonance Causes and Mitigation”.

5.9 Communication

Building a smart grid involves transforming the traditional electricity network by adding new, smart technology. It includes field installed smart sensors, field automation, new back-end IT systems, and a communications network. Smart grids provide instant information (data) about the network to make it more efficient through faster fault location and preventive maintenance and to help reduce interruptions, support more renewable energy and give Evoenergy greater control over its Network.

5.9.1.1 SCADA / Reliability Considerations:

Remote monitoring or operability must be considered in the following circumstances -

- Approximately 500 customers or more between remote switching points along trunk or branch of feeder
- Restricted or limited access to network
- Planned Open Points between feeders OR areas where 3 HV Feeder to be connected.
- First point out of the Zone Substation (after long HV cable or line run)
- Any P1 or P2 high priority customers as per PO07273 Network Emergency Response section 2.1.2
- Near known unreliable part of the network and/or worst performing HV feeders.
- Highly utilised switchgear
- On any feeder which is targeted for FLISR (Fault Location, Isolation, and Service Restoration)

The Project/Design Engineer must liaise with the Planning team and System Control to identify remote operability requirements, information on unreliable network and/or worst performing HV feeders during preparation of design.

6. DESIGN PROCESS

6.1 General

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

- Is economical (considering the whole-of-life cost), which usually means keeping structures to a minimum number, and of an economical size
- Meets all applicable technical and regulatory standards (e.g. Voltage drop, current capacity, adequate clearances, not mechanically overloaded)
- Meets all safety and environmental standards
- Is practical to construct, maintain and operate
- Has adequate reliability for the intended purpose.

The design procedure is illustrated below in figure. Note that not all steps are required for every design, and the order of the various steps may vary.

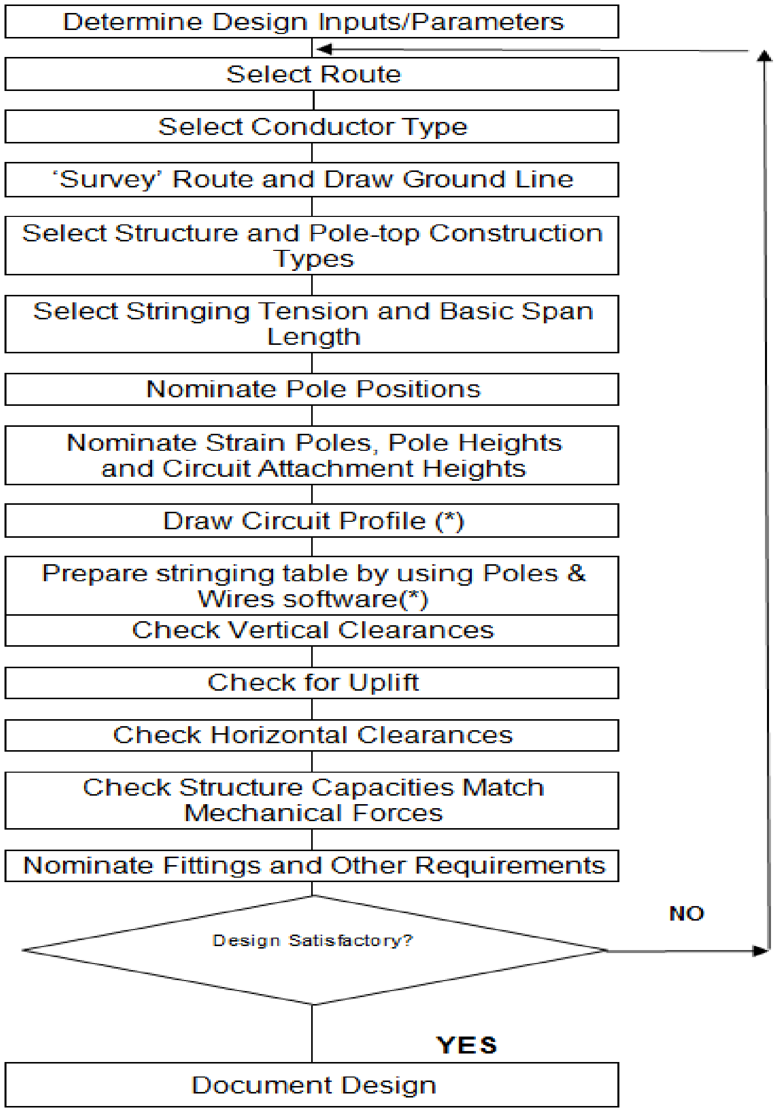


FIGURE 3. GENERAL DESIGN PROCESS

6.2 Design inputs

The design inputs/parameters must be gathered before commencing design. These may consist of the following: -

- Power transfer
- Voltage level
- Line route including beginning and end points, clearances to other structures and vegetation, ground profile
- Number of circuits
- Conductor type
- Aesthetic, heritage, and environmental constraints/considerations
- Planning requirements
- Coordination with other authorities and services
- Stakeholder requirements
- Future developments
- Land use and property owner requirements
- Project reports, specifications, and requirements

Note: Use Poles & Wires software to determine items marked (*)

6.3 Route selection

The aim of the route selection process is to select the lowest cost solution that meets the technical requirements and minimises community impacts.

Appropriate consideration should be given at the route selection stage to the use of the land proposed for the power line corridor.

Considerations should include:

- Environmental
- Risk Minimisation
- Constructability/ Maintainability/ Operation
- EMF exposure
- Efficiency- minimising conductor CSA, reducing the number of structures and line deviations

6.3.1 General pole layout/ placement considerations

The following strain section rules should be applied: -

- If strung tight (i.e. greater than or equal to 10%CBL) then limit ratio of smallest to largest span in the tension section to 2:1
- If strung slack (i.e. less than 10%CBL) then limit ratio of smallest to largest span in the tension section to the range 0.5xMES to 2xMES
- If differences in smallest to largest span in the tension section exceed these limits, then install a shackle pole

6.4 Conductor selection

Refer to Section 9: Conductors

6.5 Route survey and ground profile

Identify constraints and develop a survey plan for the selected route. Ground line profiling is required where poles are to be positioned on undulating terrain. Ground line profiling may not be necessary for areas where the ground level is relatively flat or has a consistent slope.

The route is broken into a number of sections of constant gradient. Slope distance and inclination are then drawn to scale to produce the ground profile. Alternatively, ground profile data may be shown in tabular form, suitable for computer entry. Slope and inclination can be converted to RL (reduced level) and chainage using trigonometry. Relevant features such as trees, roads, gullies, fences & obstacles are also shown on the ground profile. Note vertical scale is selected to exaggerate any slopes.

6.6 Structure selection

Refer to section 10 Poles.

6.7 Circuit profile

Using Poles & Wires software construct a model of the line showing pole positions, ground profile and lowest conductor catenary profile. Conductor catenary is based on mean equivalent span when at maximum operating temperature.

6.8 Land use

See below table permitted and non-permitted land use

PERMITTED LAND USES	NON-PERMITTED LAND USES
Grazing, agriculture, market gardening, nurseries	Large spray irrigators of the gun type
Cemeteries, both pet and human.	Children's playgrounds
Landscaping, trees and shrubs of limited height	Swimming pools
Car parking for conventional vehicles	Storage of materials
Water storage, pollution control ponds, drainage channels and floodways (swimming not permitted, and boat mast height limited)	Permanent or temporary habitation (tents, caravans)
Roads, cycleways, footpaths	Refuelling of vehicles
Golf courses, providing those fairways are sited so as to avoid insulator damage by golf balls	Aerial activities (flying, hang gliding, kites, model planes)
Neighbourhood playing fields, restricted to ground level sports and activities, with limitations on the location of goal posts, floodlights, high fencing, tennis umpires' chairs and the like.	Structures other than fences, poles of lighting standards of limited height including Saleyards or parking for large vehicles

TABLE 8. LAND USE

6.9 Pole positions and details

Locate obvious structures such as terminations, transformer poles, tee-off's, service poles (adjacent to entry points), high points, switches and reclosers first.

Next nominate strain positions at large deviation angles.

Finally, locate in-line structures based on spanning ability. Pole positions must be selected based on the ground conditions being suitable for foundations (i.e., avoid lose ground such as sand, rock etc). If a pole must be placed in difficult ground conditions, then a special foundation must be designed.

6.10 Uplift

For structures located in gullies, they may go into uplift under cold conductor tension conditions. If this is possible then the following possible remedial options must be considered: -

- Change the pole to a strain
- Move the pole position
- Reduce conductor tension
- Increase pole height
- Reduce adjacent pole heights if ground clearance allows

6.11 Mechanical loads

Poles, crossarms, foundations, stays and conductors must be checked for the maximum loading (wind, snow and ice) and the everyday condition of sustained load. If structure designs have not previously been assessed, then they must also be checked for maintenance and construction loading.

Pole loading must be checked against pole capacity summarised in section 11 Poles. If capacity significantly exceeds pole loading, then check next lowest pole strength. Alternatively, if pole capacity is insufficient, then consider: -

- Selecting stronger pole
- Fitting a stay if space permits
- Reduce conductor tensions for strain poles

In cases where the above options are unsuitable, consider adding a short slack span to an extra pole that can be stayed.

6.12 Fittings and other requirements

The design is not complete until all the details are complete. Consider the following: -

- Fitting of preform ties and armour rods in fire prone areas
- Fitting of vibration dampers
- Fitting of aerial markers
- Services and phasing
- Wildlife proofing
- Details of clamps, lugs, connectors, sleeves, bridging
- Details of pole-mounted plant, fusing and settings
- Earthing
- Lightning and surge protection
- Vegetation clearing requirements
- Special foundations

6.13 Design documentation

The following detailed design documentation package is required: -

- Structure schedule
- Conductor schedule (ruling span, sags, tensions)
- Material and plant list
- Single line diagram
- Geographical plan
- Design calculations
- Foundation design

- Route plan and longitudinal profile
- Crossing details
- Construction plans (limitations, archaeological sites, outages)
- Vegetation clearing
- Legal approvals (Property details, wayleaves, and Easements)
- Environmental documentation (typically endorsement from the Environmental team section)

6.13.1 Structure schedule

- Structure chainage positions and deviation angles
- Structure type and height data
- Span length, wind span, weight span
- Conductor tensions, vibration damper positions
- Earthing and foundation requirements

6.13.2 Plan

- The centreline of the line
- All terrain features captured by surveys and mapping scans
- All structure locations, structure types and heights
- All roads, tracks, water courses, fences, clearance obstructions etc
- Conductor stringing chart

6.13.3 Longitudinal profile

- All structure locations, structure types and heights
- Conductor sag profiles for maximum and minimum temperature conditions
- Side slope constraints
- Vegetation clearances where preservation measures are applied

6.13.4 Traceable design for verification

Technical review of the following main items is required before construction:

- Electrical clearances
- Adjacent span ratio
- Uplift on structures (cold condition)
- Structure ultimate and serviceability limit states
- Special locations (exposure to EPR and EMF)

6.13.5 As-constructed documentation

- As-constructed plans
- Finalisation of legal requirements including easements
- Erection of warning signs (e.g. water crossings)
- Network data requirements (plant numbers, asset numbers, switching numbers, test results, actual conductor rating)

7. INTERFACE TO EXISTING NETWORK

7.1 General

This section outlines considerations and requirements when extending or modifying the existing overhead power network. Careful consideration to how the existing network will interface to the new proposed network must occur. The designer is responsible for providing all details in relation to this to the relevant stakeholders.

7.2 AS/NZS 7000 limited application to existing network

The application of AS/NZS 7000 to the overhead power network is mandated through regulation in the ACT. Where works maybe considered maintenance or life extension tasks the strict application of AS/NZS 7000 need not apply. Where such tasks are programmed the work team must be provided the required information to ensure the *standard of the day* maybe applied. Appendix C of this document outlines the drawing numbers and titles of legacy constructions. All drawings are available on the drawing viewer

As prescribed in this document some legacy constructions and practices must not occur even if considered maintenance or life extension tasks.

7.3 Existing network conductor tensions

Designers must consider the actual conductor tension of adjacent spans which are outside of the proposed work area. Typically network conductors were constructed with tensions lower than that specified in design documentation or standards. Where the designer fails to recognise adjacent slack spans and considers tensions are in accordance with current design methodology the pole structures will likely lean and transfer loads to adjacent infrastructure.

The designer may overcome such issues by:

- Specifying lower conductor tensions for the proposed works where appropriate. The tension/ sag of the new conductors maybe specified to an equal and opposite load to the existing forces placed on the structure. In this instance the designer must ensure that sufficient ground clearance and clearance to third party assets are maintained
- Installing stays to the structures on each end of the network augmentation
- Include tensioning conductors adjacent to the work site as appropriate in the project

7.3.1 Determining existing applied tensions

It is preferred that designers utilise design software to determine the applied tension from existing network conductors. To determine the forces, the designer should attend site and record:

- The ambient temperature
- The number of conductors per circuit and conductor type
- Height of circuit attachment
- Length of spans
- Approximate variation in ground level

Where the design requires a greater level of accuracy the designer may request a survey to profile the groundline. The designer may also request the construction teams to restrain existing mains to ensure the design maintains the required clearances in accordance with this manual.

7.4 Maintaining/ reinstating stays

The removal of existing network stays should be avoided unless the stay poses a legitimate public hazard. Due to the challenges of installing sound pole foundations and the process of installing new stays in the backyard environment stays should not be removed unless the designer is sure the stay is not required.

Prior to approving a stay to be removed the designer must ensure:

- Existing network conductors are sufficiently sized for existing and possible future network demands
- The installed stay is not under load
- The network conductors are correctly tensioned
- Sufficient ground clearance is maintained for Evoenergy, and/ or third-party assets attached to the structure

7.5 Midspan conductor clearances in adjacent spans

The designer must ensure that adequate conductor clearances are maintained to at least one span each side of the structures located to the outer perimeters of the proposed works. Such clearances include inter circuit clearances, phase to phase and ground clearances.

Where the designer specifies a flat construction (i.e. not delta) the adjacent pole structure must not utilise crossarms shorter than that approved for current standard constructions. Where shorter legacy crossarms are in existence the designer must identify the crossarm to be changed in the project scope.

7.6 Designs to not create 3 or 4-way bare LV constructions

The designer must not specify network modifications or augmentations which result in three-way or four-way low voltage bare mains constructions. Where such scenarios occur the low voltage mains to the lower circuit (s) must be augmented to LV ABC.

This requirement allows safer access to network assets by Evoenergy representatives who may employ energised work practices on the structure. Three way and four-way bare mains constructions are difficult to apply temporary insulation to and present a high-risk work environment.

7.7 Mechanical assessment required on pole structures

Designers must arrange a pole inspection if the works increase the existing pole tip load by greater than 1kN. This requirement must be observed for all structures regardless of installation date or pole strength.

The designer should also consider the loading that will be temporarily applied to the pole during construction activities. An example of a temporary load change is where the construction crew is required or will likely lower conductors away from a structure, which transfers the load to an adjacent pole. Where temporary loads will be applied to structures the designer should allocate enough resources to manage the temporary loads (i.e. lifter borer) and arrange pole inspections of the adjacent structures as required.

7.8 Inspection of network conductors

The designer must inspect the network conductors throughout the proposed work area. Mains should be in good condition and not contain broken strands or be degraded by corrosion or annealing. Where damaged mains are noted, the project scope should identify the need to repair or replace the damaged conductors.

The designer must positively identify the existing conductor’s size and stranding. If not a standard conductor, the designer must ensure that sufficient line fittings are available to complete the proposed works. In some instances, the conductor may need to be replaced if conductor fittings are unable to be sourced. Preformed line fittings including dead ends, fan grips, line splices are typically single use items and must not be reinstalled.

7.9 Reinforced poles

The designer must consult the Overhead Network Asset Manager should a reinforced pole be inside the work area of any overhead conductor augmentation project. The Asset Manager will decide whether the reinforced pole is required to be replaced as part of the project scope.

7.10 Banned legacy constructions

This section outlines methods of construction which were previously acceptable construction in the Evoenergy network, though must not be reinstated/ renewed.

7.10.1 Bare conductor bridging

Life extension and maintenance tasks that involve the disconnection of bare conductor bridging on Low voltage circuits or 11kV tee off (multiple circuit) constructions, the bare bridging must not be reinstated. CCT is the preferred bridging conductor for the 11kV and 22kV network.

Note: Bare conductor maybe used for 11kV and 22kV bridging on double termination constructions. Tee off and double termination constructions where multiple crossarms are required must have CCT installed as the bridging material.

Low voltage LV ABC of the appropriate size is the preferred material for low voltage bridges, however grey flexible conduit maybe installed over the bare bridge as required.

7.10.2 Short 11kV cross arms

Short cross arms that were typically installed to the 11kV overhead network must be replaced with a current standard cross arm.

7.10.3 Long unsupported bridges/ bonds

Legacy constructions that resulted in long electrical bonds must not be reinstated. A hazardous bridge is one which has potential to contact a lower circuit or an object of different electrical potential or fall within 3.5m of ground line should the bridge become loose. Bridges may become loose if a network connection fails.

Where hazardous length bridges are disconnected during a project, they must not be reinstated. The designer should specify a bridging crossarm to which the bridging conductors are supported at an appropriate position on the pole structure. Should the bridge become loose the support arm will limit the risk of the energised bridge creating a hazardous scenario.

7.10.4 Existing network defects

Designers have opportunity to realise additional value when specifying new works. Designers should be aware of existing defects inside the proposed work area and where possible address the defects through their design.

Where network defects are in existence in the vicinity of the works, consultation should occur with the Asset Manager to confirm the scope of the works and provide opportunity to plan resources to repair defects whilst the proposed works are under construction.

8. ELECTRICAL REQUIREMENTS AND CLEARANCE

8.1 General

Electrical design for an overhead line must consider following:

- Conductor selection considering minimal losses, voltage drops, current carrying capacity, corona, and audible noise levels. See Appendix H of AS7000 for details.
- Power frequency, switching and lightning voltages
- Electrical clearances
- Selection of insulation
- Lightning performance
- Earthing. See Section 10 of AS7000 and Evoenergy earthing design manuals
- Electric and Magnetic fields. See section 3.14 of AS7000

Overhead network apparatus must maintain enough physical separation from objects to reduce risk of injury and increase network reliability.

Clearance requirements are outlined in drawings and documents referenced in this section and are available on drawing viewer, policies, and procedures or by request to Network Standards.

8.2 Structure geometry

Structures must be designed with adequate air clearance; in such manner it is able to perform reliably and conduct maintenance in safe manner. The electrical design determines the structure geometry and must be coordinated with the structural design.

For further detail, refer to Clause 3.6 and Appendix EE of AS7000.

8.3 Conductor clearance requirements

8.3.1 AS7000 conductor clearance requirements

Clearances to structures and other lines are given in the following tables in AS/NZS7000:

- Powerline crossings – Table 3.1 and Table 3.3
- Clearance to earthed structures – Table 3.4
- Clearance from ground, lines other than insulated service lines – Table 3.5
- Clearance from ground, insulated LV service – Table 3.6
- Clearance from structures – Table 3.7

8.3.2 Mid span phase conductor to phase conductor clearances

The designer must ensure that mid span conductor to conductor clearances are maintained in accordance with AS/NZS 7000. In consideration to assessing the adequacy of mid span inter conductor clearance to the equation under 3.7.3.2 of AS/NS 7000, and the following “k” factors should be applied:

- Bushfire prone areas= 0.6
- All other areas= 0.4

Tabled below are the typical standard constructions X and Y dimensions in consideration to *equation 3.5 AS/NZS7000 considering a 0°line deviation*:

STANDARD CONSTRUCTION GEOMETRY IN CONSIDERATION TO FIGURE 3.5 AS/NZS 7000			
Drawing number	description	X (mm)	Y (mm)
D201-0026	(11kV Inline)	950	1170
D201-0027	(11kV double strain)	950	900
D201-0028	(11kV Termination)	950	900

TABLE 9. STANDARD X AND Y GEOMETRY STANDARD CONSTRUCTION

8.3.3 Horizontal clearances from aerial line to non-flammable materials

Following minimum horizontal clearance are to be maintained between the any point of the vertical projection below the aerial line to the non-flammable material. For further details, refer to "SL2001-28" Utility Networks (Public Safety) Regulation 2001.

- Areal Conductors; U < 1kV: 2000mm
- Areal Conductors; U < 33kV: 2700mm

8.4 Support structure clearance requirements

8.4.1 Horizontal clearance from poles to adjacent structures

Allow for a minimum of 1500mm clearance between the support structure (pole) and adjacent structures.

- Driveways
- Kerb / Road

8.4.2 Horizontal clearance from poles to other services

Allow for a minimum of 1500mm clearance between the support structure (pole) and other utility services.

- Underground Water and Sewerage pipes, GAS Pipes (Distribution/ Service)
- Underground assets of other utilities, i.e., Service pits.

8.4.3 Reference relating to network clearances to structures

DRAWING NUMBER	TITLE
3811-004	Minimum Clearances Insulated & Bare Overhead Conductors
3832-018	Separation and Cover Requirements for Cables and Plant

TABLE 10. NETWORK CLEARANCE TO STRUCTURES

8.5 Third party assets clearance requirements

Evoenergy structures often have third party assets installed below the electrical network conductors. To ensure the Evoenergy structure is not compromised by the third-party asset being struck by a vehicle all specified ground clearances for low voltage network conductors must be maintained to the third-party owned assets.

Minimum clearances between Evoenergy and third-party telecommunication cables must be maintained in accordance with the below tabled documents:

DRAWING NUMBER	TITLE
390-018	Clearance requirements between Evoenergy infrastructure and telecommunication carriers cable installation
PO07218	Installation requirements for telecommunication equipment on Evoenergy assets
390-022	Third party microcell and antenna requirements radio frequency hazards minimum clearance to ground
390-023	Third party microcell and antenna requirements bare overhead mains minimum clearance requirements
390-024	Third party microcell and antenna requirements LV ABC construction required minimum clearances
390-025	Third party microcell and antenna requirements isolation switch mounting considerations fixed to Evoenergy structures

TABLE 11. REFERENCES RELATING TO NETWORK TELECOMMUNICATION ASSET CLEARANCES

8.6 Required clearances to vegetation

Ongoing vegetation management tasks should be minimised through selecting the optimal route. The designer must ensure that the proposed design does not encroach vegetation clearances outlined in the drawings tabled below:

DRAWING NUMBER	TITLE
3811-014	VEGETATION CLEARANCE REQUIREMENTS FOR EVOENERGY ZONE SUBSTATIONS IN ACT AND NSW
3811-015	VEGETATION CLEARANCE REQUIREMENTS FOR EVOENERGY GROUND ASSETS IN ACT AND NSW
3811-016	VEGETATION CLEARANCE REQUIREMENTS FOR EVOENERGY HIGH VOLTAGE UNDERGROUND AND OVERHEAD NETWORK ASSETS IN ACT
3811-017	VEGETATION CLEARANCE REQUIREMENTS FOR EVOENERGY LOW VOLTAGE UNDERGROUND AND OVERHEAD NETWORK ASSETS IN ACT
3811-018	VEGETATION CLEARANCE REQUIREMENTS FOR UG & OH TRANSMISSION LINE ASSETS IN ACT
3811-019	FALL IN HAZARDOUS VEGETATION IN ACT & NSW
3811-020	VEGETATION CLEARANCE REQUIREMENTS FOR EVOENERGY HIGH VOLTAGE UG & OH NETWORK ASSETS IN NSW
3811-021	VEGETATION CLEARANCE REQUIREMENTS FOR EVOENERGY LOW VOLTAGE UG & OH NETWORK ASSETS IN NSW

TABLE 12. VEGETATION CLEARANCE REFERENCES

Where proposed works will encroach the existing vegetation at a distance less than that allowable in the above-mentioned drawings the designer must seek all approvals and allow for the required resources to resolve the clearance issues.

Proposed designs must minimise the ongoing costs of maintaining the network including activities in relation to vegetation management.

8.7 Required clearances to pools

Designers must consider the location of existing and proposed swimming pools and spas when specifying overhead network designs. Implications that relate to swimming pools in proximity to the overhead network include earthing and personal safety should a conductor become free from a nearby structure. Clearance requirements in relation to the overhead network and swimming pools are outlined in the drawing and document tabled below:

DRAWING/ DOCUMENT NUMBER	TITLE
3832-020	Clearance Requirement for Swimming Pool from Electrical Infrastructure
PO07127	Evoenergy Distribution Earthing Design Manual

TABLE 13. REFERENCE RELATING TO CLEARANCES TO POOLS

8.8 Required clearance to streetlight assets

The following clearances apply to streetlights: -

- 100mm from bare LV to street light bracket on same pole.
- 1200mm from bare HV (11kV or 22kV) to street light bracket on same pole.

8.9 Plant, conductor, and electrical apparatus clearance requirements

Where a designer specifies structure geometry which is non-standard the clearances should not be less than those outlined in Evoenergy drawing 392-43-06. If the listed separations outlined do not meet project objectives the designer may specify reduced clearances with approval. Where structure geometry is not in compliance with the referenced documents the safety in design report should outline the variations and any associated risks or controls.

DRAWING NUMBER	TITLE
392-43-06	Plant positioning guidelines pole top construction
392-43-07	Minimum bridging separations pole top construction

TABLE 14. REFERENCES FOR DETERMINING AMENDMENTS TO STRUCTURE GEOMETRY

8.10 Stay clearances

Clearance is required between energised conductors and stay wires to prevent flashover and clashing. The minimum separation under 500Pa wind is the phase to earth clearance from drawing 392-43-07:

- 85mm for LV
- 280mm for 11kV and 22kV

8.11 Aircraft navigation overcrossing marking

Overcrossing markers must be positioned to provide warning of an approaching electrical overcrossing. The designer must specify where markers must be placed in accordance with:

DRAWING NUMBER	TITLE
392-41-20	Air navigation Overcrossing Marker Assembly
AS 3891.1	Air Navigation - Cables and Their Supporting Structures - Marking and Safety Requirements

TABLE 15. AERIAL OVER CROSSING REQUIREMENTS

8.12 Railway crossings and line design within rail corridor/ easement

Evoenergy does not maintain standardised pole constructions or design processes for railway crossings or for any Evoenergy infrastructure to be constructed inside the rail corridor.

Railway corridor crossings should be avoided as far practicable. Should the need arise for overhead conductors to cross or enter a rail corridor the designer must consult the Railway Managing Authority on the matter, as varied standards apply to these sections of network.

Working in rail corridors requires specialised training and the hazards presented in these areas are not currently managed by Evoenergy. The designer must consult with internal stakeholders to ensure the works maybe completed and maintained by Evoenergy team members currently employed in the business.

At the time of drafting this document, UGL Regional Linx managed the Country Regional Network (CRN). For further information refer to the Country Regional Network document CRN ET 002 Requirements for Electric Aerials Crossing CRN Infrastructure.

The responsible designer must ensure approval is sort from the Network Services Manager prior to progressing the design beyond initial discussions with external stakeholders in relation to Evoenergy's appetite to maintain design and worker compliance of the crossing.

8.13 Water crossings

Designer's specifying network conductors that cross waterways must ensure the design process, specified hazard mitigation controls and the proposed design meets the requirements and/or recommendations of AS6947 *Crossing of waterways by electricity infrastructure.* Water crossings do not have a standardised design process as each water crossing has varied hazards and designs should be done so in collaboration with internal stakeholders. This approach should ensure that the asset is able to be constructed, maintained, minimises risk of harm to people, maintains network reliability and has acceptable environmental impacts.

8.14 Electric and magnetic fields (EMF)

Electric and magnetic fields (EMF) must be a considered when designing or augmenting sections of the overhead network. Resulting electric fields are proportional to the voltage, while magnetic fields are proportionate to the current. It is not established that EMF has adverse effects to human health, though is of concern to members of the public.

Standards Australia has issued a recommendation in SA/SNZ HB331 to observe a prudent avoidance approach. Prudence avoidance is described as "Doing what can be done without undue inconvenience and at modest expense to avert the possible risk" (Gibbs H, 'The Gibbs Report', 1991).

8.14.1 Strategies to reduce EMF risk

Increasing distance between where people may gather to the conductors, specifying network configurations, and selecting materials that reduce EMF are three effective strategies to reduce a potential risk to health from EMF.

8.14.2 Distance

Increasing the distance between the distribution network to where humans congregate reduces exposure to EMF. EMF densities reduce in a nonlinear curve over distance from the source. Minimum distances between network assets and the groundline are mandated through designing the network to AS7000, though where possible these distances should be maximised by selecting appropriate stringing tensions and positioning structures to maximise ground clearance.

Route selection in accordance with the "Design process" section of this document reduces the risk to society by selecting the route which poses minimal risk should EMF created by the distribution network cause adverse health effects.

8.14.3 Network configuration

EMF density increases with electrical current. Configuring the network in consideration to balancing electrical loads will reduce potential EMF risk. As far as reasonably practical distribution substations should be located centrally to the area the substation will typically supply to reduce the electrical current in the conductors.

Maximum demand levels from existing substations should be reviewed when augmenting or modifying the connected network. Where substations are unevenly electrically loaded, designers may have opportunity to address the imbalance through the network augmentation design. This may be done so by requesting construction teams to connect new single-phase services to a lightly loaded network phase.

8.14.4 Material/ standard construction selection

Selecting materials and construction types may reduce potential EMF risk. Opportunity especially exists in the low voltage network where EMF is reduced by specifying bundled conductor. The positioning of adjacent unlike phase conductors reduces the combined EMF produced. Typically, the closer conductors are to one another the lower the EMF produced.

Reduced interphase clearances on the 11kV and 22kV are unable to be achieved by selecting Evoenergy standard cables. Reducing clearances between bare MV conductors increases the risk of mid-span clashing and as such is not a viable solution to reduce EMF levels.

9. CONDUCTORS

9.1 Conductor selection

Bare conductor selection consists of consideration of wire size, shape and material, electrical, mechanical, environmental, and economic factors. Conductor selection involves the consideration of:

- Electrical requirements for load and fault current ratings and joule losses.
- Mechanical requirements including annealing, drag coefficient, operating temperature, constructability (no bird caging or unravelling), permanent elongation, fatigue endurance, conductor diameter, sag and strength relationship.
- Environmental requirements for corrosion and lightning damage; and
- Economic requirements for cost of losses, capital costs, load profile, interest rate, load growth, inventory costs and construction costs (ratio of tension to suspension structures).

In general, the following standard conductors shall be used for new lines:

HV	APPLICATION	CONDUCTOR
	Urban mains	Neptune 19/3.25mm AAC
	Rural mains	Mercury 7/4.50mm AAC
		Banana 6/1/3.75mm ACSR/GZ
	Rural take offs	Raisin 3/4/2.50mm ACSR/GZ
LV	**APPLICATION**	**CONDUCTOR**
	Residential service	LV 25mm^2 2 core TW
	Residential service	LV 25mm^2 4 core TW
	Commercial service	LV ABC 95mm^2 4 core TW
	Commercial service	LV ABC 150mm^2 4 core TW

TABLE 16. CONDUCTOR SELECTION

Only in special situations where standard conductors are not suitable other conductors may be used. For rural areas, underground or covered conductor is required for bushfire mitigation. The following are possible scenarios requiring non-standard conductors.

For rural where overhead must be used, Grape 30/7/2.50mm ACSR/GZ may be required for long span mains and Imperial (3/12G SC/GZ no longer preferred) for long span, low current.

LV ABC is preferred for all LV. For LV where bare overhead must be used, Neptune 19/3.25mm AAC or Mercury 7/4.5mm AAC may be used. Choose Neptune or Mercury based on current rating.

Copper conductors are not to be used for any new works and/or extensions.

No new, bare open wire LV conductors are to be installed in the Bushfire Abatement Zones (BAZ) or rural areas. No bare LV conductors to be used in the first span from the Pole Substation for new designs.

CCT or CC cables may be considered for HV lines subject to Asset Strategy & Planning approval:

- Near vegetation (present or future)
- Where there is a likelihood of objects falling or blowing onto the mains, e.g. Tree branches, chains Where wildlife may otherwise cause outages
- Where mains are likely to be contacted by crane jibs, boat masts or other objects
- For lines located near structures

Refer to drawing D204-0005 for details of standard overhead conductors, accessories, and interface assemblies

9.2 Conductor attributes

9.2.1 Electrical properties and ratings

9.2.1.1 Bare mains

CONDUCTOR				SUMMER DAY (A)	WINTER DAY (A)	WINTER NIGHT (A)
MATERIAL	TYPE	STRANDING	TEMP (°C)			
AAC	WASP	7/0.173"	75	375	477	525
			50	192	363	429
	MERCURY	7/4.50	75	386	492	541
			50	197	374	442
	HORNET	19/0.128"	75	478	610	675
			50	236	462	552
	NEPTUNE	19/3.25	75	478	610	675
			50	236	462	552
ACSR	RAISIN	3/4/2.50	75	133	167	182
			50	73	129	149
	FERRET	6/1/0.118"	75	210	266	289
			50	113	204	237
	APPLE	6/1/2.50	75	208	262	286
			50	112	201	234
	MINK	6/1/0.144"	75	265	335	367
			50	139	256	300
	BANANA	6/1/3.75	75	273	346	379
			50	143	264	310
	GRAPE	30/7/2.50	75	468	599	664
			50	228	452	543
	WOLF	30/7/0.102"	75	489	626	695
			50	236	472	568
STEEL	3/12	3/0.104"	75	50	62	67
			50	28	48	55
COPPER	7/2.00		75	182	229	247
			50	102	177	202
	7/.080"		75	186	233	252
			50	104	180	206
	7/.104"		75	256	322	350
			50	139	247	285
	19/.064"		75	260	328	357
			50	142	252	291
	7/2.75		75	268	339	368
			50	146	260	300
	19/.083"		75	358	453	495
			50	189	346	404
	7/3.50		75	360	456	499
			50	190	349	407
	19/.101"		75	455	578	635
			50	234	439	518
			75	495	630	694

CONDUCTOR				SUMMER DAY (A)	WINTER DAY (A)	WINTER NIGHT (A)
MATERIAL	TYPE	STRANDING	TEMP (°C)			
	19/2.75		**50**	251	478	566
	37/.083”		**75**	537	684	755
			50	270	518	616
	19/3.00		**75**	550	702	774
			50	275	531	632

TABLE 17. BARE MAINS CONDUCTOR ATTRIBUTES

Notes:

- Shaded values (75°C) are for new lines. Ratings at 50°C are for older lines.

Ratings are calculated for conditions shown below:

CONDITION	AMBIENT TEMPERATURE (°C)	SOLAR RADIATION INTENSITY (W/M^2)
Summer Day	35	1000
Winter Day	15	850
Winter Night	10	0

TABLE 18. BARE MAINS CONDUCTOR CONDITIONS

Notes:

- Wind speed 1m/s normal to conductor, Emissivity of conductor: 0.5, Solar absorption coefficient: 0.5

9.2.1.2 Covered conductors

MATERIAL	CONDUCTOR NAME	NOM. CSA (MM^2)	DC RESISTANCE @20°C (Ω/KM)	CURRENT RATING (A)	
				SUMMER DAY	WINTER NIGHT
CCT (AAAC 1120)	CCT40	41.6	0.713	190	253
	CCT80	77.3	0.383	280	375
	CCT180	182.80	0.163	470	648

TABLE 19. INSULATED MAINS CABLES ATTRIBUTES

Notes:

- *Conductor operating temperature 80°C for insulated cables, 40°C ambient, Wind speed 1.0m/s*

9.2.1.3 Low voltage mains/ service cables:

MATERIAL	CONDUCTOR	SUMMER DAY (A)	WINTER NIGHT (A)
XLPE (Cross-linked polyethylene) insulated, Aluminium conductors	LV ABC 25mm^2 2CTW	110	130
	LV ABC 25mm^2 4CTW	105	120
	LV ABC 95mm^2 4CTW	235	290
	LV ABC 150mm^2 4CTW	305	390

TABLE 20. LV SERVICES CABLES:

Notes:

- 150mm² LV ABC is used for commercial/industrial service lines with max conductor temperature 75°C.
- Values are rounded to nearest 1A for values below 100, rounded to nearest 5A for values above 100.

Environmental Conditions:

CONDITION	AMBIENT TEMPERATURE (°C)	SOLAR RADIATION INTENSITY (W/M^2)	WIND VELOCITY (M/S)
Summer Day	35	1000	1.0
Winter Night	10	0	0.0

TABLE 21. ENVIRONMENTAL CONDITIONS:

Note: There are number of two-phase connections in ACT; in such cases blue phase is doubled up with neutral on a 4-core service.

9.2.2 Mechanical properties

9.2.2.1 Bare mains

MATERIAL	CONDUCTOR NAME	STRANDS (NO./DIA.)		CSA (MM^2)	NOM. CABLE DIAMETER (MM)	NOM. BREAKING LOAD / UTS (KN)	MASS (KG/M)	MODULUS OF ELASTICITY (GPA)	LINEAR EXPANSION COEFFICIENT (/°C X 10^{-6})
		Metric (mm)	Imperial (inches)						
AAC (1350)	MERCURY	7/4.50		111.30	13.50	16.80	0.305	56	23
	NEPTUNE	19/3.25		157.60	16.25	24.70	0.433	56	23
	WASP		7/0.173	106.19	13.18	16.46	0.290	59	23
ACSR/GZ	APPLE	6/1/3.00		49.50	9.00	14.90	0.171	79	19.3
	BANANA	6/1/3.75		77.31	11.30	22.70	0.268	79	19.3
	CHERRY	6/4.75+7 /1.60		120.40	14.30	33.20	0.404	76	19.9
	RAISIN	3/4/2.50		34.36	7.50	24.40	0.195	139	19.3
	FERRET		6/1/.118	49.4	9.0	14.74	0.171	86	19.3
	DOG		6/.186+7 /.062	118.5	14.15	32.5	0.396	83	19.9
	WOLF		30/7/.102	194.9	18.13	69.2	0.732	80	18.4
SC/GZ (Steel – Galv.)			3/.104 (3/12)	16.77	5.1	21.85	0.130	193	11.5
	Steel Arial M6	3/2.75		17.82	5.93	22.20	0.139	193	11.5
		7/2.00		21.99	6.00	27.40	0.177	193	11.5
			7/.104 (7/12)	38.70	7.92	50.83	0.304	193	11.5
		7/2.75		41.58	8.25	51.80	0.326	193	11.5
	Steel Stay M10	7/3.25		58.07	9.75	72.30	0.460		11.5
	Steel Stay M14	19/2.75		112.9	13.8	133	0.894		11.5
	Steel wire Rope M12	7/7/1.34		75	12	81.2	0.553		11.5
HDC (Hard Drawn Copper)		7/1.00		5.5	3	2.31	0.049	118	17
		7/1.25		8.59	3.75	3.61	0.769	118	17
	HDBC 17	7/1.75		16.84	5.25	6.89	0.151	118	17

MATERIAL	CONDUCTOR NAME	STRANDS (NO./DIA.)		CSA (MM²)	NOM. CABLE DIAMETER (MM)	NOM. BREAKING LOAD / UTS (KN)	MASS (KG/M)	MODULUS OF ELASTICITY (GPA)	LINEAR EXPANSION COEFFICIENT (/ºC X 10^{-6})
		Metric (mm)	Imperial (inches)						
	HDBC 22	7/2.00		21.99	6	9.02	0.197	118	17
	HDBC 42	7/2.75		41.58	8.25	16.7	0.373	118	17
		19/1.75		45.7	8.75	18.3	0.413	116	17
		19/2.00		59.69	10	23.9	0.538	116	17
		7/3.50		67.35	10.5	26.6	0.603	118	17
		37/1.75		89	12.3	35.6	0.806	115	17
		19/2.75		112.9	13.8	44.5	1.020	116	17
		19/3.00		134.3	15	52.8	1.210	116	17
		37/2.50		181.6	17.5	72.9	1.640	115	17
		37/2.75		219.8	19.3	86.6	1.990	115	17
			7/.064 (7/16)	14.5	4.87	6.1	0.131	124	17
			7/.080 (7/14)	22.7	6.09	9.45	0.206	124	17
			7/.104 (7/12)	38.4	7.92	15.78	0.348	124	17
			19/.064 (19/16)	39.4	8.12	16.2	0.357	124	17
			19/.083 (19/14)	66.3	10.54	26.97	0.603	124	17
			19/.101 (19/12)	98.2	12.8	39.64	0.890	124	17
			19/.116	129.6	14.73	51.72	1.175	124	17
			37/.083 (37/14)	129.1	14.75	51.5	1.170	124	17

TABLE 22. BARE MAINS MECHANICAL PROPERTIES

Notes:

- Conductors other than current preferred sizes are included for reference purposes.
- Conductor data is generally in accordance with Australian Standards and may differ slightly.

9.2.2.2 LV ABC and CCT cables

MATERIAL	CONDUCTOR NAME	CSA (MM²)	NOM. CABLE DIAMETER (MM)	NOM. BREAKING LOAD / UTS (KN)	MASS (KG/M)	MODULUS OF ELASTICITY (GPA)	LINEAR EXPANSION COEFFICIENT (/ºC X 10^{-6})
CCT (AAAC 1120 / 3.4mm XLPE)	CCT40	41.6	15.6	9.9	0.25	65	23
	CCT80	77.3	18.6	17.6	0.4	65	23
	CCT180	182.80	24.90	41.70	0.78	65	23
LV ABC (AAC / XLPE)	LV ABC95 (4C)	4 x 95	38.40	53.20	1.35	56	23
	LV ABC150 (4C)	4 x 150	45.60	84.00	2.02	56	23

TABLE 23. LV ABC AND CCT CABLE'S MECHANICAL PROPERTIES

9.2.2.3 Broadband communications cables

NETWORK	CONDUCTOR NAME	CSA CATENARY (MM²)	NOM. CABLE DIAMETER (MM)	NOM. BREAKING LOAD / UTS (KN)	MASS (KG/M)	MODULUS OF ELASTICITY (GPA)	LINEAR EXPANSION COEFFICIENT (/°C X 10⁻⁶)
Telstra	Catenary	23.1	6.15	28.75	0.176	170	11.52
	Catenary + 1 Coax	23.1	18.85	28.75	0.324	170	11.52
Optus	Catenary	30	7.0	37.35	0.18	193	11.52
	Catenary + 1 Coax	30	24.5	37.35	0.361	193	11.52
TransACT 1	7/2.00mm SC/GZ Catenary	21.99	6	27.4	0.177	193	11.52
TransACT 1	7/2.00mm SC/GZ Catenary	21.99	6	27.4	0.177	193	11.52
	Catenary + Green bundle	21.99	35	27.4	0.677	193	11.52
	Catenary + Red bundle	21.99	40	27.4	0.847	193	11.52
	Catenary + Black bundle	21.99	45	27.4	1.062	193	11.52
TransACT 2	6/1/3.75mm ACSR Catenary	77.31	11.3	22.8	0.268	79	19.3
	Catenary + Green bundle	77.31	35	22.8	0.715	79	19.3
	Catenary + Red bundle	77.31	40	22.8	0.885	79	19.3
	Catenary + Black bundle	77.31	45	22.8	1.1	79	19.3

TABLE 24. BROADBAND COMMUNICATIONS CABLES MECHANICAL PROPERTIES

9.2.3 Engineering notes

9.2.3.1 Conductor materials

Whilst copper has the lowest resistivity it is now being replaced by aluminium in most applications due to cost. Bare copper was previously used for distribution lines but is now being replaced by Aluminium. Copper is heavier than Aluminium, so it sags more.

There are number of Aluminium alloys that have been used in Australia. They include 1350, 1120 and 6201. 1350 is virtually pure Aluminium and is manufactured in a range of conductors known as AAC (All Aluminium Conductor). 1350 has the lowest resistance of all the alloys but also has the lowest strength. As strength is not important for distribution with short spans, 1350 is the best conductor for urban distribution. 1120 and 6201 are alloys of Aluminium that have higher resistance but also higher strength. Consequently, these alloys are used for rural distribution, sub-transmission, and transmission where strength is important to reduce sag on longer spans. AAC 6201 is no longer manufactured in Australia but was used for some of the early transmission lines e.g. in the Snowy Mountains and Hamersley Iron.

ACSR (Aluminium Conductor Steel Reinforced) has a galvanised steel core with outer layers of Aluminium. The steel core provides strength, and the outer Aluminium provides conductivity. This conductor is very strong, so it has low sag for long spans and is used for rural distribution, sub-transmission, and transmission.

SC/GZ (Steel Conductor Galvanised) is high strength but with high resistance. Consequently, it is used for rural distribution. SC/GZ is also used for stay wires on highly loaded poles.

9.2.3.2 Conductor designations

Conductors can be identified by their material, e.g. AAC and stranding e.g. 7/4.5 which means 7 strands of

4.5mm diameter, or by a unique name e.g. Mercury. Different sizes of conductor made of the same material and often named in a series e.g. Australian AAC series are named after planets and Imperial AAC series are named after insects. Australian ACSR series are named after fruit and the Imperial ACSR series are named after animals.

For conductors made up of the same size strand, each layer has six more strands than the previous layer. All conductors start as one central king wire, the first layer has 6 strands, the second layer has 12 strands, the third layer has 18 strands and so on. Consequently, the overall diameter can be calculated as follows: -

- 7 strands are 3 times the diameter of a single strand
- 19 strands are 5 times the diameter of a single strand
- 37 strands are 7 times the diameter of a single strand

9.2.3.3 Insulated/ Covered conductor

Insulated/covered conductors are used in the following areas to prevent flashover:

- Occasional contact with nearby vegetation
- High incidence of animal contact
- Bushfire prone requiring prevention of clashing

Insulated conductors have a metallic screen (e.g. HV cables used in UG/OH or HV dropper leads for Tx) while covered conductor (e.g. HV CCT) does not. Consequently, covered conductor is not considered touch safe.

9.2.3.4 Conductor ageing and thermal effects

Corrosion can reduce the effective cross section of conductors causing loss of strength and increased sag. Different materials have different corrosion susceptibility, and this must be considered for industrial and marine pollution. This is not expected to be a problem in the relatively clean environment of the ACT for the standard conductors used.

If conductors are run at elevated temperatures they can be annealed when they cool down, losing strength and increasing sag. Annealing effects are cumulative so the effects of overloads over time may cause excessive sag and loss of Statutory ground clearance. Consequently, conductor maximum temperatures must be limited to prevent excessive annealing over the life of the overhead line. To limit loss of strength to 3% for 1000hours operation, bare Copper and Aluminium alloys should be limited to 100ºC maximum continuous operating temperature.

For transient fault currents, the maximum temperature of common conductor materials should be limited to the following temperatures: -

- 200 ºC for bare Copper, 160 ºC for Aluminium alloys, on the basis of annealing as these materials lose 10% strength at 220 ºC and 210 ºC, respectively.
- 400 ºC of SC/GZ as Zinc melts at 420 ºC.

For LV ABC/covered conductors the maximum continuous operating temperature is limited by the polymeric material to 80ºC. Insulated service lines are limited to 75 ºC due to the insulation.

9.2.3.5 Continuous current rating

The continuous thermal rating is calculated based on a steady state energy balance. In steady state, the conductor temperature is constant, and the heat input is matched by the heat lost. Heating sources are direct and indirect (reflected from the ground), solar radiation and joule heating (i.e. I2R). Heat is lost by convection and radiation from the conductor surface. (Note that heat can also be lost by evaporation of rainwater, but this is not usually considered in the calculation.) Reference 7 explains all aspects of conductor thermal rating.

The steady state thermal current rating of a conductor can also be interpreted as the maximum current inducing the maximum steady state temperature for a given ambient condition. The heat balance equation can be represented mathematically as: -

- $P_j + P_s = P_r + P_c$

Where the heat gain terms are Pj which is the joule heating due to the resistance of the conductor and Ps is the solar heat gain. The heat loss terms are Pc which is natural and forced convection cooling and Pr is the radiation cooling. Note that joule heating is I2 R, and the above equation is solved for current.

Following figure shows the heating and cooling effects on a conductor:

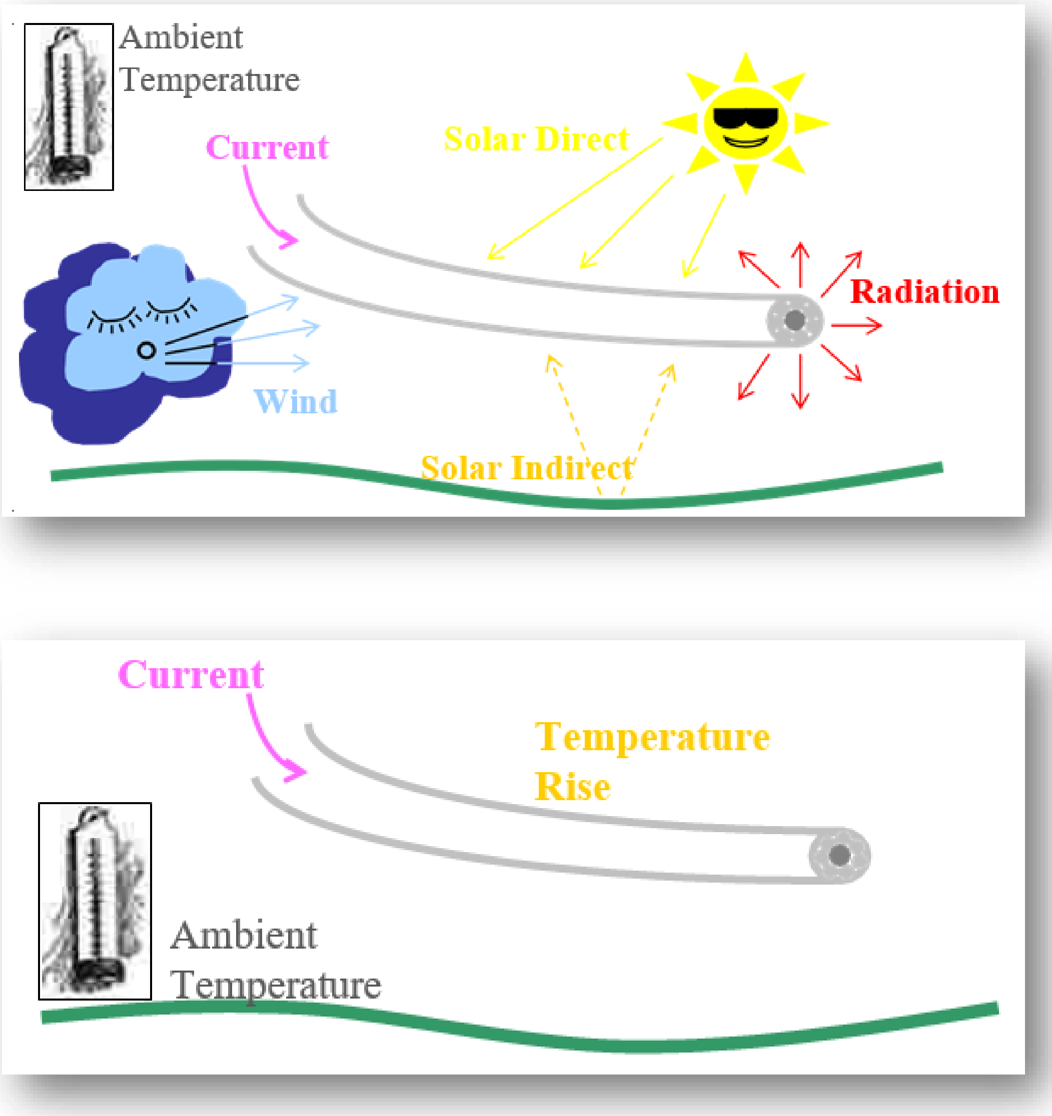


FIGURE 4. HEATING AND COOLING EFFECTS ON A CONDUCTOR

Typically, weather data is analysed to determine an ambient temperature/wind speed pair of values that have a low probability of being exceeded. The dominant parameter is wind speed. The traditional wind speed used was 2 ft/second (i.e. 0.6 m/s). Generally, wind speeds in the range 0.5 to 1 m/s are used. In the past, low maximum operating temperatures such as 49ºC have been used resulting in negligible rating in summer. A high maximum operating temperature needs to be used (e.g. greater than 60ºC) otherwise there is insufficient temperature rise to provide adequate current rating in summer.

9.2.3.6 Fault current rating

Fault ratings are calculated based on adiabatic heating. It is assumed that no heat is lost or gained during the short period of the fault. All the fault energy (i.e. Joule heating I2R) goes into raising the temperature of the conductor and no heat is lost by convection, nor radiation from the surface.

9.2.3.7 Voltage drop

Voltage drop along conductors due to load current must be checked to ensure it is within allowable range. Refer to Clause 5.7. In certain situations, current flow direction can reverse e.g. due to photovoltaics and other power sources. Voltage drop is due to current flow through not only resistance but also the reactance of conductors.

9.2.3.8 Typical conductor maximum temperatures

Maximum operating temperature is a function of the acceptable level of tensile strength of the conductor. The loss of tensile strength results to increase the sag. Typical conductor types and maximum operating and short circuit temperatures are given in the AS7000 Table AA4.

9.3 Conductor stringing

9.3.1 Conductor stringing tensions

Typical stringing tensions are provided as a percentage of conductor calculated breaking load at design temperature of 15ºC.

9.3.1.1 AAC

SPAN LENGTH (M)	APPLICATION	DESIGN TENSION (%CBL)
10-30	Slack	2.5
30-80	Urban	5
50-120	Semi-urban	10
100-170	Rural	20

TABLE 25. AAC

9.3.1.2 ACSR

SPAN LENGTH (M)	APPLICATION	DESIGN TENSION (%CBL)
150-300	Rural	22

TABLE 26. ACSR

9.3.1.3 LV ABC

SPAN LENGTH (M)	APPLICATION	DESIGN TENSION (%CBL)
10-30	Slack	2.5
30-80	Urban	5
50-120	Semi-urban	10

TABLE 27. LV ABC

Note: AAC span, and tensions can also be applied to LV service lines.

9.3.2 Stringing tensions limits

Conductor tension should be limited to prevent fatigue failures at attachment points. Recommended maximum values are given in AS/NZS7000 Appendix Y, Table Y1, Conductor Everyday Load Horizontal Tension.

Tensions in Table Y1 are based on the average temperature of the coldest month as this is when the tension will be highest. High tension reduces self-damping of the conductor and may allow excessive bending stress at attachment points due to Aeolian vibration. Aeolian vibration occurs when low speed laminar wind flows perpendicular to the conductor causing low amplitude (typically one or two diameters) vibration.

The maximum allowable tension is a function of the material in the conductor, the type of clamps and terrain. For example AAC conductor base tension limit is 18% CBL. This increases to 20.5% with helical formed ties with armour rods. If fully damped as well then, the tension limit increases to 27%CBL.

9.3.3 Creep allowance

Conductor creep allowances to be applied:

- No allowance ≤10%CBL stringing tension
- Subtract 15ºC for AAC >10%CBL stringing tension
- Subtract 12ºC ACSR >10%CBL stringing tension.

9.3.4 Engineering notes

9.3.4.1 Mean equivalent span

The mean equivalent span (MES), also known as the equivalent span or the ruling span (RS), is defined as that level dead-end span whose tension behaves identically to the tension in every span of a series of suspension spans under the same loading conditions. Every 1km or less a strain structure should be installed. The ruling span concept can only model a uniformly loaded section, that is, where identical wind and/or ice span exists on all spans in the section.

It is assumed that the attachment point is free to move along the line and there is adequate travel to equalize the tension in adjacent spans without transferring any longitudinal load onto the structure. In general, spans shorter than the ruling span tend to sag more than predicted whilst spans longer than the ruling span sag less than predicted at temperatures above the stringing temperature (assuming that the tensions were equal at the time of stringing conductor).

9.4 Line deviation limitations

Approved standard constructions are limited by line deviation. This section outlines the maximum line deviation that relates to standard constructions.

Line deviation is the angle to which the conductors of a circuit can deviate on a single structure measured in degrees.

9.4.1.1 Maximum LV ABC line deviation

CONSTRUCTION DESCRIPTION	EXAMPLE OF CONSTRUCTION TYPE	MAXIMUM ALLOWABLE LINE DEVIATION
Inline or single suspension	D202-0036	25°
Double suspension or Yoke	D202-0039	50°
Double termination / strain	D202-0040	N/A

TABLE 28. LINE DEVIATION ATTRIBUTES LV ABC

9.4.1.2 Maximum LV Bare mains line deviation

CONSTRUCTION DESCRIPTION	EXAMPLE OF CONSTRUCTION TYPE	MAXIMUM ALLOWABLE LINE DEVIATION
Inline – Top tie	D202-0024	3°
Inline- Side tie	D202-0024	15°
Double Strain	D202-0026	30°
Double termination	D202-0029	N/A

TABLE 29. LINE DEVIATION ATTRIBUTES BARE LOW VOLTAGE MAINS

9.4.1.3 Maximum 11kV/ 22kV Bare mains line deviation

CONSTRUCTION DESCRIPTION	EXAMPLE OF CONSTRUCTION TYPE	MAXIMUM ALLOWABLE LINE DEVIATION
Inline – Top tie	D201-0026	10°
Inline- Side tie	D202-0026	15°
Double Strain	D201-0027	30°
Double termination	D201-0029	N/A

TABLE 30. LINE DEVIATION ATTRIBUTES 11 AND 22KV MAINS

9.5 Conductor stress and fatigue

Fatigue failure of OH line conductors occur exclusively at the points where the conductor is secured to fittings. Causes of such failures are due to dynamic stress induced by vibration, combined with high static stress.

Designers should allow for the installation of vibration dampers, preform ties over armour rods must be considered for HV overhead lines.

10. POLES

10.1 Pole selection

10.1.1 Low voltage structures

The low voltage overhead network is typically located on leased land and is often not readily accessible. Due to restricted access and the 2003 bush fires, timber poles are not installed in backyards. Composite fibre poles are preferred in backyards. Concrete is used for higher loads, where there is good access and also in fire prone areas.

Concrete poles should not be installed in backyards due to the conductive properties of the structures.

For LV distribution lines, 9.5m long poles are typically specified. 11m long poles are used where additional ground or inter-circuit clearance is required.

The noted unit assemblies detail the pole specification including hole placements. Note concrete poles and composite fibre poles must not be drilled, should items need to be fit in locations to which holes are not provided, pole bands maybe utilised.

10.1.2 Medium voltage structures (11/22kV)

12.5m long concrete poles are the standard pole height for 22kV and 11kV structures. 14m or 15.5m concrete poles are used for HV where more clearance is required.

Non-conductive poles maybe specified as required where compliance to the Evoenergy earthing design manual is not possible with a concrete structure. The use of non-conductive poles are not preferred due to the lower cost of concrete poles and pole butt width of the approved non-conductive pole.

10.2 Pole types

10.2.1 Pole material

Three main material types are used in the manufacturing as below.

- Steel Reinforced Concrete (SRC) poles
- Fibre Reinforced Polymer (FRP) “Composite” poles
- Fibre Reinforced Cement (FRC) poles

10.2.2 Hole pattern “Type”

Pole description states the word “Type”, where “Type” defines the hole pattern or number of through holes in the X axis, Y axis, pole steps ferrules, earth ferrules that is uniquely specified in each pole part drawing, for various purposes.

For example:

- Type 1/1B hole pattern is suitable for LV circuits general assembly (mounting cross arms and conductors).
- Type 3/3C hole pattern is suitable for transformer mounting, and HV/LV circuits.
- Type 4/4C/4S hole pattern is suitable for HV/LV general assembly and for mounting switchgear (Recloser, Gas switch, Air break Switch, UG/OH)

Please refer to each pole part drawing for specific hole type details.

10.3 Pole rules

If pole tip load increases by more than 1kN then the pole must be inspected, mechanically tested, or replaced.

Generally, service line loads that are slack strung (i.e., less than 2.5%) can be ignored. In commercial/industrial areas with multiple larger size service lines, the service line loads must be included in the design.

There is no need to include wind on cross arms and small accessories as an allowance has been made in the limit state tip load. However, wind loads on large accessories must be included (i.e. equal to or greater than 100kVA transformers).

10.4 Pole–mounted switchgear

For general guidance on selecting an appropriate type of switch for application on the 11 kV and 22 kV overhead distribution network, refer to Appendix 1.

Refer to table 31 below for data on pole mounted plant that can be used to calculate wind loads.

PLANT ITEM	HORIZONTAL OFFSET FROM POLE AXIS (MM)	FACE AREA (M^2)	SIDE AREA (M^2)	WEIGHT (KG)	ATTACHMENT HEIGHT (M)
100kVA TRFR	495	0.892	0.535	765	7.4
100A REG	330	2.106	1.264	1956	-
200kVA TRFR	412	1.029	0.617	1055	7.4
200A REG	330	2.38	1.428	2836	-
315kVA TRFR	439	1.206	0.724	1425	7.7
500kVA TRFR	480	1.243	0.75	1970	7.4
NGK Gas switch	650	0.53	0.81	110	8.7
INSULECT Gas switch	900	0.22	0.32	90	8.7
Schneider Recloser	690	0.43	0.4	128	6.7
Noja Recloser	1200	0.53	0.43	100	8.5
ABB Air Break Switch	0	0.59	0.41	100	10

TABLE 31. POLE MOUNTED PLANT

Notes:

- Rural transformer attachment height is 7.55m from drawing D203-0001
- TRFR is abbreviation for transformer
- REG is abbreviation for regulator
- Horizontal offset from pole axis is the horizontal distance from pole axis for the line of action of the transformer weight
- Face area is perpendicular to line
- Side area is parallel to line
- NGK Gas switch large side area is due to insulators and arresters
- Weight for ABB Air break switch is approximate

10.5 Constraints on the use of certain poles

Following constraints are applicable to poles and may not be used in certain situation.

TYPE OF THE POLE	REASON FOR THE CONSTRAINTS
Steel Poles	Not to be installed in the Evoenergy Network in Future, due to its conductive nature.
Concrete Poles	Not to be installed in the residential backyards and used as a utility (LV pole) due to its conductive nature.
Timber Pole with Creosote	Must not to be installed in the Evoenergy Network in Future, due to the oil-type preservative may cause skin irritation.
Timber Pole with CCA - Chromated Copper Arsenate	Must not to be installed in the Evoenergy Network in Future, due potential harm to public and personnel due to toxic chemicals used in treatment.

TABLE 32. POLE CONSTRAINTS

11. FOUNDATION

11.1 General

Standard footing details are as per the following Evoenergy drawings.

DRAWING NUMBER	TITLE
D204-0014	OVERHEAD, CONDUCTORS AND ACCESSORIES, SA, POLE FOUNDATION, CONCRETE, FIBRE REINFORCED CEMENT POLES
D204-0017	OVERHEAD, CONDUCTORS AND ACCESSORIES, SA, POLE FOUNDATION, 9.5m COMPOSITE POLES

TABLE 33. POLE FOUNDATION DETAILS

Rule of thumb method of calculating the embedment depth of poles is based on 10% length plus 600mm.

AS/NZS 7000 and SA/SNZ HB331 state the mathematical formula to calculate the embedment depth based on soil condition, effective width of footing, pole height and pole tip load.

11.2 Footing design for directly embedded poles

Pole foundation should be designed based on appropriate engineering soil properties. Where soil test information is not available, an estimate of soil parameters must be made based on the site conditions, soil types. Soil parameters provided within this section can be used as a guideline for design. However, it must be confirmed by inspection during construction that the soil parameters are appropriate.

11.2.1 Serviceability limit state bearing strength (fb)

Below table provide a simple classification of soil types, with bearing strengths based on a degree of firmness or resistance to indentation.

Class	Very soft	Soft	Firm	Very firm	Hard
Soil description	Silty clays and sands; loose dry sands	Wet clays; silty loams; wet or loose sands	Damp clays; sandy clays; damp sands	Dry clays; clayey sands; coarse sands; compact sands	Gravels; dry clays
Bearing Strength (f_b) kPa	$f_b \leq 60$	$60 < f_b \leq 100$	$100 < f_b \leq 150$	$150 < f_b \leq 240$	$240 < f_b$
NOTE The above values are based on foundation deformations of approximately 12 mm under serviceability loads on building structures. For poles supporting services that are sensitive to displacements at their supporting points (e.g. microwave antennas), this degree of deformation might be inappropriate. Therefore, suitable reduction of these values may be necessary. This may be achieved by increasing the embedment depth, or the footing diameter, or both, which will reduce the bearing pressures and, consequently, the deformations.					

FIGURE 5. BARING STRENGTHS OF SOIL, AN EXTRACT FROM THE SA/SNZ HB331

11.2.2 Serviceability limit state shear strength (c_u)

The consistency of cohesive soils describes the ease with which the soil can be remoulded. Consistency is described using the terms below.

In the field, consistency of soil may be assessed either by tactical means, or by measuring the undrained shear strength by mechanical testing.

The shear strength of soil must be taken as not greater than $0.4f_b$, where f_b is the value obtained from below figure 6.

TYPICAL PROPERTIES OF COHESIVE SOILS

Term	Unit weight (kN/m^3)	Shear strength, C_u (kPa) Undrained	Field guide to consistency
Very soft	16–19	0 to 10	Exudes between fingers when squeezed in hand
Soft	17–20	10 to 25	Can be moulded by light finger pressure
Firm	17.5–21	25 to 50	Can be moulded by strong finger pressure
Stiff	18–22	50 to 100	Cannot be moulded by fingers. Can be indented by thumb
Very stiff	21–22	100 to 200	Can be indented by thumb nail
Hard	20–23	≥200	Can be indented with difficulty by thumb nail

FIGURE 6. FIELD GUIDE TO CONSISTENCY FOR COHESIVE SOILS, AN EXTRACT FROM AS7000 TABLE L1

Note;

- Further information on typical soil properties is available on AS/NZS 7000 Table L2 to Table L3.

11.3 Calculation of embedment depth

The embedment depth formular (see equation 2) can be derived by maintaining static equilibrium on the pole (see figure 7).

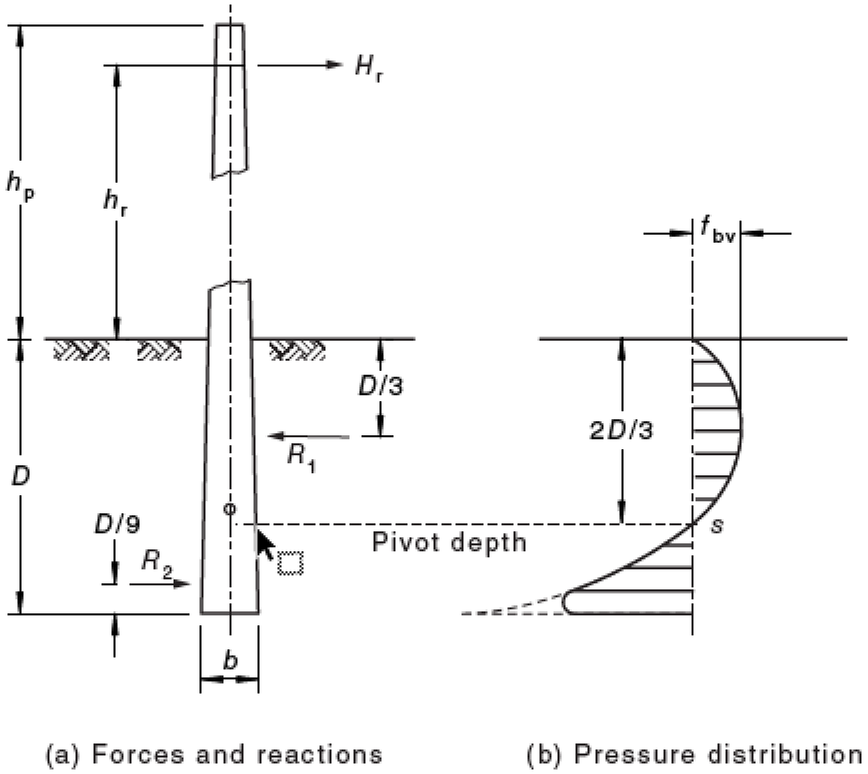


FIGURE 7. FORCES ON FOOTINGS AND DIRECT EMBEDMENT FOUNDATION, AN EXTRACT FROM THE SA/SNZ HB331 FIGURE 10.3

$$D = \frac{3.6H_r + \sqrt{12.96H_r^2 + 16.2CM}}{2C} \qquad 10.3(4)$$

where

C = $b \times f_{bu}$ for ultimate limit state, or $b \times f_b$ for serviceability limit state

- f_b = serviceability limit state bearing strength of the foundation material (kPa)
- f_{bu} = strength limit state bearing strength = $1.5f_b$
- b = effective width of the foundation, projected on a plane perpendicular to the direction of the *resultant* horizontal force acting on the pole (m)

M = overturning moment acting on the pole at ground level (kNm)

= $H_r \times h_r$

- H_r = resultant of the horizontal forces acting on the pole (kN)
- h_r = height above ground level at which H_r acts (m)

EQUATION 2: DIRECT EMBEDMENT CALCULATION, AN EXTRACT FROM THE SA/SNZ HB331 EQUATION 10.3

11.4 Minimum embedment depths for Evoenergy standard poles

APPLICATION & HOLE TYPE	POLE HEIGHT	HORIZONTAL FORCE	EFFECTIVE HEIGHT	SOIL STRENGTH	HOLE WIDTH	EMBEDMENT DEPTH
	(m)	H_r (kN)	h_r (m)	(kPa)	b(m)	**(m)**
LV- TYPE 1/1B	9.5	8	7.65	150	0.6	**1.6**
LV- TYPE 1	9.5	12	7.25	150	0.6	**2.0**
LV- TYPE 1	11.0	8	8.95	150	0.6	**1.8**
HV/LV- TYPE 4/4C	12.5	8	10.5	150	0.6	**2.0**
HV/LV- TYPE 4	12.5	12	10.2	150	0.6	**2.3**
HV/LV- TYPE 3/3C	12.5	8	10.3	150	0.6	**2.2**
HV/LV- TYPE 4S	14.0	8	12.0	150	0.6	**2.0**
HV/LV- TYPE 4S	15.5	8	13.4	150	0.6	**2.1**
Sub Transmission	17.0	12	14.6	150	0.75	**2.4**
Sub Transmission	18.5	12	16.0	150	0.75	**2.5**
Sub Transmission	20.0	12	17.4	150	0.75	**2.6**
Sub Transmission	21.4	12	18.7	150	0.75	**2.7**

TABLE 34. MINIMUM EMBEDMENT DEPTHS FOR EVOENERGY STANDARD POLES

Notes;

- Table 34 has been prepared from the equation 2, (equation 10.3 of the SA/SNZ HB331) for the standard Evoenergy LV/HV poles. For the standard foundation drawings, see table 33.
- Embedment depth is calculated based on horizontal forces on the tip of the pole (serviceability strength, H_r), effective height above ground (h_r), bearing strength of soil (f_b) and effective width of footing (b).
- Bearing strength of soil (f_b) is assumed as 150 (kPa).
- Backfill material must be fine crushed rock (DGB20 road base) and must be compacted in layers of not exceeding 200mm, for the effective width of footing (b) to be assumed as the hole width.
- The depths include the additional 0.2m to allow for soil shrinkage in the groundline zone.
- Additional moment created by weight of switchgear is considered within the calculated "Overturning moment action on pole (M)" for Substation Pole "HV/LV-Type 3/3**C**" and for Switchgear Poles "HV/LV-Type 4/4C/4S".
- Where the bearing strength of soil is "Soft" or "Very soft" (see figure 5), alternative footing design must be considered to either increase the embedment depth or use a different backfill material to strengthen the footing such as concrete encasement.

12. STAYS

12.1 General

Free standing poles of higher strength are preferred over poles with stays.

Stays are required when the applied tip load is greater than the serviceability limit of the pole, recommended embedment depths cannot be achieved, and soil strength is less "firm''.

Following Stay options are available.

- Conventional ground stay
- Head or aerial stay
- 1.2m long sidewalk stay
- 2.4m long sidewalk stay

12.2 Ground stays

Ground stays are preferred over aerial, and sidewalk/footpath stays. Standard angle is 45° to the ground. Where space is reduced, maximum angle is 60° to the ground. Note that the tension in the stay increases with angle to the ground. Stays should be attached to the pole close to the conductor load attachment point. It is preferred that there are no stays installed in backyards however stays may be installed where footing or tip loadings are exceeded with the no stay design option or where additional tip loadings require stay installation to allow the overhead line design to remain compliant

For new lines, poles that are stayed should be rated for half the applied tip load under wind conditions, if practicable. (This may not be practical on tight strung rural lines.)

12.3 Aerial stays

Aerial stays should be installed where the use of a ground stay is not suitable. Aerial stays are often required where the use of a ground stay would block a thorough fare used by vehicles (e.g. a road or driveway). If the aerial stay is attached to two Evoenergy structures with energised assets installed the installation of at least two stay insulators is required.

12.4 Sidewalk stays

Sidewalk stays should only be specified where necessary. The sidewalk stay has little ability to effectively counter horizontal forces applied to the pole structure. For this reason, they should only be specified where there is very limited space, the resultant conductor load transferred to the pole is small and the installation of a ground stay is not possible. The 2400mm sidewalk stay strut is preferred over the short 1200mm strut.

12.5 Stay wire/ fittings

Standard stay wires and fittings must only be specified for permanent installation of stays. Where required existing stays maybe repaired or transferred to reinstated ground anchors. For this reason, fittings compatible with legacy stay wires will remain a stocked item (though the wire will not).

STANDARD STAY WIRE	
M12 Braided galvanized steel rope	Minimum calculated breaking load- 81kN Maximum allowable stay tension – 32.4kN
19/2.75 Galvanised steel conductor	Minimum calculated breaking load- 133kN Maximum allowable stay tension – 53.2kN (=133 x 0.4)

TABLE 35. STANDARD STAY WIRE

M12 wire rope is the preferred stay wire. This product is more easily installed and reduces risk of injury to construction team members. 19/2.75 should be specified only where necessary, this product is heavy and is hard to bend.

A serviceability reduction factor of 0.4 has been applied to the minimum calculated breaking loads to allow for the reduction of product strength observed over a long period. The serviceability factor is appropriate due to the friction point where the guylok and stay wire connect.

Where appropriate, a strength reduction factor of 0.8 is recommended by the AS7000.

12.5.1 Stay insulator requirements

Stay insulators must be provided to all stays regardless of construction types. The position of the stay insulator must be so that should the stay lose tension that the stay section connected to pole is electrically separated to the lower section. The resting/ broken stay wire must have the insulator positioned at least 2700mm above ground line.

The stay insulator electrical rating must be specified for the greatest circuit voltage on the structure (i.e. a mixed 11kV and 240V structure must have an insulator of at least 95kV BIL- suited to the 11kV network). The fixed position of the stay and the network conductors does not limit the need of an insulator to be installed in the stay.

12.6 Standard stay constructions

STANDARD STAY WIRE CONSTRUCTIONS	
D204-0008	Standard stay on a concrete or composite pole (19/2.75 SC)
D204-0010	Aerial Stay on concrete or composite pole (19/2.75 SC)
D204-0013	Sidewalk stay on a concrete or composite pole (19/2.75 SC)
D204-0031	Standard ground stay at 45-60 deg; vertical footing, M20 stay rod anchor type, with M12 steel rope.
D204-0032	Aerial Stay at 13-30 deg; with M12 steel rope.
D204-0033	Sidewalk Stay, Vertical footing, platypus K60 anchor type, with M12 steel rope.
D204-0034	Standard ground stay at 45-60 deg; anchor to ground w/o/ footing, platypus K60 anchor type, with M12 steel rope.
D204-0035	Sidewalk Stay, Vertical footing, M20 stay rod anchor type, with M12 steel rope.
392-2-02	TransACT cables/ stays.

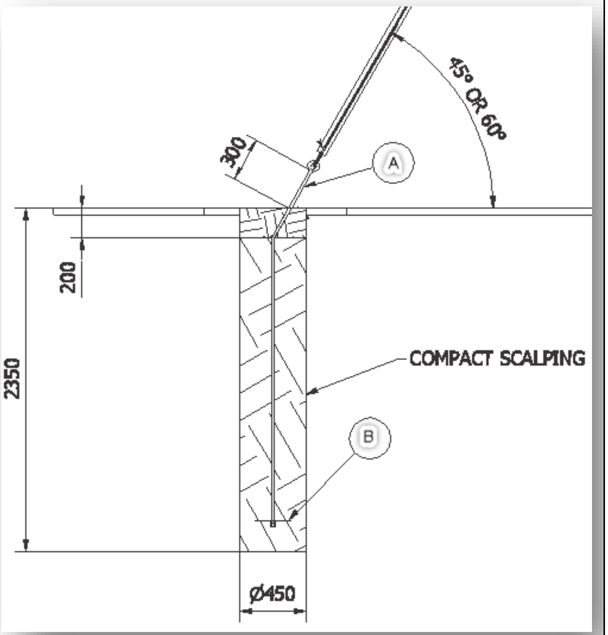
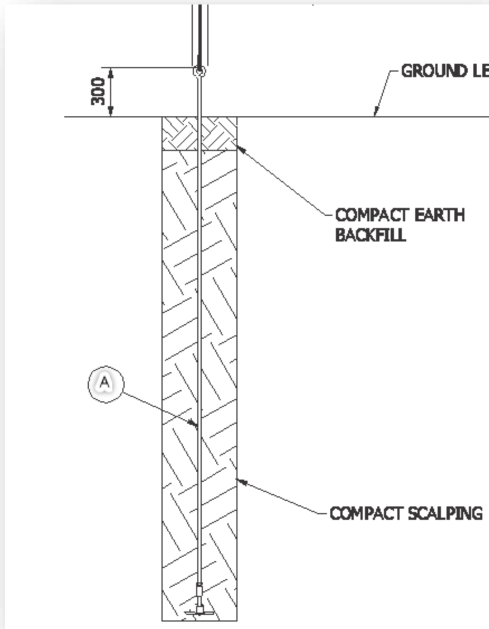
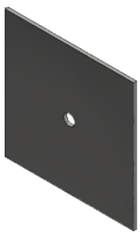
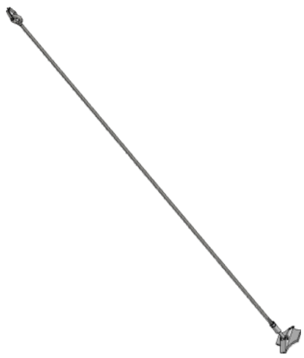
TABLE 36. STANDARDS STAY CONSTRUCTIONS

12.7 Foundations/ footing

For both the stays wires options, a vertical footing is recommended with below anchor rods.

- For the M12 SC/GZ stay, a vertical foundation is installed with the “Platypus” anchor which has a proof load of 35kN. This proof load sets the maximum load on the stay and connections.
- For the M14 19/2.75mm SC/GZ stay, a vertical foundation is installed with the M20 stay rod, square washer, which has a minimum tensile strength of 95kN. Therefore, for a 45 deg stay, maximum stay load is set as 67kN.

Following stay footing configurations are available, for the ground stays (45 to 60 deg) and sidewalk stays.

FOR 19/2.75 SC STAY WIRE	M12 STEEL WIRE ROPE
	
Extract from D204-0031 VERTICAL FOOTING WITH COMPACT SCALPING AND A: STAY ROD, M20 X 2500MM LG, GALV, C/W HEX NUT – 1065725, D104-0043; AND B: SQUARE WASHER, M20, 250 X 250 X 6  	Extract from D204-0033 VERTICAL FOOTING WITH COMPACT SCALPING AND A: STAY, TIGHTER ANCHORS TYPE K60 C/W M20 CLEVIS, 3M X M20 GALV THREADED ROD, – 1170865 - D104-0047 
Tensile failing load of the anchor rod is 95kN	"Platypus" anchor rod is load tested for 35kN

12.8 Stay loading consideration

Both the footing strength and stay wire tension must be considered when determining the counter force for the tip load.

Preferred installation angle for ground stays is 45º to the horizontal, maximum 60º.

For head, or aerial stays, maximum angle to horizontal is 30º.

The determination of the loadings considers the efficiency of the stay installed at the maximum allowable tension. The stated kN values are that of the combined total horizontal resultant load applied to the pole.

The stay must be specified to withstand the calculated resultant horizontal forces applied to the pole structure. The designer must not consider that the pole structure will share the load. Should the pole move for any reason (weak footing, wind loading, deflections etc) the full resultant load could be transferred to the stay assembly.

STAY TYPE	Θ	F	F
		M14: 19/2.75 SC/ GZ (53.2KN MAX STAY TENSION)	M12: GZ/SC ROPE (PREFERRED) (32.4KN MAX STAY TENSION)
Aerial	10	52kN	31kN
Ground	**45**	**37.61kN**	**22.9kN** (=81 x 0.4 x cos 45)
Ground	60	26kN	16kN

TABLE 37. STAY LOADING

Notes:

- θ is angle in degrees between stay & horizontal.
- F is horizontal load on pole at stay attachment point in kN.
- Designer must ensure a sufficient stay footing is installed to resist the applied loadings

12.9 Ground/aerial stay wire tension

This section assists the designer to select the required stay wire in consideration to the angle which the stay will be installed and the horizontal resultant force loading at the position where the stay is attached.

12.9.1 Calculation of stay tension

To calculate the tension that will be transferred to the stay wire the designer must consider the:

- Proposed angle that the stay will be installed
- The attachment height of the stay above ground
- And the height above ground where the forces will be applied (typically considered at the tip)

Stay tension is calculated as below:

$$F_{Stay} = (F_{tip}/\cos\theta) \times (H_{tip}/H_{att})$$

Where:

F_{Stay} = Stay tension in kN

F_{tip} = Resultant horizontal loading, applied at tip in kN

Θ= Angle of stay to the ground

H_{tip} = Pole tip height above ground in m

H_{att} = Stay attachment height above ground in m

12.10 Sidewalk stay wire selection/ tension

This section assists the designer to select the required stay assembly when specifying a sidewalk stay.

12.10.1 Calculation of stay tension

To calculate the tension that will be transferred to the stay wire the designer must consider the:

- Proposed angle that the stay will be installed
- The angle of the stay to vertical
- The distance from the centre of the pole to the ground anchor

  $F_{Stay} = F_{tip} \times H_{tip} / D \times \cos\theta$ *(Taking moments around the base of the pole)*

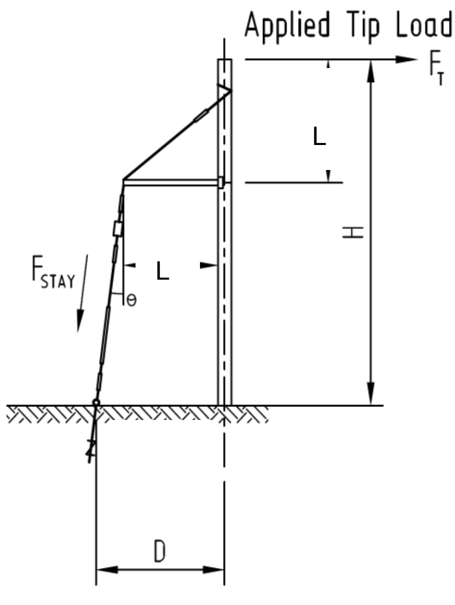
  Where:

- FStay= Stay tension in kN
- Ftip= Resultant horizontal loading, applied at tip in kN
- Θ= Angle of stay to the vertical plane (measured from the end of the strut to the ground anchor)
- Htip= Pole tip height above ground in m
- D = Distance from ground anchor to centre of pole in m

12.10.2 Maximum pole tip loading

Formular:

- Ft = Fs * D * COS(θ) /H
- D = L + (H-L) * TAN(θ)



M12 GZ/SC ROPE STAY, CBL OF 81KN WITH 0.4 SF (SAFETY FACTOR)					
Fs (kN)	32.4	H (m)	10.5	L (m)	1.2
θ (deg)	5	10	15	20	**45***
Ft (kN)	6.2	8.6	11.0	13.3	**22.9**
D (m)	2.0	2.8	3.7	4.6	10.5
M14 (19/2.75MM) SC/GZ STAY, CBL OF 133KN WITH 0.4 SF					
Fs (kN)	53.2	H (m)	10.5	L (m)	1.2
θ (deg)	5	10	15	20	**45***
Ft (kN)	10.2	14.2	18.1	21.8	**37.6**
D (m)	2.0	2.8	3.7	4.6	10.5
M12 GZ/SC ROPE STAY, CBL OF 81KN WITH 0.4 SF					
Fs (kN)	32.4	H (m)	10.5	L (m)	2.4
θ (deg)	5	10	15	20	**45***
Ft (kN)	9.6	11.6	13.6	15.5	**22.9**
D (m)	3.1	3.8	4.6	5.3	10.5
M14 (19/2.75MM) SC/GZ STAY, CBL OF 133KN WITH 0.4 SF					
Fs (kN)	53.2	H (m)	10.5	L (m)	2.4
θ (deg)	5	10	15	20	**45***
Ft (kN)	15.7	19.1	22.4	25.5	**37.6**
D (m)	3.1	3.8	4.6	5.3	10.5

TABLE 38. POLE TIP LOADING

Note *: The angle 45 deg is included in this calculation table for the cross-reference purposes.

12.11 Engineering notes

Stays should be positioned to achieve the most effective use of the stay's strength. In particular, position stay on outside of deviation angle so that it bisects the deviation angle. Keep angle between stay and ground in the range 45° to 60°.

Stay insulators should be positioned such that the stay wire on the structure side of the stay insulator cannot be accessed from the ground by workers or the general public when intact (minimum 2.4 metres above ground) or when in a broken stay wire state and also positioned such to maximise the ability to insulate the stay to ground in the event of a fallen conductor directly onto the stay. Ensure that stay wire insulators have a withstand rating that exceeds line voltage are installed in stay wires. The stay insulator also prevents leakage currents from corroding stay anchors.

13. EARTHING

13.1 General

Purpose of an overhead earthing system, earth down leads, grading rings is to ensure that the following objectives are addressed.

- Protective equipment will operate in a faulted situation,
- For the reliable operation of network (lightning performance online)
- Provide conductive / low resistance path to for the fault current
- Control step and touch potential
- Avoid damages to switchgear and properties

For further details, refer to Section 10 of AS7000

13.2 Types of OH earthing (Separate vs CMEN)

The default earthing arrangement for the Evoenergy overhead network is the separately earthed system. In certain circumstances the CMEN system may be implemented to meet the requirements of the earthing design.

Evoenergy document “Distribution Earthing Design and Construction Manual” describes these two options for distribution earthing systems. (i.e., Substation)

Selection of the appropriate earthing system is subject to the earthing design and calculations by the network designer and is not to be implemented in a default manner.

All CMEN connections must be labelled on the pole and the CMEN bond. All CMEN substations must be updated in ArcFM to ensure visibility in ADMS.

13.3 Reference manual

Refer to PO07127: Distribution Earthing Design Manual

13.4 Reference standard construction drawings

Refer to the Evoenergy Earthing Standard for earthing requirements of overhead lines.

DRAWING NUMBER	TITLE
D204-0004	OVERHEAD, CONDUCTORS AND ACCESSORIES, SA, EARTHING, EARTH STAKE FOR A CONCRETE POLE
D204-0006	OVERHEAD, CONDUCTORS AND ACCESSORIES, SA, EARTHING, HV DEEP EARTH ELECTRODE FOR A CONCRETE POLE
D204-0007	OVERHEAD, CONDUCTORS AND ACCESSORIES, SA, EARTHING, ADDITIONAL HV DEEP EARTH ELECTRODE FOR A CONCRETE POLE
D204-0012	OVERHEAD, CONDUCTORS AND ACCESSORIES, SA, EARTHING, HV AND LV DEEP EARTH ELECTRODES, FOR A POLE SUBSTATION ON A CONCRETE POLE
D204-0029	OVERHEAD, CONDUCTORS AND ACCESSORIES, SA, EARTHING, BURIED GRADING RING FOR CONDUCTIVE POLE
D204-0037	OVERHEAD, CONDUCTORS AND ACCESSORIES, SA, EARTHING, HV DEEP EARTH ELECTRODES, FOR A FIBRE REINFORCED CEMENT POLE

TABLE 39. STANDARDS CONSTRUCTION DRAWINGS

14. OVERHEAD LINE ACCESSORIES

14.1 General

Overhead line accessories must comply with relevant Australian Standards.

RELEVANT AUSTRALIAN STANDARDS RELATING TO THE OVERHEAD COMPONENTS	
AS 1154.1	Insulator and conductor fittings for overhead power line
AS 1154.2	Insulator And Conductor Fittings for Overhead Power Lines - Dimensions
AS 1154.3	Insulator And Conductor Fittings for Overhead Power Lines - Performance and General Requirements for Helical Fittings
AS 3609	Insulators - Porcelain Stay Type - Voltages Greater Than 1000 V AC
AS/NZS 2947.2	Insulators - Porcelain and Glass for Overhead Power Lines - Voltages Greater Than 1000 V AC. - Characteristics
AS 62217	Polymeric Insulators for Indoor and Outdoor Use with A Nominal Voltage > 1000 V - General Definitions, Test Methods and Acceptance Criteria

TABLE 40. AUSTRALIAN STANDARDS FOR OVERHEAD COMPONENTS

14.2 Insulators

Insulator is required to withstand both electrical and mechanical stresses applied to it over the lifetime.

There are three types of overvoltage electrical stress which can occur in overhear powerlines are:

- Lightning induces
- Switching surges, ferroresonance
- Power frequency overvoltage

Mechanical stress includes, Tensile, compressive or cantilever loading from conductor tension and weight.

According to the Australian Bureau of meteorology Canberra typically experiences lighting events as below:

RELEVANT LIGHTNING DATA	
Average annual total lightning flash density	5-10 flashes km²/ Year
Average annual ground lightning flash density	1-2 flashes km²/ Year
Average annual thunder days	20-25 days

TABLE 41. LIGHTNING DATA

Over voltages can be damaging to the overhead and underground network assets. Overvoltage stresses the electrical insulation of the network which may lead to premature failure.

For further details, refer to AS7000 Appendix P "Insulation Guidelines"

14.3 Surge arresters

Surge arrester is used in the overhead network to improve the network reliability and protection of the valuable assets including below:

- Protect pole substations
- Protect UG/OH, underground to overhead network connections
- Protect covered conductors from failure
- Improve lightning outage rate
- Protect Switchgear i.e., Air Break Switches, Gas Load Break Switches, Vacuum Switches

For the Surge Arresters specified to be used in the Evoenergy network, refer to PO07392 Technical Specification - 11kV and 22kV Surge Arresters

14.4 Cross arms

Standard cross arm material is composite fibre. Application of cross arms: -

- 100mm x 100mm x 1.7m for LV intermediate poles. Drawing D104-0003.
- 100mm x 100mm x 2m for HV intermediate poles. Drawing D104-0054.
- 125mm x 125mm x 2m for HV strain/termination poles. Drawing D104-0031.
- 125mm x 125mm x 2.7m for HV recloser links. Drawing D104-0119.

Cross arm strength limits are as follows: -

CROSS ARM	LENGTH	CANTILEVER	LOAD
SIZE (MM^3)	(M)	SERVICEABILITY (KN)	WIND (KN)
100x100x5	1.7	6.3	15.7
100x100x5	2	5.9	14.7
125x125x6.5	2	11.7	29.3
125x125x6.5	2.7	8.2	20.5

TABLE 42. CROSS ARM STRENGTH LIMITS

Notes:

- Based on Wagner ultimate moment rating of 16.7kN.m for 100x100x5.
- Based on Wagner ultimate moment rating of 33.16kN.m for 125x125x6.5.
- Lever arm for 1.7m cross arm of 0.8m.
- Lever arm for 2m cross arm of 0.85m.
- Lever arm for 2.7m cross arm of 1.212m.
- Strength reduction factor of 0.75 for strength and 0.3 for serviceability.

14.5 Conductor attachments and ties

Conductors must be attached or secured using standard approved parts wherever possible. Where a designer is required to use non-standard methods or materials, they should ensure the components are fit for duty and meet the required Australian or International standards.

- The use of preformed dead ends (fan grips) should be used for terminating bare overhead conductors wherever possible.

- Thimbles must be installed to all overhead conductors when terminating to disc and long rod insulators.
- Terminating cables to LV shackle insulators and stay insulators need not utilise thimbles.
- Preformed line ties must be installed over Armour rods on all HV inline constructions with line tension. (Urban/ Rural, except slack spans)
- Hand ties should be installed for 11/22kV bridging as required, where no line tension is present. (slack)
- Hand ties are required to be installed for all low voltage and 11/22kV copper pin / straight through constructions.

Evoenergy documents relating to conductor fixing selection and hand ties are tabled below:

CONDUCTOR FIXING REFERENCES	
D204-0001	Interface table, cables, and line fitting selection table
D201-0006	SA, Pole top, 11/22kV inline pole top insulator on a concrete pole
D201-0007	SA, Insulator, 11kV pin insulator for a composite crossarm c/w conductor fittings
392-36-01	Hand tie details for HV overhead conductors
392-36-04	Hand tie details for LV overhead conductors & HV overhead bridging conductors
392-36-02	High Voltage overhead conductor top tie application
392-36-03	High Voltage overhead conductor side tie application

TABLE 43. CONDUCTOR ATTACHMENT REFERENCES

14.6 Armour rods and preformed ties

Preformed line ties must be installed over the armour rods, for all 11/22kV inline constructions (pole top insulators and cross arm pin insulators), for SC/GZ, AAC and ACSR conductors.

For standard constructions refer to D201-0006 and D201-0007. For interface parts selection of Armour rods and Ties, refer to D204-0001.

14.7 Vibration dampers

Designers should allow for the installation of dampers to reduce the risk of asset damage due to aeolian vibration where required. Aeolian vibration occurs when wind passes over the conductor, which creates vortices (eddies) on the back side of the conductor.

Spiral vibration dampers (SVD) must be installed at each end of the span in the following circumstances:

- In rural areas
- Where the spans exceed 100m.
- Where conductor tension exceeds 10%
- Where the spans exceed 240m, two SVDs are required at each end of the span.

Refer to drawing D204-0001 and 3810-001 for spiral vibration damper selection and installation details.

14.8 Low voltage spreaders

Low voltage spreaders must be specified and installed on bare low voltage mains in accordance with the documents outlined below:

LOW VOLTAGE SPREADER- NETWORK REQUIREMENTS	
3812-001	Criteria for the use of LV spreaders
D204-0001	Conductor fittings, deadends, splices, armour rods, ties, SVDs, guyloks, clevis thimbles and spreader rods

TABLE 44. LV SPREADERS

14.9 Aerial markers

There are two situations where aerial markers are required: -

- Two poles back on a distribution line either side prior to the line traversing a transmission line.
- Helicopter pads, airstrips and when the ground clearance or conductor length exceeds AS3891 requirements e.g. deep valleys.

Where there is potential for aircraft strike to longer spans in deep valleys, markers are required. E.g. rural lines subject to helicopter patrols.

For air navigation overcrossing marker installation rules refer to drawing 392-41-20.

Permanent design marking of overhead conductors and their supporting structures should be undertaken in accordance with AS 3891.1-2008: Air navigation - Cables and their supporting structures - Marking and safety requirements - Permanent marking of overhead cables and their supporting structures for other than planned low-level flying. This is generally a design requirement around airports and helicopter landing strip or where conductors traverse a valley and heights above the tree canopy. Where low-level flying is undertaken e.g. line patrols, then AS3891.2 should also be used.

14.10 Temporary visual indicators

The Purpose of the Visual indicators are for the safety when working on or near the overhead power lines.

14.10.1 Overhead mains (LV) line covers

Line Covers (Tiger tails) shall be installed on all four (4) Low Voltage bare conductors. A pole tip calculation is required to ensure safe workload of poles in not exceeded due to the extra weight of the Line covers (tiger tails).

Line Covers (Tiger tails) must pass the worksite by a minimum distance of 5 metres beyond either side of the worksite.

Where Line covers are too long to completely cover length of the span of conductor, they may be doubled up over each other to cover a conductor, where gaps are present close to cross arms conductor shall be covered with insulating mats.

Line Cover (Tiger Tail) Specifications:

Colour	Length	Working Voltage	Rating Ø - Ø Brush Contact Only	ID	Weight
Yellow/Black	2.5m	650 V	14.6kV	35mm	1.3kg

14.10.2 Overhead Powerlines (MV) indicator flags

Indicator Flags to be installed on Medium Voltage Overhead powerlines are to be **staggered** at no greater than 5 meters apart. (As per figure 8) A consideration will be taken into account of what work is being conducted and the spacing shall be decreased, if required due to a risk assessment conducted on the worksite.

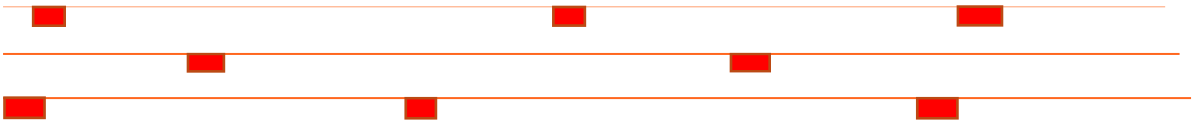


FIGURE 8. SPACING OF INDICATOR FLAGS

14.10.3 Service line (LV) line covers

FIGURE 9. TIGER TAILS

Install insulated matting and 'tiger tails' at the point of attachment and over the overhead service lines before the work commences.

14.11 Non-standard insulators and fittings

From time to time a designer may need to specify non-standard conductor fittings for a particular project. An example of such an occurrence could be the need to utilise a non-standard conductor to achieve a design which optimises value. The use of non-standard fitting should be avoided unless necessary. Amongst other issues placing a non-standard solution to the network may have issues in the future should maintenance or repair of the asset be required.

The designer is required to ensure the considerations and requirements of this section are observed.

14.11.1 Risk assessment

Before any non-standard product may be utilised on a project the designer must conduct a risk assessment. The risk assessment must be conducted in accordance with current risk management and procurement procedures. The risk assessment must consider the risks that may result for the entire life cycle of the product. As required the designer may need to catalogue spare parts that relate to the product for future repair and maintenance tasks.

14.11.2 Strength reduction factors

Strength and serviceability reduction factors must be applied and considered in the design. AS/NZS 7000 outlines the typical safety reduction factors that should be considered when designing or specifying overhead lines. In some instances, strength and serviceability reduction factors must be applied. Serviceability factors are applied to ensure the product remains in a serviceable state. Some products may be limited by attributes other than strength (i.e. deflection in composite fibre poles). Where a strength reduction factor is not identified in AS/NZS7000 the designer should consult a subject matter expert to discuss an applicable factor.

The materials listed below must have the assigned strength/serviceability factors applied which is not outlined in AS/NZS 7000 Where these reduction factors are not applied a risk assessment and formal determination of suitability conducted by a subject matter expert must be completed.

Due to an observed failure- A serviceability reduction factor of **0.4** must be applied to the calculated breaking load / minimum breaking load (CBL/ MBL). The serviceability factor is appropriate because of friction at the guylok interface.

15. SWITCHGEAR

15.1 General

This section provides general guidance to the designers and other relevant personnel on the application of switches on the overhead 11 kV and 22 kV network.

The following principles should be applied when selecting an appropriate type of switch for application on a distribution overhead feeder.

Generally, the switching devices to be used on the overhead distribution network will have switching functionality as stated below. However, each design and application should be consistent with switch capability and therefore needs to be confirmed by reference to the detailed switch specification.

Any switch that will be installed as a normally open point must be specified in consultation with the Planning group.

Switchgear must comply with PO07399 - Technical Specification – Overhead Switchgear.

15.2 Three phase air-break switch (air)

Load break and make capacity of air-break switches is limited to the switch specification. Generally, these switches DO NOT have fault make or fault break functionality. Gas switches are preferred as the air-break switches require regular maintenance have a lower making and breaking capacity.

Air break switches must not be installed in bushfire prone

15.3 Three phase gas switch (SF6)

Typical operational functionality: load break, load make, fault make.

Note: Any make/break capacity is limited by the switch specification. Generally, these switches DO NOT have **fault break capacity.**

15.4 Three phase reclosers (vacuum)

Typical operational functionality: load break, load make, fault make, fault break.

Reclosers, if necessary, can be set for multiple fault break/fault make operation. (i.e. typically two or three attempts to clear the fault. Most recloser switches have provisions for remote operation or monitoring.

Currently reclosers (specifically the NOJA recloser) maybe used where remote operation is required on the network. The necessity for a switch to have remote operation capabilities must be confirmed with the network planning group.

15.4.1 Recloser configuration

The below requirements must be considered when specifying the installation of a recloser to the network.

Reclosers do not provide a visible break for the purpose of network isolation and access. A visible break is required and can be achieved by:

4. Isolating links or air-break switch on an adjacent pole
5. Installing the recloser with inline isolating links

If a visible break can be achieved by existing switchgear on an adjacent pole, a recloser without isolating links may be installed, see D201-0040.

If the recloser is to be installed in a bushfire prone area, a recloser without inline isolating links MUST be used, see D201-0040.

If a visible break is unable to be achieved by switchgear on an adjacent pole, and the installation is not in a bushfire prone area, a recloser with isolating links must be installed, see D201-0042.

DRAWING NUMBER	BRIEF DESCRIPTION	APPLICATION CONDITIONS
D201-0040	Recloser without inline isolating links	• In a bushfire prone area only; or • When an isolating links or air-break switch on an adjacent pole to achieve a “visible break”.
D201-0042	Recloser with inline isolating links	• When a “visible break” is unable to be achieved by switchgear on an adjacent pole; and • the installation is not in a bushfire prone area

TABLE 45. RECLOSER APPLICATION CONDITION SUMMARY

15.5 Switch selection considerations

Warning - Application of switches which is not consistent with their intended use or specification creates a safety hazard.

The following principles should be applied when installing a new switch, or replacing an existing switching device, on the overhead distribution network.

- Each switching device needs to be applied consistently with the intended use and manufacturer’s specifications
- Mandatory consultation with system control personnel (Control Room Manager) and system planning personnel (Primary Assets Manager) for all design projects is required to determine
- Whether the switch is required in the specific location
- If the switch is essential, what functionality of the switch is required (i.e. what type of switch)

In case of existing switch replacements, if there is no need for the switching device in the specific location, remove the device from the network rather than replace. Generally, the switch selection is based on economic, operational and safety factors. From a cost perspective, the preference for the switching devices is as follows:

- First preference: Air-break switch
- Second preference: Gas switch
- Third preference: Recloser

From an operational perspective, installation of a device other than an air-break switch can be applied in the following circumstances:

- Locations which require frequent operations of a switching device
- Frequented and special locations (e.g. next to schools etc)
- Feeder open points, on long feeders, located far away from a zone substation

From an operational perspective, air break switches should NOT be used in the following situations:

- Locations which are prone to ferroresonance may require a gas switch
- In rural areas, BAZ and other fire prone areas
- On 11 kV feeders at points which interface 132 kV and 66 kV bulk supply networks
- 11 kV or 22 kV links which have to be replaced should only be replaced with a suitably selected three phase switching device where there is a technical need, such as ferroresonance
- Reclosers should be installed in locations where they can be justified by an improvement in reliability (e.g., through Service Target Performance Incentive Scheme or sectionalise poorly performing sections of a feeder etc)

- For gas switches and reclosers, remote operation/monitoring should be installed only if the additional cost can be justified (e.g. through Service Target Incentive Scheme, savings in cost and switching time etc)
- The above principles provide general guidance. However, in specific circumstances a departure from the above principles may be justified. Additional information and guidance should be sought from the Standards Section

15.6 Site attributes for overhead switch devices

15.6.1 Site access

The designer must as so far as reasonably practicable ensure that the switching device is installed on the network where it may be accessed safely. Site selection should prioritise the switcher's safety by:

- Ensuring that devices that require a switcher to climb are accessible by an elevated work platform
- That there is sufficient space within close proximity of the device for a team member to park safely
- Clear pedestrian access- i.e., a switcher is not required to climb steep embankments or climb over obstacles to access the site

15.6.2 Traffic considerations

When specifying the location of switching device the designer must consider the vehicular traffic hazard that will pass the worksite. Team members accessing the site for operational purposes (to operate the device only) should not require full traffic management to undertake the switching operation. This work is considered intermittent work in accordance with AS1742.3-(2009) *Manual of uniform traffic control devices- part 3 Traffic control for works on roads*. The switcher must be able to park a vehicle safely within proximity of the device.

Where the switching device is located within 6m of the road edge or kerb the designer should propose a network location considering requirements outlined in AS1742.3 (2009) Cl 4.4.2 and Cl 4.4.4 in relation to intermittent work. If a switching task is unable to be conducted at the site as intermittent works another site should be selected or permanent engineering controls be installed at the work site to allow safe access. It is not appropriate to locate switching devices where traffic control would need to be instated for a simple switching operation (task taking less than 20 minutes).

Where workers can attend site & park outside of live traffic lane (inc. any cycling lane) with following attributes the location maybe suitable without the need for traffic control for switching operations:

- Speed limits of less than 50km/hr and ability to park outside of a live traffic lane
  - Minimum sight distance of 50m
- Speed limits greater than 90km/hr and ability to park on verge or median
  - Greater than 1.2m of clearance from any traffic lane from where a worker may stand (including accessing and egressing vehicles)
  - The area that the switcher will be standing to operate the device is greater than 3m clear of any live traffic lane.
  - Approach speed of 90km/hr- minimum sight distance 540m (NSW RMS 18.898)
  - Approach speed of 100 km/hr – minimum sight distance of 600m (NSW RMS 18.898)

15.6.3 Control enclosure location.

As required the designer must specify the location of the control enclosure for each site. Wherever possible the control enclosure should be placed on the opposite side of the pole to the direction of the nearest live traffic lane. This requirement will position the switcher to face oncoming traffic when accessing the enclosure. The switcher should never be placed with their back facing the nearest live traffic lane. The designer must also ensure that an extension ladder is able to be installed on the site with the top of the ladder resting below the control enclosure on relatively level ground.

VERSION CONTROL

VERSION	DETAILS	APPROVED
1.0	Initial Document	Santanu Chaudhuri, Wayne Cleland 23/03/2015
2.0		Wayne Cleland 09/04/2015
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4.0	Rebranding to EVO Energy	Wahid Ibrahim 16/01/2018
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5.1	Minor updates to sections 4.1, 4.11, 4.12, 9.2, 9.5, 10.2, 11, 13.2, 14.5, 14.6, 14.7 and 15.4. by M. Senanayake, J. Primmer.	N. Azizi; W. Cleland; 21/11/2023

DOCUMENT CONTROL

DOCUMENT OWNER	DOCUMENT CUSTODIAN	PUBLISH DATE	REVIEW DATE
Group Manager, Strategy and Operations	Principal Engineer Standards and Specifications	30/11/2023	30/11/2025

APPENDIX A – O/H NETWORK LEGACY DRAWINGS

DRAWING #	DESCRIPTION
392-2-00	POLE GUY CONNECTION DETAILS FOR WOOD POLES
392-2-01	POLE STAY DETAILS FOR CONCRETE AND TIMBER POLES
392-2-02	POLE STAY CONNECTION REQUIREMENTS FOR TRANSACT WORK
392-2-03	POLE GUY CONNECTION DETAILS PLATIPUS STAY FOR CONCRETE POLES
392-2-04	SIDEWALK STAY ASSEMBLY
392-36-01	HAND TIE DETAILS FOR OVERHEAD CONDUCTORS (CURRENT DRAWING)
392-36-02	HIGH VOLTAGE OVERHEAD CONDUCTOR TOP TIE APPLICATION
392-36-03	HIGH VOLTAGE OVERHEAD CONDUCTOR SIDE TIE APPLICATION
392-36-04	HAND TIE DETAILS FOR LV OVERHEAD CONDUCTORS AND HV OVERHEAD BRIDGING
392-36-05	CONDUCTOR TO INSULATOR TIES APPLICATION SELECTION
392-41-00	11KV WOOD POLE ASSEMBLY
392-41-01	11KV ANGLE POLE 'S' STRAP ASSEMBLY
392-41-02	11KV DOUBLE TERMINATION WOOD POLE ASSEMBLY
392-41-03	11KV INLINE WOOD POLE ASSEMBLY WITH 90 TAKE OFF
392-41-04	11KV DOUBLE STRAIN WITH LINKS ON WOOD POLE ASSEMBLY
392-41-05	11KV & LV INLINE WOOD POLE ASSEMBLY
392-41-06	11KV DOUBLE STRAIN WOOD POLE ASSEMBLY WITH LV 'S' STRAP
392-41-07	11KV & LV DOUBLE TERMINATION WOOD POLE ASSEMBLY
392-41-08	11KV LINK WOOD POLE ASSEMBLY WITH LV THROUGH LINE ASSEMBLY
392-41-09	11KV DOUBLE TERMINATION CONCRETE POLE ASSEMBLY
392-41-10	11KV INLINE CONCRETE POLE ASSEMBLY
392-41-11	11KV CONCRETE POLE WITH DOUBLE STRAIN LINK ASSEMBLY
392-41-12	11KV CONCRETE ANGLE POLE WITH 'S' STRAP ASSEMBLY
392-41-13	11KV INLINE CONCRETE POLE ASSEMBLY WITH 90 DEGREE TAKEOFF
392-41-14	11KV TWIN CIRCUIT INTERMEDIATE WOOD POLE
392-41-15	11KV TERMINAL WOOD POLE VERTICAL ARRANGEMENT
392-41-16	11KV TWIN CIRCUIT SINGLE TERMINATION WOOD POLE
392-41-17	11KV TWIN CIRCUIT STRAIN WOOD POLE
392-41-18	BIRD FLASHOVER/ BUSHFIRE MITIGATION CONSTRUCTION 11KV CONCRETE POLE
392-41-20	AIR NAVIGATION OVERCROSSING MARKER ASSEMBLY
392-41-21	NULEC RECLOSER WOOD POLE MOUNTED WITH LV EQUIPMENT ASSEMBLY
392-41-22	TYPICAL NULEC RECLOSER WITH UG/OH CONNECTION EQUIPMENT
392-41-23	NULEC RECLOSER WITH BYPASS LINKS GENERAL ARRANGEMENT
392-41-24	HV OUTDOOR WOOD POLE MOUNTED 12KV 400A METERING ASSEMBLY

DRAWING #	DESCRIPTION
392-41-25	11KV AND LV INLINE CONCRETE POLE ASSEMBLY
392-41-26	11KV INLINE CONCRETE POLE ASSEMBLY WITH DROP OUT FUSES ON 90 DEGREE TAKE OFF
392-41-28	11KV DOUBLE STRAIN CONCRETE POLE ASSEMBLY
392-41-30	GENERAL ARRANGEMENT OF RECLOSER WITH LOADSIDE UGOH CONNECTION
392-41-31	11KV OVERHEAD INSULATOR ASSEMBLY DETAILS INLINE INSULATOR ASSEMBLIES FOR CROSS ARM APPLICATIONS
392-41-32	11KV OVERHEAD INSULATOR ASSEMBLY DETAILS STRAIN INSULATOR ASSEMBLIES FOR CROSS ARM APPLICATIONS
392-41-33	11KV OVERHEAD INSULATOR ASSEMBLY DETAILS STRAIN INSULATOR ASSEMBLIES FOR CONCRETE POLE TOP APPLICATIONS
392-41-34	11KV OVERHEAD INSULATOR ASSEMBLY DETAILS STRAIN/PIN INSULATOR ASSEMBLIES FOR WOOD POLE TOP APPLICATIONS
392-41-35	11/22KV HARDWOOD CROSS ARM ASSEMBLIES FOR CONCRETE AND WOOD POLES
392-41-36	11/22KV COMPOSITE FIBRE CROSSARM ASSEMBLIES FOR CONCRETE POLES
392-41-37	11/22KV COMPOSITE FIBRE CROSSARM ASSEMBLIES FOR CONCRETE AND WOOD POLES
392-41-38	11KV OVERHEAD INSULATOR ASSEMBLY DETAILS INLINE INSULATOR ASSEMBLIES FOR POLE TOP APPLICATIONS
392-41-39	22KV OVERHEAD INSULATOR ASSEMBLY DETAILS STRAIN INSULATOR ASSEMBLIES FOR WOOD POLE TOP APPLICATIONS
392-41-40	22KV OVERHEAD INSULATOR ASSEMBLY DETAILS INLINE INSULATOR ASSEMBLIES FOR CROSS ARM APPLICATIONS
392-41-41	22KV OVERHEAD INSULATOR ASSEMBLY DETAILS STRAIN INSULATOR ASSEMBLIES FOR CROSS ARM APPLICATIONS
392-41-42	22KV OVERHEAD INSULATOR ASSEMBLY DETAILS INLINE INSULATOR ASSEMBLIES FOR POLE TOP APPLICATIONS
392-41-43	22KV OVERHEAD INSULATOR ASSEMBLY DETAILS STRAIN INSULATOR ASSEMBLIES FOR CONCRETE POLE TOP APPLICATIONS
392-41-44	22KV OVERHEAD INSULATOR ASSEMBLY DETAILS STRAIN/PIN INSULATOR ASSEMBLIES FOR WOOD POLE TOP APPLICATIONS
392-41-45	22KV OVERHEAD INSULATOR ASSEMBLY DETAILS STRAIN INSULATOR ASSEMBLIES FOR WOOD POLE TOP APPLICATIONS
392-41-46	11kV NULEC RECLOSER CONTROLLING POLE MOUNTED REGULATORS CONSTRUCTION DETAILS
392-42-00	LV IN LINE WOOD POLE ASSEMBLY
392-42-01	LV TERMINATION WOOD POLE ASSEMBLY
392-42-02	LV ANGLE POLE S STRAP ASSEMBLY
392-42-03	LV DOUBLE TERMINATION POLE ASSEMBLY
392-42-04	LV IN LINE WOOD POLE ASSEMBLY WITH 90 DEGREE TAKE OFF
392-42-05	LV LINE DEVIATION CONSTRUCTION DETAIL

DRAWING #	DESCRIPTION
392-42-06	TEMPORARY SUPPLY FOR OVERHEAD NETWORK
392-42-07	LV DOUBLE STRAIN WOOD POLE ASSEMBLY WITH 80 DEGREE MAXIMUM DEVIATION
392-42-08	LV INLINE CONCRETE POLE ASSEMBLY
392-42-09	LV CONCRETE ANGLE POLE 'S' STRAP ASSEMBLY
392-42-10	LV CONCRETE TERMINATION POLE ASSEMBLY
392-42-11	9.5 8KN. TAPERED OCTAGONAL GALVANISED STEEL POLE.
392-42-12	LV DOUBLE TERMINATION CONCRETE POLE ASSEMBLY
392-42-13	LV INLINE CONCRETE POLE ASSEMBLY WITH 90 DEG TAKE OFF
392-42-14	LV INLINE STEEL POLE ASSEMBLY
392-42-15	LV TERMINATION STEEL POLE ASSEMBLY
392-42-16	LV DOUBLE STRAIN STEEL POLE ASSEMBLY WITH ISOLATING LINKS
392-42-17	LV DOUBLE TERMINATION STEEL POLE ASSEMBLY
392-42-18	LVABC INLINE & LVABC INLINE TEE-OFF ASSEMBLIES
392-42-19	LVABC INLINE ASSEMBLY
392-42-20	ASSEMBLY REQUIREMENTS FIBREGLASS POLES
392-42-21	LV HARDWOOD KINGBOLT MOUNTED CROSSARM ASSEMBLIES FOR LV CONCRETE POLES
392-42-22	LV HARDWOOD KINGBOLT MOUNTED CROSSARM ASSEMBLIES FOR HV CONCRETE POLES
392-42-23	LV HARDWOOD BRACKET MOUNTED CROSSARM ASSEMBLIES FOR LV AND HV CONCRETE POLES
392-42-24	LV HARDWOOD KINGBOLT MOUNTED CROSSARM ASSEMBLIES FOR LV COMPOSITE FIBRE POLES
392-42-25	LV HARDWOOD KINGBOLT MOUNTED CROSSARM ASSEMBLIES FOR LV STEEL POLES
392-42-26	LV HARDWOOD BRACKET MOUNTED CROSSARM ASSEMBLIES FOR LV STEEL POLES
392-42-27	LV HARDWOOD KINGBOLT MOUNTED CROSSARM ASSEMBLIES FOR LV WOOD POLES
392-42-28	LV HARDWOOD KINGBOLT MOUNTED CROSSARM ASSEMBLIES FOR HV WOOD POLES
392-42-29	LV OVERHEAD INSULATOR ASSEMBLY DETAILS FOR HARDWOOD CROSSARM APPLICATIONS
392-42-30	LV OVERHEAD INSULATOR ASSEMBLY DETAILS FOR COMPOSITE FIBRE CROSSARM APPLICATIONS
392-43-01	OVERHEAD CONSTRUCTION GENERAL BOLT AND WASHER ARRANGEMENTS FOR HARDWOOD CROSSARM APPLICATIONS
392-43-02	OVERHEAD CONSTRUCTION GENERAL BOLT AND WASHER ARRANGEMENTS FOR WOOD POLE APPLICATIONS
392-43-03	OVERHEAD CONSTRUCTION GENERAL BOLT AND WASHER ARRANGEMENTS FOR CONCRETE & COMPOSITE FIBRE POLE APPLICATIONS

DRAWING #	DESCRIPTION
392-43-04	OVERHEAD CONSTRUCTION GENERAL BOLT AND WASHER ARRANGEMENTS FOR COMPOSITE FIBRE CROSSARM APPLICATIONS
392-43-05	OVERHEAD CONSTRUCTION GENERAL BOLT AND WASHER ARRANGEMENTS FOR STEEL POLE APPLICATIONS
392-43-06	PLANT POSITIONING GUIDELINES POLE TOP CONSTRUCTION
392-43-07	MINIMUM BRIDGING SEPARATIONS POLE TOP CONSTRUCTION
392-43-10	POLE SLEEVE INSTALLATION
392-51-00	11KV STRAIGHT THROUGH JOINT FOR 3/C 11 PLY SW.PVC CABLE
392-51-01	11KV XLPE INSULATED SINGLE CORE CABLE INDOOR HEAT SHRINK TERMINATIONS
392-51-02	CABUS 11KV OUTDOOR SEALING ENDS CABLE STRIPPING AND ASSEMBLY
392-51-03	11KV UG/OH CONNECTION IN LINE WOOD POLE ASSEMBLY
392-51-04	11kV UG/OH CONNECTION THROUGH LINE LINK WOOD POLE ASSEMBLY
392-51-05	11KV UG/OH CONNECTION IN LINE WOOD POLE ASSEMBLY WITH LV THROUGH LINE ASSEMBLY
392-51-06	11KV UG/OH CONNECTION INLINE CONCRETE POLE ASSEMBLY
392-51-07	11kV UG/OH CONNECTION THROUGH LINE LINK WITH LV THROUGH LINE ON INLINE WOOD POLE
392-51-08	11KV UG/OH CONNECTION THROUGH LINE LINK ASSEMBLY OPTION 1
392-51-09	11KV UG/OH CONNECTION INLINE POLE ASSEMBLY OPTION 1 OPTION 1
392-51-10	11KV IN LINE POLE ASSEMBLY WITH 9O DEG TAKE OFF AND UG/OH CONNECTION
392-51-11	11kV TERMINATION WOOD POLE ASSEMBLY WITH UG/OH CONNECTION AND LV INLINE
392-51-12	11kV TERMINATION WOOD POLE ASSEMBLY WITH UG/OH CONNECTION THROUGH LINK ASSEMBLY
392-51-13	11KV TERMINATION WOOD POLE ASSEMBLY WITH UG/OH CONNECTION THROUGH LINK ASSEMBLY
392-51-14	11KV TERMINATION WOOD POLE ASSEMBLY WITH UG/OH CONNECTION AND LV IN LINE OPTION
392-51-15	11KV TERMINATION CONCRETE POLE ASSEMBLY WITH UG/OH CONNECTION & LINKS
392-51-16	11kV IN LINE CONCRETE POLE ASSEMBLY WITH UG/OH CONNECTION AND LINKS
392-51-17	11kV TERMINATION WOOD POLE ASSEMBLY WITH UG/OH CONNECTION THROUGH LINK ASSEMBLY
392-51-18	11kV UG/OH SURGE DIVERTER CONNECTION AND EARTHING CONNECTION DETAILS
392-51-19	11kV TERMINATION CONCRETE POLE ASSEMBLY
392-51-20	CONNECTION DETAILS OVERHEAD SWITCHGEAR
392-51-21	11kV UG/OH CONCRETE AND TIMBER POLE CABLE TERMINATION ASSEMBLY

DRAWING #	DESCRIPTION
392-51-22	11kV ISOLATING LINKS ON HV POLES GENERAL ARRANGEMENTS AND MINIMUM SEPARATIONS
392-54-03	GENERAL ARRANGEMENT NEW ZEALAND INSULATOR SEALING ENDS
392-61-00	SINGLE POLE SUBSTATION FOR CONCRETE POLES
392-61-01	SINGLE POLE TERMINATION SUBSTATION ASSEMBLY FOR CONCRETE POLES
392-61-02	TWO POLE SUBSTATION ARRANGEMENT (WOOD POLES)
392-61-03	SINGLE POLE SUBSTATION RURAL ARRANGEMENT
392-61-04	MULTI CIRCUIT SINGLE CONCRETE POLE POLE SUBSTATION
392-61-05	MULTI CIRCUIT SINGLE CONCRETE POLE SUBSTATION
392-61-06	11KV AND 22KV POLE SUBSTATION ADDITIONAL REQUIREMENTS IN WILDLIFE PRONE AREAS
392-62-01	SWITCHGEAR RE-ARRANGEMENT TWO POLE SUBSTATION
392-71-00	11KV AIR BREAK SWITCH ASSEMBLY FOR WOOD POLE
392-71-01	11KV AIR BREAK SWITCH ASSEMBLY WITH LV THROUGH LINE ASSEMBLY
392-71-02	11KV AIR BREAK SWITCH ASSEMBLY FOR CONCRETE POLES
392-71-03	11KV AIR BREAK SWITCH GENERAL ASSEMBLY SPECIFICATION DWG FOR CONCRETE POLES
392-71-04	HAYCOLEC AIR BREAK SWITCH ASSEMBLY TYPE A24 630A FOR CONCRETE POLES
392-71-05	11kV AIR BREAK SWITCH ASSEMBLY FAULT MAKE TYPE FOR CONCRETE POLES
392-71-06	11kV NGK GAS SWITCH MOUNTING ARRANGEMENT ON WOOD POLE NORMALLY OPEN OPERATION
392-71-07	MOUNTING ARRANGEMENT FOR 11kV NGK GAS SWITCH ON CONCRETE POLE
392-71-08	11kV AIR BREAK SWITCH WITH LINK STICK OPERATION ASSEMBLY
392-71-09	MOUNTING BRACKET FOR LINK STICK OPERATED AIR BREAK SWITCH
392-71-10	MOUNTING ARRANGEMENT FOR 11kV & 22kV NGK GAS SWITCH & UG/OH CONNECTION ON DOUBLE STRAIN CONCRETE POLE ASSEMBLY
392-71-11	GENERAL ARRANGEMENT UG/OH WITH GAS SWITCH 11kV AND 22kV
392-72-00	LV DOUBLE TERMINATION WOOD POLE ASSEMBLY WITH ISOLATING LINKS
392-72-01	LV DOUBLE TERMINATION CONCRETE POLE ASSEMBLY WITH ISOLATING LINKS
392-72-02	LVABC DOUBLE STRAIN & LVABC DOUBLE STRAIN WITH LINKS ASSEMBLIES
392-73-01	TYPICAL HIGH VOLTAGE HIGH VOLTAGE EXPULSION DROPOUT FUSE (DOUBLE VENTING)
392-73-03	S&C POWER FUSE TYPE SMD 20 GENERAL ARRANGEMENT & MOUNTING
392-73-04	S&C TYPE SMD-20 BORIC ACID DROPOUT FUSE ASSEMBLY
392-73-05	S&C TYPE SMD-20 FUSE BASE WITH SMU-20 FUSE UNIT EXPLODED VIEW