SA Power Networks

Technical Standard - TS110

Electrical Design, Civil/Electrical Works and Testing for 66kV Underground Sub-Transmission Networks

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Contents

1. Purpose

This technical standard sets out the minimum requirements for conducting electrical design, civil, electrical installation, testing and commissioning works for SA Power Networks' 66kV underground sub-transmission network.

2. Scope

This technical standard is applicable to **all parties,** whose activities are associated with the SA Power Networks 66kV underground sub-transmission networks, and which will become a component of SA Power Networks' infrastructure.

This technical standard does not include the requirements for the installations within substation boundary (refer to Manuals 28, 29, 30), or (33kV or less) underground distribution networks (refer to TS100, TS085, TS105), or the application of sub-marine cables (ie project specific).

SA Power Networks shall determine whether the work is to be contestable (refer to NICC400), and stipulate engineering requirements including any additional requirements that are project specific.

The civil and electrical works are principally governed by the Electricity (General) Regulations 2012, WHS Regulations 2012, other statutory authorities, AS/NZS standards requirements and includes any specific design plans, drawings and documents that are part of the project requirements.

Any changes required to the approved design, must be submitted for approval to the relevant SA Power Networks Project Manager, prior to being incorporated within the design.

Subject to approval, upon completing the works, the relevant construction contractor shall be responsible for recording and forwarding detailed information on the completed works in accordance with SA Power Networks' requirments to the relevant SA Power Networks Project Manager within 6 weeks of completion of the installation works.

3. Deviation from this Standard

Deviation from any specific requirement(s) of this Standard will only be permitted with the written approval of SA Power Networks' Manager Network Planning.

Contact 'Standards and Equipment Team' via Hotline on (08) 8404 4200 or send an email to: networkstandards@sapowernetworks.com.au.

4. Grace Period

1. The maximum grace period acceptable by SA Power Networks for implementing this technical standard is 3 months from the date of publication.
2. All projects that are not in receipt of 'Specification Compliance' at the revised date of issue for this technical standard will need to incorporate the latest requirements. This is applicable to both the design and construction phases of the project.
3. The validity period for 'Specification Compliance' is 60 days.
4. On the expiry of 'Specification Compliance', any specification change (without a documented exemption) shall be incorporated into the design and construction of the SA Power Networks infrastructure.

5. Publications Access

The library of operational manuals, E-drawings, Distribution Standard Templates (DST) and AutoCAD templates are available to registered contractors from SA Power Networks' secured internet website at https://etsa-hc4.accellion.net/courier/web/1000@/wmLogin.html.

To arrange access, please contact 'Standards and Equipment Team' via Hotline (08) 8404 4200 or send an email to: networkstandards@sapowernetworks.com.au.

6. Intellectual Property

Utilising the SA Power Networks specification for any installation other than an installation intended to be vested and or connected to SA Power Networks' network without SA Power Networks' approval is an offence. SA Power Networks view such misuse seriously and may take legal action for any identified breach.

If anyone wishes to utilise the SA Power Networks specification for a design that is not being vested to SA Power Networks, then they shall request written approval from SA Power Networks' Manager Network Planning.

Contact 'Standards and Equipment Team' via Hotline on (08) 8404 4200 or send an email to: networkstandards@sapowernetworks.com.au.

7. General Requirements

Before commencing works, refer to NICC404 'Working in the vicinity of the SA Power Networks Infrastructure - Network Access Permit Process.

Civil works shall ensure that the area around the equipment vaults and or footings are kept clean, tidy and have finished surfaces, which will assist the electrical works to be carried out in a safe environment.

All excavation sites which are required to be left open and or unattended (eg left unsupervised) over-night shall be effectively covered for public safety, eliminating potential hazard, theft control and or any accidental damage to SA Power Networks' asset. In some cases, site security personnel may also be required.

SA Power Networks will undertake audits to ensure that the work complies with the design and reserves the right not to accept any materials or workmanship that it deems substandard.

Where the soil is identified from a site associated with 'Potentially Contaminating Activities' (PCA) such as, a petrol station or industrial facility, please refer to **Section 7.5** and **Appendix G**, for more details.

7.1 Contestable Works

SA Power Networks shall determine whether the work is contestable, define the scope of the project, detail the additional project specifications and stipulate any site specific engineering requirements.

Where there is a mixture of contestable and non-contestable works, the design shall specify the extent of works that can be undertaken by a contractor (contestable) and the extent of works that can only be undertaken by SA Power Networks (non-contestable).

Refer to NICC400 for more detail.

7.2 Design Stages

SA Power Networks implements a structured project process, which has three stages of design ie 'Preliminary', 'For Construction' and 'As Constructed', each serving a function as a project moves through from concept to completion.

The design drawings format and details shall comply with the requirements stipulated in TS099.

All relevant legislative, regulatory and clearance requirements to third party assets shall be complied with. More references are available in the SA Power Networks documents, such as:

1. Relevant 66kV E-drawings series (E1500 to E1519)
2. TS102: 'Easement Standard Distribution/Sub-Transmission Networks'
3. TS109: 'Earthing of the Distribution/Sub-Transmission Networks'

7.3 Working near SA Power Networks' Infrastructure

Any works by **any parties** requiring access within the vicinity of any existing SA Power Networks' electrical infrastructure shall comply with the requirements specified in NICC404: 'Working in the vicinity of SA Power Networks' Infrastructure - Network Access Permit Process'.

7.4 Work Health and Safety (WHS)

All works shall be completed in compliance with the latest version of WH&S Regulations 2012 and SafeWork SA Codes of Practice including any additional SA Power Networks project specific requirements.

7.5 Waste Soil Management

The soil extracted using the hydro vacuum excavation process or similar may be contaminated. If the soil extracted is from a 'Potentially Contaminated Activities' (PCA) site, then it shall be flagged by the licensed transporter (ie the hydrovac contractor) and included in the waste transport certificate and other documentation, that accompanies the liquid waste.

This documentation will be provided at the gate of the EPA licensed receiving facility and a copy shall be submitted to the relevant SA Power Networks Project Manager.

For more details, refer to **Appendix G**: 'Waste Soil Management Procedure - Summary'.

7.6 Council Roads

For a public road that is not under the control of DPTI (ie Department of Planning Transport and Infrastructure), the authorisation to excavate, backfill and any other specific requirements shall be sourced from the relevant council.

SA Power Networks will require a copy of any conditions, the approval from the relevant council and details of the civil works as a part of the SA Power Networks civil infrastructure works compliance form TS105 C2.

7.7 DPTI Roads

There are specific DPTI requirements for undertaking any works (including Boring works) on DPTI roads, which apply to all parties. For DPTI roads, DPTI requires a minimum 1m depth of cover.

Refer to http://www.dpti.sa.gov.au/ for more details.

7.8 Railway/Tram Corridors - Access Permit Requirements

For seeking access permission for working in the vicinity of Adelaide Rail and Tram system, please contact the DPTI rail network access team (0408 312 340) or email network.access@sa.gov.au and submit the online form, at least 28 days prior to commencing any works.

For more details, visit DPTI's website https://www.dpti.sa.gov.au/.

7.9 Road Reserve

Electrical equipment can be located in a road reserve (ie Road Reserve, Council Parks and Parklands) only after acquiring written approval from the relevant authorities (eg DPTI, Council, Adelaide Parklands Authority and or State Government).

7.10 Stakeholder Management

SA Power Networks or its contractors may deem it necessary to perform stakeholder management for a specific project, on a needs basis.

For this stakeholder management to be effective, all contractors engaged shall closely liaise and provide support to SA Power Networks, their customers and or their nominated stakeholder management consultants in relation to the performance of the works.

7.11 Third Party Consents

The route design shall give consideration to the location of existing overhead and underground assets and shall ensure that adequate clearances from third party assets are maintained.

SA Power Networks will require evidence of such investigations and where necessary, permission from the relevant third party to proceed with the proposed route or installation.

Where such consent is not granted, the designer shall modify the design (within reason) to an extent practical to achieve the desired rating and overall project outcome.

Where this is not achievable, the relevant SA Power Networks Project Manager shall be advised in order to negotiate directly with the relevant third party.

All correspondence between the designer and or installer, and said third party will be provided to the SA Power Networks Project Manager to assist with these negotiations.

7.12 SA Power Networks Works

The relevant SA Power Networks Project Manager shall assist with the following:

1. Identifying affected properties and obtaining property ownership details.
2. Obtaining and registering easement agreements (based on final route design and survey information).
3. Liaising with Council(s) regarding final approvals and the issue of notification drawings.
4. Liaising with and obtaining other authority approvals where applicable (eg SCAP, Native Vegetation, Indigenous Heritage, DPTI, Railway Authorities etc).
5. Providing appropriate SA Power Networks' Environmental Guidelines (eg Waste Soil Management, Waste Management Guideline etc).
6. Providing information on known areas containing plant, pest plants and or animal diseases.
7. Identifying any significant vegetation to be avoided by the route and provide details of such to the designer.
8. Arranging for geotechnical survey of the route including measuring soil thermal resistivity and contamination testing and ensuring results are provided to the designer.
9. Arranging third party asset location.
10. Providing design reference data (eg initial route selection) and supplying site specific specifications as requested.
11. Arranging for impedance testing of the finished circuit from substation to substation.
12. Ensuring that design drawings revisions are lodged with the SA Power Networks Facilities Records Team, throughout the project and that final 'As Constructed' information lodgement requirement are met.

8. Design Works

The design works shall address the following:

1. Obtaining 'Dial Before You Dig' information, refer to NICC404 for more details.
2. Determining final cable routes and cable trench alignment.
3. Determining the final route selection by liaising with council and other relevant authorities.
4. Nominating soil sampling locations and depths for the purposes of ascertaining the thermal resistivity of the native soil.
5. Ensuring geotechnical route survey information used in calculating the required cable ratings is documented within the final design report and the location of sampling points is recorded on cable route drawings referred to within the design report.
6. Calculating cable pull details including tensions and direction.
7. Determining sheath voltage rise for each cable section.
8. Based on information provided by SA Power Networks, identifying any joint bay locations, cable pull direction, pulling pits, the location of any lubrication points, any signposted significant vegetation zones including signpost number and extent of zone indicated on the design drawings.
9. Preparing a separate detailed design drawing for inclusion of the cable route within the SA Power Networks Geographical Information System (GIS), satellite backgrounds, vertical cable profile and dimensions of all the SA Power Networks proposed infrastructure from fixed points (eg back of kerb, property boundary, survey markers) and third party assets. This is necessary for presentation to other authorities.
10. Providing a schematic showing the earthing arrangements.
11. Providing detailed drawings of any joint bays.
12. Providing details of proposed FTB components and proportions required to achieve the desired 'Thermal Ratings' (TR).
13. Producing a 'Detailed Design Report' as specified in **Section 17**.
14. Preparing 'Drawings' in the format specified in TS099.
15. Ensuring that all cable circuits shall have sufficient cable loops near terminal positions to enable the cable to be easily terminated and re-terminated in the case of a termination failure.
16. Providing the cable lengths and material quantities for estimation.
17. Calculating the cable impedance for the installation.

Where the materials selected deviate from those already approved for use by SA Power Networks on its network or as specified within the site specific design specification, the designer shall explicitly highlight any variation together with an explanation as to why an alternate item of equipment has been selected for approval by SA Power Networks.

In order to approve any alternate item of equipment specified by the designer, SA Power Networks may require:

1. Copies of type test certificates;
2. Product documentation;
3. Product drawings;
4. Details of previous use (including referrals); and or
5. Inspection of the manufacturing facility.

8.1 Design Specifications

SA Power Networks will supply a site specific specification (eg engineering requirements) relating to the site specific cable project, which will include the following information:

1. Project scope and description.
2. Required completion date, if applicable, to satisfy system loading requirements.
3. Proposed cable / circuit route drawings with suggested joint bay locations and nominal circuit length.
4. Any site specific underground trenchless techniques requirements.
5. Details of any project specific load profile to be used in determining the achievable rating, the continuous and cyclic summer rating requirements including provision of load information for other circuits in close proximity.
6. Any site specific cable or line survey requirements.
7. Details of power cables / cable sizes including any specific requirements for compatibility with existing cable installations, cable joints and terminations.
8. Segregation requirements for multiple circuits along a common route where these differ from those minimum requirements stated in this document.
9. Type of sheath conductor earth bonding arrangements to be employed.
10. Spare equipment requirements.
11. Pole top termination support, substation sealing end support and or terminal pole sealing end support structure drawings, as required.
12. Protection requirements, where relevant to the scope of the works.
13. Specific requirements of flowable thermal backfill (FTB) around conduit and sand backfill where these differ from those requirements stated in this document.
14. Preferred method of cable installation, conduits depth, number of spare conduits required, including typical conduits arrangements.
15. Any project specific design or construction requirements or constraints.
16. List of reference drawings or reference materials not specified in this standard.
17. Any special conditions or arrangements already made for easements, right(s)-of-way, and access to private land, local council / roads authority for powerlines in public roads.
18. Provide identification of any significant vegetation.
19. Provide design quotation which may be required for issuing offer to customer.

Note that within **three (3) months** (or as otherwise negotiated with the designer) from the date of an order, the designer shall submit details of their designs for the cable installation, which shall include a drawing to show the electrical design, and a complete list of the materials required for the installation together with a draft design report for comment by SA Power Networks prior to issuing the final design report.

Designs shall comply with all relevant E-Drawings and specifications, in particular:

1. E1510 series - 66kV Over / Under Termination Earthing Arrangement
2. E1545 series - 66kV Over / Under Arrangements
3. Site specific design requirements specified within the project specification issued by SA Power Networks.

8.2 Thermal Rating

The required load cycle and thermal rating (if different from that provided in **Sections 8.3** and **8.5**), then it will be provided in the site specific cable specification. Thermal ratings shall be calculated in accordance with IEC60287 and shall consider the native soil thermal resistivity (TR) values found in the initial route survey.

Inputs into the thermal rating calculations will take into consideration:

1. Rating types:
   (a) Continuous rating
   (b) Cyclic rating
2. proximity and loading of other sub-transmission lines or distribution feeder cables in service, where relevant
3. Load cycle for cyclic rating
4. Conductor temperature limits:
   (a) 90°C for continuous and cyclic rating
5. Ambient ground temperature:
   (a) nominally 25°C for summer and 15°C for winter
   (b) Refer to **Section 8.4,** for more details.
6. Moisture content:
   (a) 0% for FTB material and within 50°C isotherm
   (b) 0% for Sand backfill
   (c) 0% for Native soil (unless otherwise agreed)
   (d) Refer to **Sections 8.6**, **8.7** and **8.8**, for more details
7. Thermal properties of cables and conduits

The maximum dimensions of the 50°C isotherm shall be calculated for the continuous and cyclic rating scenarios. For open trenching, the trench shall be backfilled so that the worst-case 50°C isotherm is fully contained within the flowable thermal backfill (FTB).

A greater thickness of FTB from those specified in Section 8.6 and Appendices C and D may be needed to accommodate the 50°C isotherm.

8.3 Normalised Load Curve Values

All cable rating calculations shall be approved by the SA Power Networks Manager Network Planning, to ensure that the proposed cable size / installation arrangement will achieve the required ratings taking into consideration the cable arrangement, depth of burial, load curve, proximity to other cables (ie heat sources), soil temperature and soil thermal resistivity as a minimum.

Unless otherwise directed within the site specific cable specification, the continuous and cyclic summer ratings are to be based on a 'Top Hat' load curve of 50% continuously rated current for 16 hours and 100% continuously rated current for 8 hours. The normalised load values for this curve are shown in **Table 1**.

Table 1
Normalised Load Curve

Hour	0	1	2	3	4	5	6	7	8	9	10	11
Load	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1.0	1.0	1.0
Hour	12	13	14	15	16	17	18	19	20	21	22	23
Load	1.0	1.0	1.0	1.0	1.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5

8.4 Ambient Summer Ground Temperature

The cable rating calculations should apply an appropriate value from **Table 2** based on the proposed depth of burial.

Table 2
Cable Depth vs Summer Soil Temperature

Cable Depth (in mm)	Summer Soil Temperature
≥ 900 & < 2500	25°C
≥ 2500 & < 4000	23°C
≥ 4000 & < 6000	22°C
≥ 6000 & < 8000	21°C
≥ 8000	20°C

8.5 Thermal Resistivity (TR) Values

Sand backfill and flowable thermal backfill (FTB) shall have TR values as specified in **Table 3**. Where the requirements of **Table 3** can not be met, the SA Power Networks Network Planning Department are to be consulted regarding the rating achievable based on the site conditions or advise alternate arrangements required to achieve the required rating.

Table 3
Thermal Resistivity (TR) Values

Installation Method	Open Trench	Trenchless Techniques
Sand Backfill (at 0% moisture content)	TR ≤ 1.0 °Km/W	N/A
Flowable Thermal Backfill (FTB)	TR ≤ 0.9 °Km/W	N/A

8.6 Flowable Thermal Backfill (FTB) Specification

The following design factors shall be considered for using FTB:

1. Designers shall ensure that the conduits can support the weight of the FTB.
2. FTB thermal resistivity shall be less than or equal to 0.9 °Km/W.
3. 0% moisture contents for FTB material and within 50°C isotherm.
4. FTB shall be laid minimum of 100mm surrounding all conduits in an open trench.
5. Ensure the FTB mixture is durable and resistant to erosion; this is achievable since it is often less permeable than the in-situ material.
6. Low compressive strength (eg 3 MPa) FTB mix grade shall be used to allow use of conventional methods (such as hand tools or backhoe) to gain future access to the conduits and cables.
7. For further requirements, refer to **Sections 11.4** and **15.4**.

8.7 Sand Backfill Specification

The sand backfill shall comply with the following:

1. It shall contain a mixture of grain sizes complying with the values specified in **Table 4** to minimise air gaps.
2. The thermal resistivity value for sand back fill shall be less than or equal to 1.0 °Km/W at 0% moisture content. If this value is exceeded then this must be analysed to confirm the required rating.
3. It shall be compacted as stated in **Section 11.5** to minimise air gaps.
4. For further sand testing requirements, refer to **Section 15.3**.

Table 4
Sand Backfill Specification

Test Method	Test	Permitted Test Values
AS 1141.11.1	**Grading Sieve Sizes (mm) AS 1152**	**% Percent Passing**
	4.75	100
	2.36	98 - 100
	1.18	94 - 100
	0.6	85 - 100
	0.425	55 - 100
	0.3	25 -100
	0.15	5 - 40
	0.075	0 - 10

Note: Where the sand backfill material has been selected for its thermal resistivity as per **Table 3**, but does not fully satisfy the grading requirements specified in **Table 4**, the thermal resistivity requirements shall take precedence, however the relevant SA Power Networks Project Manager's approval is still required.

8.8 Native Soil

The thermal resistivity (TR) of the surrounding soil is a very important factor affecting current carrying capability of the underground cables, particularly for directly buried cables. Normally, the higher TR of the surrounding native soil, the lesser current the cable can carry, whereas a lower TR makes it easier to dissipate the heat energy produced by cables.

The moisture content (MC) of the soil has a direct impact on the soil's TR. The soil's TR has an inverse relationship with soil's MC. A higher MC will result in a lower TR of the soil.

The achievable cable ratings are reliant upon the soil's native TR and is prone to being further dried out due to heat generated by the cable.

The native soil shall be tested along the cable route, at various points and at appropriate depths to ascertain both its contamination levels and its TR.

Should a cable rating based on an alternative TR moisture content from that specified in **Section 8.2** be used, the designer shall provide evidence to SA Power Networks justifying why the use of a TR value at the higher moisture content is considered appropriate.

8.9 Cable Specification

The cable specification shall be provided by SA Power Networks. Only those cable types approved by SA Power Networks shall be installed on the network. Refer to **Table 5** for underground cable sizes and stock item numbers.

8.9.1 66kV Underground Cable

For 66kV, SA Power Networks has three cable sizes available for use, 300mm^2 (CK9280), 1600mm^2 (CK9281) and 2000mm^2 (Non-Stock Item) Copper XLPE cable.

8.9.2 Earth Continuity Cable (ECC)

The earth continuity cable shall be a minimum of 240mm^2, single core compact Copper, XLPE / PVC, Green / Yellow (ie CK9250) and shall be bonded in accordance with SA Power Networks' E-Drawings E1011 & E1510 and be constructed to AS/NZS 5000.1.

8.9.3 Bonding Cable

The bonding cable for connecting the cable's screen to the link boxes shall be 240mm^2 Copper, XLPE / PVC, Black (ie CK9251) bonded in accordance with SA Power Networks' E-Drawings E1011 & E1510 and be constructed to AS/NZS 5000.1.

Table 5
Underground Cable Sizes & Stock Item Numbers

Voltage	Underground Cable Sizes	Screen Type	SAPN Stock Item Number
66kV	**300mm²** 1 Core Cu XLPE	Lead Alloy Sheath	**CK9280**
	1600mm² 1 Core Cu XLPE	Lead Alloy Sheath	**CK9281**
	2000mm² 1 Core Cu XLPE	Lead Alloy Sheath	**Non-Stock**
0.6/1kV Earth Continuity Cable	**240mm²** 1 Core Cu XLPE/PVC Green/Yellow	N/A	**CK9250**
0.6/1kV Bonding Cable	**240mm²** Cu XLPE/PVC Black	N/A	**CK9251**

Note: Cu = Copper and N/A = Not Applicable

8.10 Separation to Other Services

No other third party services are to be laid in parallel with 66kV cables (at any depth) within 3m measured horizontally from the outer phase cables. Where this requirement cannot be met, the SA Power Networks Manager Network Planning shall determine and agree any site specific clearance.

Where any of the new 66kV circuits are required to cross existing 66kV circuits, the preference is for the new 66kV cable to cross under the existing 66kV cables.

All other services crossing existing and or new 66kV cables will require approval from the SA Power Networks Manager Network Planning.

Refer to **Table 6** for minimum separation requirements between 66kV and other services.

Table 6
Minimum Separation between 66kV and Other Services

Installation Method	Open Trench	Trenchless Techniques
Cable Configuration	**Flat Spaced / Trefoil**	**Flat Spaced / Trefoil**
Minimum Horizontal separation to 11kV / 7.6kV feeders, (mm)	2000	2000
Minimum Vertical separation to 11kV / 7.6kV feeders, (mm)	600	600
Minimum Horizontal separation to other 66kV circuits, (mm)	2000	2000
Minimum Vertical separation to other 66kV circuits, (mm)	600	1600
Preferred minimum Horizontal separation to third party assets, (mm)	3000	3000
Preferred minimum Vertical separation to third party assets, (mm)	1000	1600

8.11 Design Drawings

All of the following drawings shall be submitted with the design:

1. General arrangement of the cable system including:
   (a) detailed earthing system including sheath bonding and earthing system;
   (b) joint bays, pits and accessories;
   (c) cable route plan/s showing cable alignment, trench profile, trench dimensions, clearances and orientation to other underground services, coordinates, chainage, etc;
   (d) drawings detailing the route, bore depth and bore pit locations (where applicable for HDD), lubrication injection points, preferred direction of cable pull;
   (e) cable crossing details showing trench cross-section drawings, longitudinal section, site plan, etc; and
   (f) any other drawing appropriate to the equipment installation.
2. A detailed general arrangement drawing and material list for each accessory, including:
   (a) outdoor sealing end and support structure dimensional requirements;
   (b) each type of joint;
   (c) each type of link box ie joint bay and sealing end types;
   (d) sheath voltage limiters;
   (e) each type of special tool or die;
   (f) link box and covers.

The drawings shall be modified by the contractor as required by SA Power Networks and resubmitted for final approval. The design drawing files shall be in AutoCAD format and be compliant with the requirements of TS099.

8.12 Safe Clearance to Buildings

The Electricity (General) Regulations 2012, requires a safe horizontal clearance between a building or a structure and 66kV underground powerlines as 3m minimum.

Any installation not meeting these requirements, will be non-compliant without an exemption from the OTR, which shall be agreed by SA Power Networks. The associated party, will need to supply the OTR exemption document, along with the SA Power Networks civil infrastructure works compliance form TS105 C2.

8.13 Trench Design

Before commencing trench works, obtain 'Dial Before You Dig' information and refer to NICC404 for more details on Network Access Permit process.

The cable trench design drawings submitted to SA Power Networks for approval shall comply with the requirements of TS099 and shall include fully dimensioned cross-sections of the trenches including the cables, cable depths, cover slabs, sizes, spacing of ducts, cable markers and cable marker balls where applicable and these dimensions shall constitute 'Standard Trenches' within the terms of the contract and for the determination of contract price adjustments.

Where possible, trenches should be designed to be less than 1500mm deep to avoid the need for additional shoring, refer to **Appendices C** and **D** for typical 66kV cable trench arrangements. the SA Power Networks' Project Manager will require notification of any variations in the trench dimensions from the approved design for re-approval.

8.14 Lubrication Injection Points (LIPs) and Pulling Pits

The route design shall include details of any Lubrication Injection Points (LIPs) and any pulling pits together with any calculations used to arrive at the LIP and pulling pit locations.
SA Power Networks in conjunction with the cable installer will nominate the number and location of LIPs and pulling pits prior to commencement of conduit installation.

Installation of any LIPs shall be according to the design and as per project specifications. Notionally, LIPs and / or pulling pits may be required before bends and over long lengths, where heavy cable hauling is expected.

The location of the LIPs and pulling pits shall be recorded on the construction drawings and final 'as built' drawings. The lubricant used shall be fit for purpose and care shall be taken to ensure that no spillage or site contamination occurs as a result of its use.

Copies of 'Safety Data Sheets (SDS)' shall be provided to SA Power Networks for any lubricant proposed prior to its use. Copies of the SDS shall be available on site during cable pulling. Refer to **Section 13.11:** 'Polywater® Lubricant J' as SA Power Networks' preferred lubricant.

8.15 Use of Bentonite

The use of Bentonite, other slurries or grouts to fill conduits in attempting to achieve the desired cable ratings is 'Prohibited'.

Grouts or slurries used to fill voids within metallic sleeves around conduits (ie external to the conduits) installed using trenchless techniques for strength or surrounding soil reinforcement purposes are allowed, provided the TR of the material used is no worse than that of the native soil surrounding the conduits determined through site specific testing and if required to achieve the specified rating(s).

8.16 Cable Laying Parameters

Unless otherwise specified, all new 66kV cables shall be installed in conduits in order to expedite reinstatement of the trench, either in a flat spaced or trefoil arrangement whilst seeking to achieve the specified continuous and cyclic ratings as well as ensuring future civil works for SA Power Networks are kept to a minimum. Refer to **Appendices C** and **D** for typical 66kV cable open trench arrangements.

Where the use of open trenching is deemed impractical by the designer, trenchless techniques may be used, for more details, refer to **Appendix E**.

The preferred minimum cover for any 66kV cable is 1200mm, including those sections of cable located within a substation. However, subject to SA Power Networks' approval, the minimum cover may be reduced to 1m, where the cable is protected by a mechanical barrier eg concrete cable cover slabs or polymeric cable cover strip complying with AS 4702 (for Electricity Act & Regulation compliance). **Table 7** provides installation requirements.

Table 7
Cable Laying Parameters

Installation Method	**Open Trench**	**Trenchless Techniques**
Cable Configuration	**Flat Spaced / Trefoil**	**Flat Spaced / Trefoil**
Minimum depth to top of conduit, (mm)	1000	1000
Preferred minimum depth to top of conduit, (mm)	1200	1200
FTB surround all conduits, (mm)	100	N/A
Sand Backfill (mm)	To top of trench	N/A

Notes:

1. Installation at depths greater than 3m is not permitted unless approved by SA Power Networks.
2. Wherever practical, cables shall be installed as close as possible to the preferred minimum depth.
3. Sand backfill and FTB as applicable shall have TR values as per **Table 3**.

8.17 Determining the Best Cable Route

Prior to the commencement of any cable or civil installation works, the cable route and installation design details shall be finalised as part of the project design process and all necessary agreements, permits and easement details shall be in the possession of the relevant SA Power Networks Project Manager.

The following are the general requirements for achieving best cable route:

1. Simulate cable / conduit route versus allowable cable pull tension, sidewall pressure around bends and determine required quantity of lubricant, before finalising the actual design.
2. Reduce cable pulling tensions by using appropriate conduit sweep bends within the minimum cable bending radii specified by the cable manufacturer.
3. Minimise the number of joint bays, within the design whilst not exceeding maximum cable pulling tensions or minimum bending radii.
4. Allow locations for lubrication injection points (LIPs), in particular, prior to bends (if deemed necessary).
5. Minimise number of bends per duct run and maintain straight-line cable route.
6. Prefer footpath reserve for cable trench and cable joints, to facilitate safer future access.
7. Allow jointing / pulling bays to avoid long duct runs.

The designer shall consider the minimum internal bending radii of the nominated size cable within the design and ensure that such ratings and or dimensions are not exceeded. Where cables are expected to curve, appropriate conduit bends shall be specified by the designer and installed by the civil contractor.

The cable pulling tension during installation shall not exceed the cable manufacturer's specified maximum pulling tension. SA Power Networks will consult with its nominated installer to designate the following:

1. The need for and location of any pulling pits and or lubrication injection points (LIPs).
2. Details of the preferred direction of cable pull and any pulling pits or LIPs are to be indicated on the design drawings.

The designer shall provide calculated cable pulling tension values and indicate these on the design drawing as stated in TS099, which should also include indication of the preferred direction of cable pull as nominated by cable installer, pulling pits and or LIPs locations, where applicable.

8.18 Joint Bay / Pit

In general, cable section lengths shall be maximised so that a minimum number of joint bays needed are minimised, consistent with the constraints of the earth bonding system design.

The designer shall familiarise themselves with local conditions in relation to joint location to avoid road intersections and existing buried services, with the view to cause the least disruption to road traffic during construction or in the future.

The following factors shall be considered for locating Joint Bays (but not limited to):

1. All joint bay locations shall be investigated by trial-hole excavation in order to confirm that the location is suitable for the bay/pit construction intended.
2. The joint bay arrangement shall include internal and external dimensions, location of joints, support details for cables and joints, bonding lead conduits, link boxes and earthing details.
3. Pulling tension calculations shall be used to ensure the cables can be successfully installed within the constraints of pulling tensions and sidewall pressures.
4. The dimensions of each joint bay/pit shall be based on:
   (a) Number of cables;
   (b) Distance required to space out cables for jointing;
   (c) Length of joints; and
   (d) Parking distance required for jointing components / accessories.
5. Design drawings and layout for each joint bay (including any pit and vault) shall be submitted to the relevant SA Power Networks' Project Manager for approval.
6. Joint locations and approximate drum lengths shall be determined by the designer.
7. Joint bays shall be suitably large enough for jointers to carry out the work efficiently.
8. All joint bays, irrespective of whether a cable runs down the middle of the road shall be located adjacent to the kerb unless otherwise agreed by SA Power Networks.
9. SA Power Networks shall be notified of the number and location of any additional pulling pits by the cable installer for incorporation within the design.
10. For further requirements, refer to Sections 10.4, 13.4 and 13.5.

8.19 Specific Design

For Telecommunications Design, refer to TS201 for more details.

8.19.1 Bridge Crossing Design

SA Power Networks shall only maintain their assets which are installed on the bridge (ie cabling and conduit system). The owner of the bridge shall maintain the bridge and its supporting structural elements (eg hangers, cable trays, pipes etc) used for holding the conduits and cable system.

The designer shall meet the following requirements:

1. Where steel pipes containing SA Power Networks' underground cables (eg 3xsingle core, distribution feeder cables or communication etc) are attached to the railway line's and or tram line's bridge crossing structure and are bonded to the electrified rail and or tram network, then all single core cables for a given circuit shall be contained within the same (single) steel pipe. (Do not install 3 single core cables within 3 steel pipes).
2. Where medium or heavy seamless stainless steel tubing is required, the designer shall ensure that it complies with AS 1074 and the relevant SA Power Networks Project Manager is notified.

8.19.2 Service Bridge Arrangement

For a service bridge, installer of the SA Power Networks infrastructure along with other utilities' services (eg APA gas, SA Water, third-party telecommunication etc) shall meet following specific requirements:

1. Electrical cable and conduit systems shall be mechanically protected
2. Underground cables when installed in air are limited to their steady state 'in air' ratings, therefore shall be protected from sun's ultraviolet (UV) radiation
3. Install conduits and spare conduits as specified in this standard
4. Maintain separation for other utilities' services as specified in **Table 6**
5. Minimum Separation between 66kV and Other Services
6. Where two or more 66kV circuits are to be installed in parallel, 2m minimum separation between circuits is required and 3m minimum for third party services, although preference will be to maintain a 3m separation between cuircuits where possible. For critical circuits, more detailed analysis may be required
7. Supports, clamps and hardware are to be 316 stainless steel

8.19.3 Bridge Cable Tray Arrangement

Before commencing any cable-tray arrangement works associated with a bridge crossing, seek approval from the relevant SA Power Networks' Project Manager and the bridge owner. The designer shall include the following minimum requirements with the design:

1. Consider criteria for mechanical, UV and vandalism protection including future repairs and durability for the life of the infrastructure
2. Include cable rating calculations
3. Provide engineering design calculations (including mechanical loadings)
4. Supply bridge structural drawings
5. Include details of cable tray clamps, conduits and pipe supports

8.20 Railway and Tram Network Design

8.20.1 Design Requirements

The following are the requirements for designing underground conduit and cable systems within railway and or tram boundaries:

1. Submit sufficient information to the relevant SA Power Networks Project Manager, which shall include section of 'Digital Cadastral Data Base' (DCDB) with street names, rail/tram lines information, any crossing point etc, clearly marked on the preliminary design drawing for the assessment.
2. Conduct risk assessment and consider additional factors such as rail and or tram safety, environmental criteria, any mandatory procedures etc.
3. The design live loads may be specified by rail/tram authority, else as minimum comply with AS 4799 - Table A1 of Appendix titled: 'ADMD Tables' load values.
4. Shall comply with requirements specified in AS 4799 and AS/NZS 3000.
5. Earth Potential Rise (EPR) design limits shall be as per AS 2067.
6. Any metallic casing shall be protected against electrolysis, corrosion and induced currents in accordance with AS/NZS 2832.1 and statutory requirements. The steel bore casings shall be electrically isolated from any type of cable pits.

7. Cable joints/splices are not permitted for the entire cable length within the railway and or tram corridor's reserve crossing.
8. Consider relevant factors as specified in **Section 8.1**.
9. The electrical and telecommunications conduits and spare conduits requirements as specified.
10. Where multiple HV feeder circuits cross under the railway and or tram network, a separate bore hole for each circuit is required.
11. Within metropolitan Adelaide, it shall be assumed that a CMEN system is in place. The continuity of any existing CMEN conductors shall be maintained at underground railway and or tram crossings.
12. Where existing HV overhead mains with CMEN conductor are to be undergrounded (no LV mains), the CMEN conductor shall be terminated at the over/under poles and bonded to the underground cables' screen wires at each end, to maintain CMEN continuity.

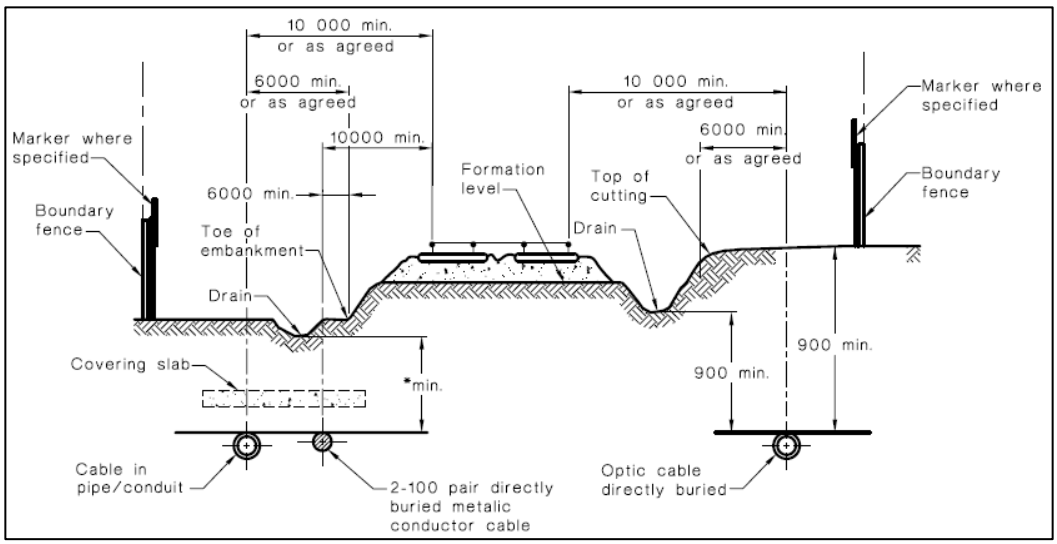
8.20.2 Separation Requirements

The minimum separations specified in the Figure 1, Figure 2, **Figure 3** and Figure 4 are as specified in AS 4799. In relation to $25kV_{AC}$ rail or $600V_{DC}$ tram network, tracks and its formation, all services, pits and pipelines, shall not be located within 6m of the toe of banks or top of cuttings, or within 10m of the nearest track.

To maintain sufficient clearance from railway/tram facilities, all services, pits and pipelines shall be laid at least 3m clear of all railway/tram structures, cattle pits and stops, drains, signaling equipment, overhead masts, poles, underground cables, buildings, points and crossings, bridges and culverts.

Pipeline routes, cable routes, carrier pipes and encasing pipes shall be separated by a clear spacing of at least 600mm in the horizontal plane from other pipelines and from power and communication cables, unless agreed to otherwise, in writing, by the relevant parties.

8.20.2.1 Conduits/Cables (Laid Parallel) near Tracks

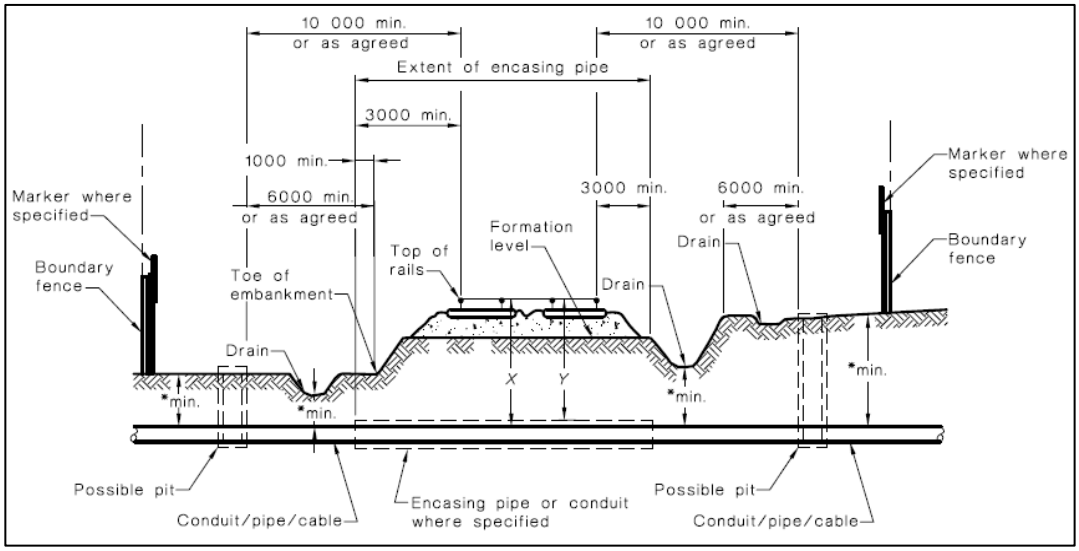


Note: * = 600 min. Increase to 900 min. for directly buried optic cable.

Figure 1: Conduits/Cables (Laid Parallel) under Railway or Tram Lines

(Reference: AS 4799, Section - 6)

8.20.2.2 Conduits/Cables (Crossing) under Tracks



Note: * = 600 min. Increase to 900 min. for directly buried optic cable.

Figure 2: Conduits/Cables (Crossing) under Railway or Tram Lines

(Reference: AS 4799, Section - 6)

Table 8

Minimum Depth of Conduits/ Cables Crossing under Rail/Tram Tracks

Dimension	Description	Minimum Depth (mm)
X (Refer to **Figure 2**)	Depth between top of rail/tram tracks and top of conduit, pipe or cable	1200/1500 (directly buried optic cable) 2000 (Electrical cables)
Y (Refer to **Figure 2**)	Depth between top of rail/tram tracks and encasing pipe	1200/2000 (Electrical cables)

8.20.2.3 Horizontal Separation from Rail/Tram Lines

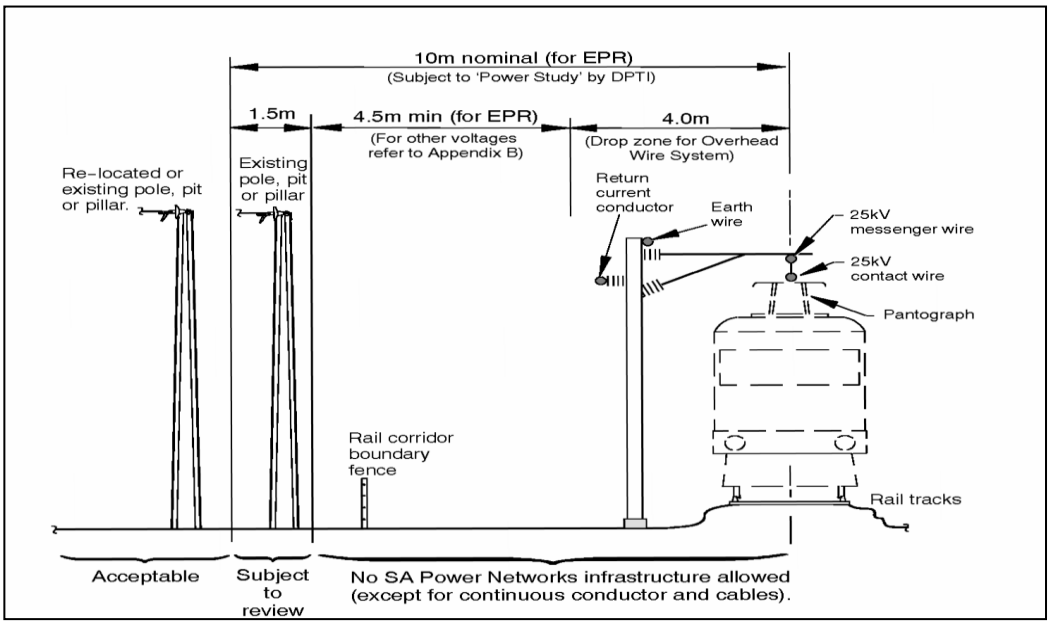


Figure 3: Horizontal Separation from Railway or Tram Lines

8.20.2.4 Vertical Separation from Rail/Tram Lines

1. The vertical clearance between upper overhead 66kV lines and lower overhead 25kV$_{AC}$ railway or overhead 600V$_{DC}$ tram lines shall be minimum 4.6m. The vertical clearances shall be measured from the OH 25kV$_{AC}$ railway or OH 600V$_{DC}$ tram lines' highest point of the 'Overhead Contact Line Zone and Pantograph Zone (OCLPZ)' or its supporting structure, whichever is the highest.
2. Relevant 3rd Party telecommunication carrier owners shall consult DPTI in relation to the clearances requirements with 25kV$_{AC}$ railway or 600V$_{DC}$ tram lines network.

8.20.2.5 Conduit/Casing Extension (Crossing) under Tracks

Where power cables crosses under tracks, they shall be enclosed. The top of the encasing pipe with cables in conduits shall be at a depth of not less than 2m below the top of rail and shall be maintained at this depth for not less 3m beyond the each outer rail track line, when measured at right angles to the track. Refer to **Figure 4**.

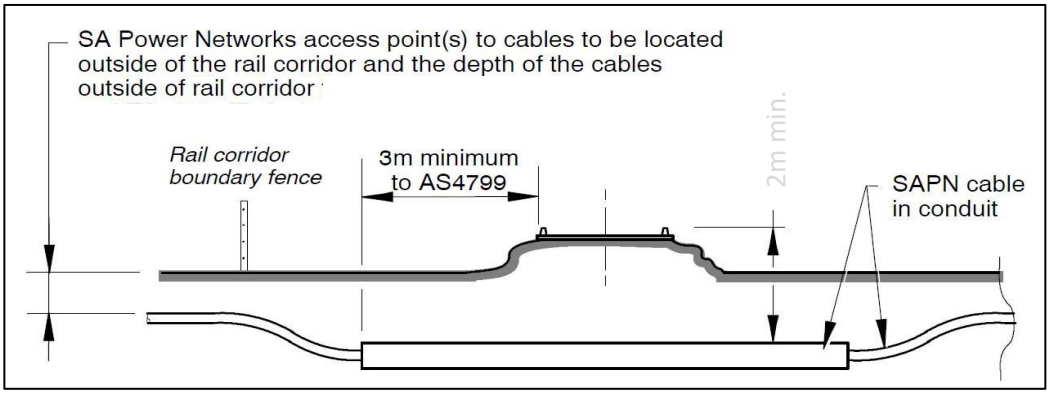


Figure 4: Conduit/Casing Extension (Crossing) under Railway or Tram Lines

9. Easements

Where the cable is to be installed within property designated as 'Private Property or Crown Land', easements are to be provided to SA Power Networks for all 66kV cables and equipment as specified in TS102.

The following are the general rules for underground 66kV cable easements:

1. A minimum easement of 3m either side of the outer phase cable is required for SA Power Networks' underground 66kV cables.
2. Where multiple 66kV circuits exist in a single trench, the easement width will need to be increased such that the 3m requirement from the outer phases is met for each circuit.
3. All easements in favour of SA Power Networks are to be 'Easements in Gross' and registered on title plans.

10. Earthing Design

Within the metropolitan area, SA Power Networks utilises a 'Common Multiple Earth Neutral' (CMEN) system which has a neutral that is common to the HV and LV systems and is continuously connected back to the substation earth.

Within rural areas, 'Multiple Earth HV / LV Neutral' (MEN) system is used as the standard earthing system.

With SA Power Networks' approval and only within a localised area, a 'Localised CMEN' system can be used, where the neutral is not connected back to the substation earth.

Please refer to TS109 for detailed information on earthing design requirements and also refer to E-drawings E1011 and E1510 for earthing arrangement drawings. For accessing E-drawings, please refer to **Section 5**.

The designer shall describe in detail, with drawings, the arrangements proposed to be used for bonding and earthing of the complete cable systems and shall include calculations of sheath voltages and, (where cross-bonding is used) any circulating currents.

The cable sheath bonding and earthing arrangement shall be designed to ensure that, under normal conditions, the sheath voltage will not exceed 65V AC root-mean-square (rms) at any point in the installation and that sheath losses due to circulating currents are minimised.

Where cost-effective, SA Power Networks will consider designs that have sheath voltages up to 200V, AC rms , but, these designs shall be submitted to the relevant SA Power Networks' Project Manager, who will consult SA Power Networks' Cable Management Engineer, before providing an approval.

The cable's sheath bonding and earthing arrangement shall be designed to withstand the ultimate transient overvoltages, 50Hz AC, short circuit fault current level of **31.5kA** and associated backup clearance time for **1 second**, unless otherwise specified. For details regarding the type of approved earthing/bonding cables, refer to **Sections 8.9.2** and **8.9.3**.

For 66kV cables, neutral screens are to be either single point or cross bonded to earth. All joints and earth stake connections shall be fully sealed against ingress of moisture. SA Power Networks will specify 'on a site by site basis', whether a single point bonded or cross bonded sheath / screen earthing arrangement is to be used.

Where the screen bonding method specified is to use the single point bonding method, link boxes at each cable termination (eg Gas Insulated Switchgear, over / under transition structure) or joint bay, Sheath Voltage Limiters (SVL) shall be installed in the link box at the end of the cable screens that are not solidly earthed.

For single point bonding, each section of cable shall have one-end direct bonded to earth with the remote end earthed via a SVL. The final arrangement will be subject to the final route design and the number of joint bays required. An earth continuity cable (ECC) will be required to be run as close as possible to the phase cables. The ECC is to be transposed halfway along the relevant cable section to balance the cable system's impedances.

The cross bonding method sees the sheaths of the phase cables bonded in succession such that the sheath currents are canceled out over the three minor sections and utilise SVLs to minimise any transient sheath overvoltages. The combination of the minor sections form a major section which are bonded directly to earth at each end.

The design should ensure that the induced voltages of the three minor sections balance to almost zero and should look to ensure that the lengths of each minor section are the same (or as close as practical). For single phase cables installed in flat formation, the cables shall be transposed between minor sections.

The use of cross bonding will typically be limited only to long cable installations or where there is a low likehood that the cable will need to be split in future (eg to cut in a new substation).

The submitted design shall indicate the type of earthing arrangement to be employed at each joint bay. The SA Power Networks preference is for those locations accessible to the public to be directly bonded to earth as per E1510.

10.1 At Substation Ends

Surge Arresters: 1 surge arrester per phase (except at Gas Insulated Switchgear terminations).

1. Bonding for all cable neutral screens to earth is to be via a link box.
2. Preference will be for the cables to be bonded to earth via SVLs at the substation ends of the cable with the remote ends directly bonded to earth.

10.2 Earthing via Link Box

Bonding for all cable neutral screens to earth is to be via a link box. Link boxes may contain either, 6 SVLs, 6 direct earth links or a combination of 3 SVLs and 3 direct earth links.

The type of connection to earth made at each link box will ultimately depend on the number of joint bays employed for each circuit and shall be detailed within the design report and associated design drawings.

10.3 Earthing at Terminal Pole

The maximum value of earth resistance at each pole shall be 5Ω (in dry conditions). The earth electrode system may include the pole footing but must not include any remote earth via CMEN connections.

Additional earth electrodes shall be connected if the footing alone is more than 5Ω.

Earthing electrodes shall be constructed from stainless steel clad mild steel rods of not less than 12mm diameter.

If the required resistance can not be achieved with 4 electrodes then refer to SA Power Networks' Project Manager for further consideration.

10.4 Earthing of Joint Bays

An earth-bar shall be provided [with four (4) spare 13mm diameter holes] for temporary earth connections and be positioned such as not to be a hazard during initial installation or repair works.

Joint bays shall be fitted with copper earth rods in each corner of the joint bay and an interconnecting earth grid consisting of at least 120mm^2 bare copper.

All connections are to be CAD welded. This scheme shall be interconnected and bonded to any reinforcing within the concrete and the earthing continuity cable (ECC).

The earth resistance achieved by the arrangement shall be 5Ω or less.

11. Civil Works

11.1 General

Before commencing trench works, obtain 'Dial Before You Dig' information and perform any localised asset location activities (eg GPR, slot trenching). Refer to NICC404 for more details on SA Power Networks' Network Access Permit process.

All excavation sites which are required to be left open and or unattended (eg left unsupervised) overnight shall be effectively covered for public safety, eliminating potential hazard, theft control and or any accidental damage to SA Power Networks' asset. In some cases, site security personnel may also be required.

Any trench with a depth 1500mm and over, below the finished ground level, shall comply with the specific requirements stipulated in Work Health & Safety Regulations 2012.

SA Power Networks shall be the final arbiter of whether the civil works conducted have been undertaken to a satisfactory standard. SA Power Networks reserves the right to reject such civil works either during or after their installation on the basis of workmanship and or deviation from the design, refer to **Section 3**, for more details.

The civil installations shall only be deemed 'adopted' by SA Power Networks once the cable has been successfully installed, tested and energised for a period of 24 hours (ie soaked) without failure.

The approval to backfill the trench does not absolve the civil contractor of its liability to remediate the installation until such time as the cable itself has been successfully installed, tested and placed in to service.

Where the soil is identified from a site associated with 'Potentially Contaminating Activities' (PCA) such as a substation, petrol station or industrial facility, please refer to **Sections 7.5** and **11.3**, for more details.

The party responsible for performing the civil works shall address the following:

1. Ensuring that the assets are installed according to the design (ie depth, spacing, materials).
2. Ensuring the security and integrity of the site (including any materials) for the duration of the civil works.
3. Developing and submiting all traffic management plans during the civil works.
4. Liaising and co-ordinating with other parties who may require access within the area of work.
5. Performing all tests (eg FTB, Sand Backfill Testing) required to ensure the integrity of the future cable installation.
6. Developing SWMS for the tasks to be performed and ensure that the overall security and safety of the work area is achievable.
7. Managing any contractors or sub-contractors required to complete the works.
8. Recording and submiting 'As Constructed' information for each section of the conduit installation, ensuring that they have suitably recorded the length, depth and position of the conduits with respect to other underground services and obstructions.
9. The civil installer shall give notice upon the completion of laying of each length of conduit and shall not commence to backfill the trench until notified by SA Power Networks that it is satisfied with the conduit installations. SA Power Networks may require internal inspection/proving of the conduits and prior to backfilling of the trench using either mechanical or visual means, refer to **Section 11.2.3**, for more details.
10. Ensure that the project's design drawings are updated to an 'As Constructed' state and issued to the relevant SA Power Networks' Project Manager within 6 weeks of completion of the civil installation in the format specified in TS099.
11. The 'As Constructed' drawings shall be an accurate representation of the installed assets, including highly detailed underground asset location information produced through survey by a qualified surveyor. Copies of the surveyor's qualifications and calibration / test certificates for any surveying equipment used in producing these drawings shall be provided with the drawings to SA Power Networks' Project Manager. Any costs incurred by SA Power Networks in correcting or amending such drawings such that the drawings comply with SA Power Networks' standards may be offset from the contractors invoice, invoiced to the contractor or returned to the contractor for revision – refer **Section 18**.

11.2 Conduit Installation

Precautions shall be taken to ensure that all conduit ends, joints and alignment will not damage or cause high tensions in excess of the maximum permissible pulling tension of the cable during installation and shall consider the following:

1. The conduits, couplings and accessories shall be installed in strict compliance with the manufacturer's instructions.
2. To maintain spacing and prevent floating when pouring with FTB material, suitable spacers between the conduits and clamping systems shall be fitted at suitable intervals prior to pouring the FTB, refer to **Section 12.3**, for more details.
3. Closed metallic loops must not be introduced around power cable conduits, using items such as metallic ducts, metallic strapping, external steelwork or any ferromagnetic material or structures, to avoid circulating current being induced in such materials.
4. All bends shall be pre-formed by the conduit manufacturer prior to arriving at the work site. Conduit bends shall not be made by bending straight conduit sections.
5. All spare conduits shall be fitted with a draw rope and sealed against the ingress of water and any foreign material.
6. Refer to **Appendices C** and **D**, for typical flat and trefoil arrangements.
7. Refer to Sections 11.4 and 11.5, for more details.

11.2.1 Conduit Storage

Degraded conduits (for example due to UV exposure) will not be accepted and SA Power Networks reserves the right to inspect conduit storage facilities and conduits quality, prior to their installation.

The orange PVC conduit specified by SA Power Networks does not contain UV stabilisers. If exposed to UV radiation (ie sunlight) over time, it will whiten on the surface and although it will not lose tensile strength, it will become brittle and can become subject to damage from impact loads, rendering it unsuitable for use on SA Power Networks installations.

SA Power Networks may request for alternative storage arrangements, where deemed necessary, to minimise damage to stored conduits, due to prolonged exposure to sunlight, heat entrapment, poor ventilation and or inferior storage conditions (eg conduits covered under black sheeting, over stacking, contaminated area etc is not permitted).

11.2.2 Conduit Preparation

The following are the requirements for conduits preparation, prior to their installation:

1. Do not install (under any circumstances) any conduit with a kink in its length. If damaged conduits are identified, then it shall be rectified by the installer.
2. All conduits shall be internally clean, free of debris and the internal edge shall be smooth, chamfered and deburred (ie sharp edges removed).
3. Where conduits are required to be cut, they shall be cleanly 'cut square and true' using a rotational pipe cutter. Note that the use of hand saws is not acceptable.
4. All PE pipe joints which have been butt welded should be internally 'de-beaded'.
5. Conduits shall be prepared considering the direction of the cable pull to ensure the cable's outer serving is not inadvertently damaged during installation.

11.2.3 Proving of Conduits

Prior to backfilling of the trench and before installing any cable into a conduit, the conduit's integrity and suitability shall be inspected. Any identified defects shall be rectified. Conduit (including spares) proving work shall comply with the following:

1. Three stage proving process:
   (a) all conduits shall be thoroughly cleaned using a scraper and a cylindrical brush.
   (b) an approved solid mandrel of diameter 12mm less than the internal diameter of the conduit and 230mm in length shall be pulled through every conduit.
   (c) a suitably sized rubber pig with four (4) rings with minimum 2mm less than inside diameter of conduit shall be pulled through every conduit.
2. Jamming of the mandrel and/or visible damage to the pig shall be investigated by the Contractor and any necessary rectification work required shall be at their expense.
3. SA Power Networks reserves the right to request:
   (a) That a waste length of cable to be installed be passed through the conduits and/or video cameras be used to inspect the conduits where reasonable concern exists.
   (b) That a mandrel be pulled through each conduit. The mandrel shall have a diameter equal to Dc and length L per the following formula:

   $L = 2 \times R_b \times \sin(a/2)$ and $a = 2 \times \cos^{-1}[(R_b - Di + Dc)/R_b]$
   Where,
   L = mandrel length;
   R_b = minimum bend radius;
   Di = ID of bore pipe; and
   Dc = diameter of cable

11.2.4 Sealing Works

To protect the SA Power Networks infrastructure from the impact of vermin, all sealing work shall comply with the requirements specified in TS303 'Vermin Control'. Refer to TS303 for more details.

11.2.5 Conduit End Caps

To prevent the entry of water, dirt and / or other foreign matter entering the conduits, conduit end caps shall be installed for all conduits that are to remain vacant and or left empty overnight.

For all empty conduits, the exposed ends shall be squarely cut and cleaned, to enable correct fitting of the conduit caps. Refer to **Table 9** for conduit cap stock item numbers.

Table 9: Conduit End Cap (Push On)

Cap Types	Minimum Cap Length (mm)	SA Power Networks' Stock Item Number
100 PVC, Orange	35	NC6503
150 PVC, Orange	35	NC6504
150 PVC, Gray	38	NC6505
200 PVC, Orange	40	NC6506
100 PVC, White	91	NC6501

Notes: Prior to use of any non-listed items in Table 9, it shall be specified with the project scope and will require approval from SA Power Networks' Project Manager.

11.3 Hydro Vacuum Excavation

The soil extracted using the hydro vacuum excavation process may be contaminated. If the soil extracted is from a 'Potentially Contaminated Activities' (PCA) site or has been identified as contaminated through site specific test results, then it shall be flagged by the licensed transporter (ie the hydrovac contractor) and included in the waste transport certificate and other documentation, that accompanies the liquid waste. This documentation will be provided at the gate of the EPA licensed receiving facility and a copy shall be submitted to the relevant SA Power Networks' Project Manager.

At higher water excavator pressures, there is a possibility of damaging existing direct buried SA Power Networks' cables (eg Paper Lead, Paper Insulated Lead Covered and Fibre-Optic). To avoid damage to SA Power Networks' cables and conduits, the following are the minimum requirements:

1. The hydro vacuum excavation jet nozzle shall be maintained at 100mm minimum clearance above the ground surface;
2. The working water excavator pressure shall not exceed 2000 psi (ie 13,790 kilopascals); and
3. Comply with NICC404 requirements.

11.4 Flowable Thermal Backfill (FTB) Works

FTB installation works shall consider the following:

1. FTB shall be supplied and transported to site using agitator trucks. The FTB pour shall be controlled around the conduits.
2. The normal FTB mix design should not require additional mechanical vibration or compaction to enable it to surround the installed conduits.
3. Where compaction of the FTB is required, immersion vibrators should be used in preference to other compaction methods. Where such methods are required to be employed, the use of such equipment shall be constantly monitored to ensure complete coverage of the FTB.
4. As the FTB cures and begins to solidify, it will bleed excess water to the surface, all such excess water should be removed and disposed of in accordance with environmental guidelines/requirements.
5. Any formwork or shoring materials used prior to the pouring of the FTB should be removed during the pouring of the FTB or within one hour of it being poured whilst still in a semi-fluid state.
6. The FTB should not be allowed to develop cracks as it flows into voids created by the removal of such shoring or formwork. If cracks do result, these should be filled using additional FTB.
7. SA Power Networks reserves the right to request a FTB test compliance certificate for the FTB mix proposed. Refer to **Section 8.6**, for more details.
8. Prior to use of any proposed FTB, the contractor shall supply compliance certificate / testing report to the relevant SA Power Networks' Project Manager, when requested. Refer to **Section 15.4**, for more details.
9. Before commencing the backfilling operations of any trench excavation, surplus-jointing materials, any waste materials, all rubbish including timber, foreign material, tree roots, rock, free water and slurry shall be removed from the trench.
10. Determine the maximum depth of pour of FTB around an underground facility to avoid the pipe or culvert becoming buoyant.
11. Anchor conduits to avoid floatation and consider lateral pressures due to its liquid state.

12. The use of conduit spacers are required to maintain conduit separation. Install conduit spacers as specified by the relevant SA Power Networks Project Manager. The separation between conduits shall be as per project specification.
13. Coverage of the FTB is to be minimum 100mm all around conduits or as specified within the design.
14. Install protective cover slabs, marker balls (eg 3M or similar); marker tapes below ground and install cable markers above ground as specified.
15. The rate or staging of the pours shall be determined to prevent the floatation of the conduit.
16. Due to its flowability, it needs to be confined to the area being filled until setting has taken place. This shall be ensured prior to pouring.
17. A minimum curing time of between 4 - 8 hours should be allowed prior to backfilling the remainder of the trench with sand backfill. A curing time of 24 hours is preferred prior to commencement of any further backfilling operations.
18. The FTB strength shall be appropriate for the situation. It should be noted that higher grade strengths makes re-excavation work difficult and should therefore be avoided.
19. Take due care for early shrinkage due to cold or wet weather conditions, which may prolong the product setting time.
20. Deeper applications may require pouring in stages depending on the lateral pressures exerted and the type of formwork. In such cases up to 12 hours or longer may be required between the successive stages of placement. The contractor shall provide a construction 'work method' statement describing how this will be achieved to the relevant SA Power Networks' Project Manager for approval.
21. At and near the final surface level, any standard or site specific reinstatement instructions by landowners, councils or Government departments are to be followed. As a minimum, surfaces shall be reinstated to the same condition as prior to the commencement of excavation.
22. For a typical 66kV roadway installation, refer to **Appendices C** and **D** of this document.

11.5 Sand Backfill Works

The sand backfill works shall consider following requirements:

1. Sand backfill shall comply with the requirements specified in this Sections 8.7, 11.5 and 15.3.
2. The sand backfill shall be used from the top of the cured FTB layer all the way to the ground level of the trench including reinstatement of surfaces. Refer to **Appendices C** and **D**, for more details.
3. Backfilling shall be uniformly compacted in horizontal layers not exceeding 200mm in depth.
4. Backfilling compaction (over the FTB layer) shall not be less than 95% of Maximum Dry Density (M.D.D) standard (avoiding any damage to our asset) to provide a cohesive uniform layer.
5. Compaction shall be tested at random depths every 5m or less and a minimum of three compaction tests per trench is required.
6. The re-use of the native soil as a backfill material is prohibited unless otherwise approved explicitly by SA Power Networks.
7. SA Power Networks shall be notified prior to the commencement of each stage of the conduits installation to ensure the requirements of the design have been met.

8. Where long sections of conduit are to be installed, the trench may be backfilled as soon as practicable following an approval from the relevant SA Power Networks' Project Manager.
9. Detailed survey shall be undertaken and a photographic record of the installation process shall be made prior to backfilling of the trench.

11.6 Final Reinstatement of Trenches

During trenching works, where, pavement marking (eg raised pavement markers or pavement bars), road furniture (eg road signs, guide posts, safety barrier), concrete kerbing, gutter, medians and traffic islands, footpath and brick paved areas, road drainage systems, vegetation and secondary paving etc are disturbed then they shall be reinstated to the condition in which they existed prior to the commencement of works.

Final reinstatement of excavations in public roadways, footpaths and easement areas shall be in accordance with the requirements of the appropriate controlling authority or to the condition in which they existed prior to the commencement of works (as appropriate).

Photographic evidence of the original condition of the site should be recorded prior to the commencement of any civil works.

11.7 Trenchless Works

Many forms of trenchless techniques exist for the installation of electrical conduits and cables from horizontal directional drilling (HDD), micro-tunnelling, impact moling, thrust boring and pipe jacking to name but a few.

Where the use of trenchless techniques have been specified, it is the responsibility of the civil installer to nominate the trenchless method to be employed taking into consideration the acceptable variations from the nominated cable alignment (ie both horizontal and vertical) specified within the design to achieve the nominated cable ratings.

Consult SA Power Networks' Project Manager to determine case-by-case need for cable hauling pit which will be subject to cable pulling calculations.

Trenchless/Boring works are limited to 4m depth maximum, otherwise copper cables shall be installed to achieve appropriate cable ratings, consult SA Power Networks' Project Manager for the advice.

Where SA Power Networks reasonably deems the works unacceptable due to its variation from the design, the civil installer shall be responsible for re-performing the works.

Where works are to be conducted using trenchless techniques, the following requirements shall be met:

1. The installation of heavy duty (HD) conduit shall be subject to stringent quality assurance / quality control (QA / QC). SA Power Networks will undertake audits to ensure that the work complies with the design and reserves the right not to accept any materials or workmanship that it deems substandard.
2. The contractor shall not deviate from the design alignment and depth without SA Power Networks' approval. Unapproved deviations will not be accepted.
3. Welding of high- density polyethylene (HDPE) bore tube shall comply as minimum with the relevant AS/NZS standards and the manufacturer's recommendations.
4. Internal butt weld beads shall be minimised by chamfering the internal tube diameter prior to butt welding. On request, the contractor shall submit a weld sample that has been split longitudinally for review.
5. The use of electro-fusion joints shall be subject to individual approval.

6. The pipe end(s) and the fitting shall be installed and prepared as per manufacturer's requirements (eg dry, contaminant free, scraped), correctly aligned and free of any bending stress.
7. If necessary, joints can be constructed off-site and transported on-site, however, works shall be conducted within sanitary conditions similar to those required for cable terminations.
8. Use of pipe clamps to secure the pipe(s) so they cannot move is acceptable as long as the fitting is satisfactorily supported to prevent it sagging during the fusion procedure. SA Power Networks may request a sample for review.
9. Bore tube ends using PE pipe, shall be cut square and true using a rotational pipe cutter and the internal edge shall be chamfered and deburred using router. Note that the use of hand saws is not acceptable.
10. Bore tube shall be terminated horizontally at the required depth, separation and configuration to match the trenched conduits. A reducer is to be used to transition from PE to PVC conduits.
11. In a borehole, ensure that all cables / conduits / spare conduits be contained within the same metal pipe encasement. Such encasements are not required to be earthed.
12. Where an encasing pipe is required, this shall be incorporated within the design, including the location and bore pit dimensions required for proper installation. The designer shall identify whether the encasement requires backfilling in order to achieve the desired continuous and or cyclic rating of the cable.
13. Where the encasement is required to be backfilled, the designer shall specify the type of material and the TR requirements of the backfill to be used. Refer to **Section 8.15**, for limited use of Bentonite material.
14. Select appropriate conduit bend radii to suit the minimum bending radius of the cable used. For cable minimum bending radius refer to manufacturer's data or consult SA Power Networks' Project Manager. Refer to **Section 12.2**, for conduit bend sizes.
15. Prior to use of any non-listed items within this standard, they shall be specified with the project scope and will require approval from SA Power Networks' Project Manager.
16. SA Power Networks reserves the right to request that conduits be inspected with video cameras following installation of the conduit. Conduits (including spares) shall follow the proving process as specified in the **Section 11.2.3**.
17. The requirement for grouting around conduits to prevent washout / subsidence where an encasement pipe has not been used shall be assessed by a competent Geotechnical Engineer. If grouting is required it shall be supervised by an independent expert to ensure compliance.
18. Conduits must be installed in a manner to ensure their configuration / spacing as designed is maintained. Refer to **Section 12.3**, for conduit spacers requirements.
19. At suitable intervals, use non-metallic straps to hold conduits in their desired configuration prior to their insertion into borehole.
20. Polypropylene (PP) straps used in packaging of sizes; [Width (mm) x Thickness (mm) x Length (m), Breaking Strain (kg)]:
    (a) 12mm x 0.55mm x 1000m, 80kg, or
    (b) 15mm x 0.55mm x 1000m, 110kg, are acceptable for use in strapping conduits. Such strapping should be applied at 1m minimum intervals to prevent conduit rotation during insertion.

21. Breakouts for pits shall be formed using PVC pipe and fittings. Minimum bend radii shall be 800mm.
22. Where specified, fill the resulting voids with suitable slurry, when installing multi-conduits in the bored hole or the hole exceeds the outer diameter of the conduit by more than 25mm.
23. Prior to installing polypropylene draw rope, ensure conduits are glued and cured appropriately.
24. Install a polypropylene draw rope compliant with AS 4142.1, through each conduit (including spare conduits, where specified) for cable pulling. Under no circumstances shall a draw rope be loaded in excess of its 'Safe Working Load' (SWL). The minimum breaking load should never be considered as being the SWL. Draw rope should be capable of pulling hauling rope for specified cable size thru relevant cable length.
25. Bore logs shall be submitted on a daily basis for review and will be audited. The bore log shall accompany the "As Constructed" plan to confirm depth and alignment along each bore.
26. The bore log shall be neat and legible, presented in tabular form. Information provided shall comply with TS099 and as a minimum include the following for each bore:
    (a) Project name and location;
    (b) Contractor details;
    (c) Date;
    (d) Bore number;
    (e) Size and Number of conduits installed;
    (f) Alignment with property boundary;
    (g) Depth below finished surface level to the top of the bore at minimum 3m spacing and at lesser intervals as required to comprehensively describe bends and complex arrangements; and
    (h) Other information considered necessary by either the Contractor or Liaison Person.
27. Refer to **Figure 5** for 'Separation between Multiple Bores'.

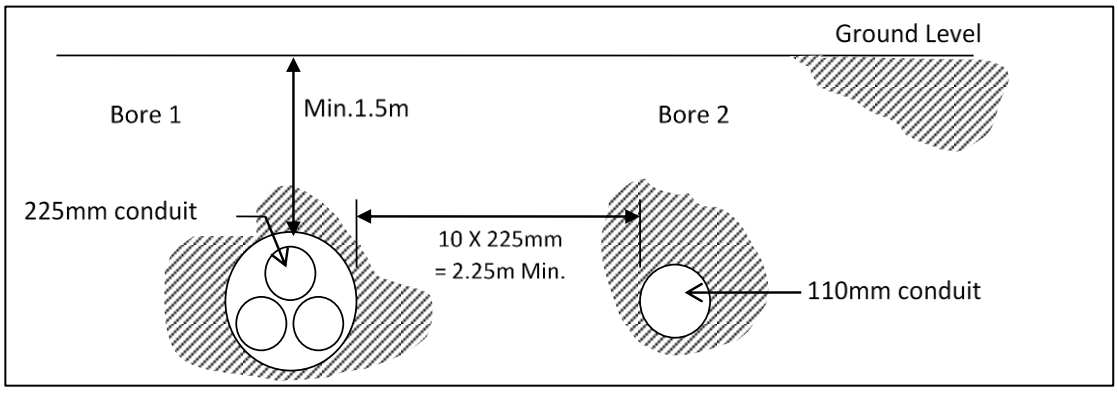


Figure 5: Separation between Multiple Bores

11.7.1 Radius of Curvature

The design radius of curvature of the bore shall make allowance for both the minimum bend radius of the drill pipe and the minimum bend radius of the conduit and cable and also make allowances for steering inaccuracies.

The HDD Contractor shall ensure the design radius of curvature is a minimum of 20% larger than governing minimum bend radius of either the drill pipe or conduit.

Where possible the HDD Contractor should make the design radius of curvature as large as possible to minimise installation loads and stresses for both the conduit and subsequent cable hauling.

Where possible, any horizontal and vertical radii shall be drilled separately to avoid combination bends.

11.8 Civil Works Forms

The TS105A (Forms) series assists in verifying all project works are completed to our standards.

As stated in TS105 Part D 'Index of Forms - Major Projects', the relevant forms shall be completed and submitted to SA Power Networks' representative. Refer to **Appendix F** for sample of forms.

11.8.1 Notification Form

The civil works notification form TS105 C1 'SA Power Networks' Civil Infrastructure Works Notification Form' is the component of the SA Power Networks asset inspection and vesting process.

The civil contractor shall complete and submit form TS105 C1 to SA Power Networks' representative at least 10 business days prior to commencement of any civil works.

Civil works shall not proceed until the responsible civil contractor have received acknowledgement of receipt and approval of this form from the SA Power Networks representative.

11.8.2 Compliance Form

On completion of civil works, the civil contractor shall complete and submit the form TS105 C2 'SA Power Networks' Civil Infrastructure Works Compliance Form' to the SA Power Networks representative.

If the civil contractor delays or does not submit these completed forms, then this may result in delays electrical and connection works.

12. Materials and Accessories

12.1 Conduit Sizes

Table 10
PVC Conduit Sizes for Open Trench- Straight Length
(Reference AS/NZS 2053.2:2001 Table 101 & AS/NZS 1477:2017)

Conduit Nominal Size (mm) (See Note 4)	Conduit Type (See Note 1)	Conduit Required	For use with the following Cable Sizes Only	Conduit Technical Data					SA Power Networks' Stock Item Number (Comply with AS/NZS 2053) (See Notes 2, 3, 4)
				Mean Outside Diam. (mm)	Mean Inside Diam. (mm)	Wall Thickness (mm)		Straight Length (m)	
						Min.	Max.		
100	**HD** PVC PN 12 (Orange)	1	**CK9250** (ECC, 240mm^2) **CK9251** (Bonding cable, 240mm^2)	114.1	101.7	5.9	6.7	4	NC4535
150	**HD** PVC PN 12 (Orange)	3	**CK9280** (300mm^2) (Individual conduit – 1 cable in single conduit)	160.0	142.7	8.3	9.3	4	NC4536
200	**HD** PVC PN 12 (Orange)	3	**CK9281** (1600mm^2) (Individual conduit – 1 cable in single conduit)	225.0	203.1	10.5	11.7	4	NC4537
100 (Telecom)	**HD** PVC PN 12 (White)	1	**Optic Fibre Cable**	114.1	101.7	5.9	6.7	4	NC4538

Notes:

1. HD PVC = Heavy Duty Polyvinyl Chloride
2. Install a polypropylene draw rope compliant with AS 4142.1, through each conduit (including spare conduits, where specified) for cable pulling. Under no circumstances shall a draw rope be loaded in excess of its 'Safe Working Load' (SWL). The minimum breaking load should never be considered as being the SWL. Draw rope should be capable of pulling hauling rope for specified cable size thru relevant cable length.
3. All conduits installed shall be clean and free from debris or internal rough edges which may cause damage to the cable's outer sheath during cable installation. Similarly, all PE pipe joints shall be internally 'de-beaded' to prevent damage to the outer serving of the cable.
4. Prior to use of any non-listed items in Table 10, it shall be specified with the project scope and will require approval from SA Power Networks' Project Manager.

Table 11
PE Polyethylene Conduits HDPE for directional boring/drilling
(Reference AS/NZS 4130:2018 Table 2)

Conduit Nominal Size (mm) (See Note 4)	Conduit Type (See Note 1)	Conduit Required	For use with the following Cable Sizes Only	Maxi. Pulling Force (kN)	Conduit Technical Data (Comply with AS/NZS 4130) (See Notes 2, 3, 4 & 5)						SA Power Networks' Stock Item Number (Comply with AS/NZS 4130) (See Notes 2, 3, 4)
					Wall Thickness (mm)		Inside Diam. (mm)		Mean Outside Diam. (mm)	Nominal Length (m)	
					Min.	Max.	Min.	Max.			
Polyethylene Conduits HDPE - Coils											
110	PE Coils SDR 17 Orange	1	**CK9250** (ECC, 240mm^2) **CK9251** (Bonding cable, 240mm^2)	22.0	6.6	7.4	95.2	97.8	110.5	100	NC5800
125	PE Coils SDR 17 Orange	1	**CK9250** (ECC, 240mm^2) **CK9251** (Bonding cable, 240mm^2)	28.2	7.4	8.3	108.4	111.4	125.6	100	NC5801
110 (Telecom)	PE Coils SDR 17 White	1	**Optic Fibre Cable**	22.0	6.6	7.4	95.2	97.8	110.5	100	NC5802
Polyethylene Conduits HDPE - Straight Length											
180	HDPE SDR 17 Orange	3	**CK9280** (300mm^2) (Individual conduit - 1 cable in single conduit)	58.5	10.7	11.9	156.2	160.3	180.9	12	NC5810
225	HDPE SDR 17 Orange	3	**CK9281** (1600mm^2) (Individual conduit - 1 cable in single conduit)	90.9	13.4	14.9	195.2	200.3	226.1	12	NC5811

Notes:

1. SDR = Standard Dimension Ratio, PE = Polyethylene, HDPE = High Density Polyethylene
2. Install a polypropylene draw rope compliant with AS 4142.1, through each conduit (including spare conduits, where specified) for cable pulling. Under no circumstances shall a draw rope be loaded in excess of its 'Safe Working Load' (SWL). The minimum breaking load should never be considered as being the SWL. Draw rope should be capable of pulling hauling rope for specified cable size thru relevant cable length.
3. All conduits installed shall be clean and free from debris or internal rough edges which may cause damage to the cable's outer sheath during cable installation. Similarly, all PE pipe joints shall be internally 'de-beaded' to prevent damage to the outer serving of the cable.
4. Prior to use of any non-listed items in Table 11, it shall be specified with the project scope and will require approval from SA Power Networks' Project Manager.

12.2 Conduit Bend Sizes

Table 12
Heavy Duty PVC Conduit Bend Sizes

Conduit Size (mm)	Conduit Bend 'Bending Radius' (mm) (See Note 1)	Conduit Bend 'Bend Angle' (Degrees) (See Note 3)	Conduit Bend Bell End Type (See Note 2)	SA Power Networks' Stock Item Number Conduit Bend (See Note 4)	For use with the following Cable Only
100 HD PVC (Orange)	900	90	F-F	NC5741	**CK9250** (ECC, 240mm^2) **CK9251** (Bonding cable, 240mm^2)
	1200	15	M-F	NC5770	
		30	M-F	NC5771	
		45	F-F	NC5772	
		90	F-F	NC5773	
	1830	15	M-F	NC5774	
		30	M-F	NC5775	
		45	F-F	NC5776	
		90	F-F	NC5743	
100 HD PVC (White)	800	45	M-F	NC5930	**Telecommunication Cables**
		90	M-F	NC5929	
150 HD PVC (Orange)	1830	30	F-F	NC5783	**CK9280** (300mm^2)
		45	F-F	NC5781	
		90	F-F	NC5782	
200 HD PVC (Orange)	1800	22	F-F	NC5785	**CK9281** (1600mm^2)
		30	F-F	NC5786	
		45	F-F	NC5787	

Notes:

1. The conduit bending radius shall be greater than the minimum bending radius of the cable to assist in cable installation. For the cable's minimum bending radius, refer to manufacturer's data or consult SA Power Networks' Project Manager.
2. 'M-F' = Male to Female ends and 'F-F' = Female to Female ends.
3. The conduit bending radius does not change when 2 or more bends are added together.
4. Prior to use of any non-listed items in Table 12, it shall be specified with the project scope and will require approval from SA Power Networks' Project Manager.

12.3 PE Conduit to PVC Conduit - Couplings

Table 13
PE Conduit to PVC Conduit - Couplings

PE Conduit Type	PVC Conduit Type	Couplings Length (mm)	SA Power Networks' Stock Item Number Couplings
PE 110, Orange	HD PVC 100, Orange	250	NC8160
PE 125, Orange	HD PVC 100, Orange	300	NC8161
PE 180, Orange	HD PVC 150, Orange	370	NC8162
PE 225, Orange	HD PVC 200, Orange	500	NC8163
PE 110, White	HD PVC 100, White	250	NC8164

Note: Prior to use of any non-listed items in Table 13, it shall be specified with the project scope and will require approval from SA Power Networks' Project Manager.

12.4 Conduit Spacers

Conduits shall be separated using methods which:

1. do not adversely impact the thermal properties of the installation (ie create a thermal barrier to heat dissipation);
2. maintain the required separation between conduits (ie use conduit spacers);
3. prevent the conduits from 'floating' during pouring of the FTB.

Conduit spacers assist in maintaining the required separation between the conduits and spare conduits. Conduit spacers will help ensuring proper heat dissipation and will prevent conduits from being disturbed during bedding and backfilling compaction works.

Conduits and conduit spacers are to be securely staked or anchored to limit movement at the start and end of conduits run, at 2m to 3m intervals, however, the required numbers of conduit spacers and their installation method, shall be followed as per manufacturer's instructions. A variety of conduit spacing systems are commercially available.

Use of conduit spacers is a mandatory requirement for SA Power Networks' 66kV UG Sub-Transmission Network. Refer to **Figure 6** for an example.

Note that baffle spacers (ie cut outs made from 15mm PVC sheet) are not permitted.

Figure 6: Example of conduit spacers

12.5 Cable Protection Cover Slabs

The civil contractor shall supply and install either polymeric cable protection cover slabs to AS 4702, Stock item, RN0202 (300mm wide, 5mm thick, 15m long roll) or concrete cover slabs to AS 3600 placed over the cables in a continuous line.

The polymeric or concrete cover slabs shall be placed above the FTB layer and at least 200mm above the top of the conduits. The slabs shall overlap SA Power Networks infrastructure by a minimum of 50mm overhang per side. If more than one cover slab is required then they shall also overlap by 50mm.

The following text shall be imprinted on concrete slabs, 'DANGER - ELECTRICAL 66,000 VOLT CABLES' in letters a minimum of 40mm high with spacing between the warnings at a maximum of 2m. All earthing / fibre optic cables shall also be protected with cover slabs or an agreed protective barrier.

12.6 Marker Tapes (Below Ground)

Orange coloured plastic cable marker tapes to AS/NZS 2648.1 (Stock Item. KS3765, 150mm wide, 500m long roll or equivalent) shall be installed longitudinally in all trenches placed centrally at a depth of half the distance measured from the final ground level to the top of the conduits. The number of tapes required is as per **Table 14**.

Table 14
Minimum Numbers of Marker Tapes Requirements

Trench Width in (mm)	Minimum Number of Marker Tapes Required
Up to 500	One
501 up to 1000	Two
1001 up to 2000	Three

12.7 Marker Tapes with Trace Wires (Below Ground)

When the SA Power Networks telecommunications conduits carry only optic fibre cables, then marker tape with a tracer wire must be installed above the fibre conduit at the nominated distance.

This is only required when optic fibre cables or casings do not have a tracer wire built-in, or the optical fibre cables are not capable of tracing functionality. Please consult SA Power Networks' Project Manager for further clarification.

12.8 Cable Marker Disc (Ground Level)

The contractor shall supply and install cable marker disc (Stock Item. KS3722, or equivalent), at ground level, as specified by SA Power Networks or as shown within the design drawings.

SA Power Networks shall approve the cable marker disc design and its method of installation. When specified, ground level cable marker discs are required where the cable crosses roads and in footpaths.

In a continuous trench, cable marker disc shall be placed:

1. at the beginning and end of the trench;
2. the start, end and the apex of a bend; and
3. at intervals of at least 15m maximum.

If trenchless techniques are to be used, '3M iD Near Surface Marker (Stock No: 80611321300)' shall be placed at each end of the pulling pit and at other locations as per project specification.

The cable marker disc shall be placed at any other significant underground asset. Please consult the relevant SA Power Networks' Project Manager for appropriate location of cable markers.

12.9 Marker Balls (Below Ground)

Marker balls have a self levelling Radio Frequency Identification (RFID) tag within the ball that enables an asset locator to determine the location of underground facilities. Two types of marker are approved for use on the SA Power Networks Network :

1. 3M iD Near Surface Marker (Product No: 1433-XR/iD, Stock No: 80611321300); and
2. 3M iD Ball Marker (Product No: 1422-XR/iD, Stock No: 80611142201).

The 'Near Surface' marker is intended only for use in retro-installations or where trenchless techniques are employed, whilst all open trench installations shall employ the 'Ball Marker' product.

When specified, the marker ball shall be placed above the centre phase cable, ideally below the marker tape.

Each 3M marker shall be issued by SA Power Networks and pre-programmed to contain the following information:

1. Ball number (default in the ball);
2. SA Power Networks;
3. Caution High Voltage Cables in Vicinity;
4. 66kV.

The marker's serial number and position relative to the cable and final ground level is to be recorded by the installer on 'As Built' drawings together with a 'Global Positioning System' (GPS) co-ordinate (as designated in TS099) to enable its location to be stored within SA Power Networks' GIS. In a continuous trench, marker balls shall be placed:

1. at the beginning and end of the trench;
2. the start, end and apex of a bend;
3. either side of any road crossing; and
4. at the start and end of a change in depth.

If trenchless techniques are used, marker balls shall be placed at each end of the pulling pit. The marker balls shall be placed at any other significant underground asset. Please consult the relevant SA Power Networks Project Manager for appropriate location selection for placing marker balls and also refer to **Appendices C** and **D** for more details.

12.10 Danger Sign (Above Ground)

Above ground 66kV cable signage and fibre installed signs shall be installed within railway corridors in accordance with the requirements of AS 4799. If similar 66kV cable signage is required to be installed elsewhere, then please consult the relevant SA Power Networks' Project Manager in the first instance.

The danger signage shall consist of a metal sign, mounted on posts installed within the vicinity of the underground cable. In particular, these markers shall warn of the presence of underground cables and indicate the following:

1. the cable's operating voltage (ie 66,000V);
2. ownership (ie SA Power Networks);
3. advise that digging or material storage is not permitted; and
4. emergency contact details (ie SA Power Networks - Faults and Emergencies Call Centre - 13 13 66).

An example is included in **Figure 7** and dimensions as per AS 4799.

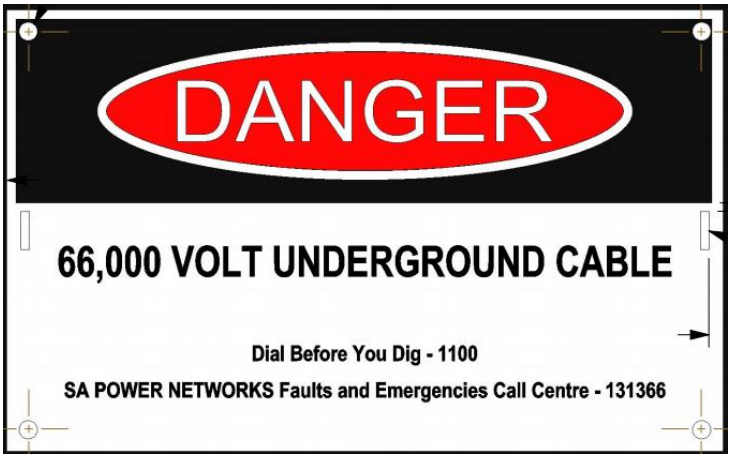


Figure 7: Example of 66kV Danger Sign (KS1633)

12.11 Excavation of Trenches - Safety and Security

In order to minimise inconvenience to the public, trenches are not to be left open longer than necessary. Sections of trench shall be excavated in the order in which they are to have cables installed. Alternatively, the conduits may be installed and the trench re-instated with the cable pull / installation taking place at a later date.

There are various ways to control exposed cables / conduits sites, for example, installation of road metal plates for trafficable areas, use of roadside solid barriers and / or building temporary fences. The use of bunting as a barrier is not considered an adequate safety or security measure.

After any conduit has been installed and until the whole of the conduits to be laid in the trench have been covered with their protective cover slabs, no sharp metal tools such as spades or crowbars shall be used in the trenches or placed in such a position that they can fall into the trench.

The following minimum safety and security measures shall be implemented for excavated open sites:

1. All excavation sites which are required to be left open / unattended (eg left unsupervised over-night) shall be effectively covered for public safety, eliminating potential hazard, theft control and/or any accidental damage to our asset.
2. Where cable drums or other equipment etc are required to be left on site overnight, a security guard or other precautions shall be employed.

All exposed cables (ie in jointing bays, in open trenches) shall be treated as ‘Live’ unless and until identified as ‘Dead’.Where cables have been installed in areas accessible to the public but have not been energised or otherwise monitored via SCADA by SA Power Networks' Network Operations Centre (NOC), security arrangements shall be put in place to ensure the integrity of the cable installation from theft or vandalism at the cost of the installer.

13. Electrical Works

13.1 General

Prior to the commencement of any cable installation works, the cable route and installation design details shall be finalised as part of the project design process and all necessary agreements, permits and easements shall be obtained.

The installer is completely responsible for the, supply, installation, testing and commissioning of the cable system as specified in the project specific contractual arrangements as required.

SA Power Networks is prepared to purchase or provide appropriate special tools and equipment used by the installer for the jointing and terminating of the cables provided that they are returned to SA Power Networks in a satisfactory condition. The installer shall list the tools and equipment available for purchase in its pricing schedule.

Where an installer uses SA Power Networks’ tools / equipment, the installer shall be liable for any cost incurred in rectifying any damage or replacement to such tools / equipment, prior to their return in suitable condition. Please consult the relevant SA Power Networks’ Project Manager for any advice. The cable installer shall be responsible for noting the cable drum number, direction of pull and other relevant information on the ‘As Built’ drawings. The cable installation works shall address the following:

1. Installing the cable as per the design and ensuring that the cable installation does not damage or exceed the pulling limitations of the cable.
2. Ensuring that the asset drawings are produced according to the specification and design.
3. Developing and submiting all traffic management plans.

4. Liaising and co-ordinating with other parties who may require access within the area of work.
5. Performing all tests (eg Insulation resistance testing, Phase rotation testing) required to ensure the integrity of the cable installation.
6. Developing SWMS for the tasks to be performed and ensuring that the overall security and safety of the work area is achievable.
7. Managing any third party contractors (eg Jointers / Terminators) required to complete the works.
8. Managing the overall program of works during the cable installation phase.
9. Ensuring that the project design drawings are updated to an 'As Constructed' state and issued to the relevant SA Power Networks' Project Manager together with any test results for inclusion within SA Power Networks' GIS system and in accordance with the requirements of TS099.
10. Where the conduits have not been installed by others or installed and reinstated prior to the cable's installation, ensure the 'As Constructed' design drawing are an accurate representation of the installed assets, including highly detailed underground asset location information. Record and submit 'As Constructed' information produced through survey by a qualified surveyor. Copies of the surveyor's qualifications and calibration/test certificates for any surveying equipment used in producing these drawings shall be provided with the drawings to the relevant SA Power Networks' Project Manager.

13.2 Cable Pulling Works

The contractor shall ensure necessary safe working conditions on site to eliminate accidents and cable damage during pulling/installation. The cable installer shall pull the cable into the trench or conduits in a manner approved by SA Power Networks and as specified on the design drawings. The SA Power Networks Network Planning department shall be notified a minimum of four (4) weeks before commencing such works.

Every winch and/or caterpillar or hauling device used in cable pulling operations must be fitted with a calibrated dynamometer (tension meter) such that the actual tensions during cable pulling operations can be continuously monitored and recorded. When using caterpillar machines and motor rollers their action must be automatically synchronised with the overall cable pulling system. The installer shall provide copies of certificates of calibration to SA Power Networks' Project Manager on request.

The installer shall submit to the relevant SA Power Networks Project Manager, not less than five (5) working days prior to cable pulling operations, sketches, mechanical stress calculations and a brief description of the method(s) proposed for pulling and laying of each section of cable, including the number and position of personnel along the cable section route during the laying operations.

The installer must ensure that when pulling cable into a substation from outside the substation (for example, where a cable drum is located outside the substation fence or at joint bay), precautions shall be taken to guard against transferred earth potential hazards as outlined in ESAA Guide D(b) 26 - 1995.

13.3 Cable Cutting and Sealing Works

All cables shall always be protected against moisture ingress, including while being laid, regardless of site and/or weather conditions.

Cable ends which are not intended to be worked on immediately after laying must be electrically shorted and sealed against moisture ingress as soon as they are cut. The seals and electrical shorts must not be removed until the cables are ready to be tested or connected.

Sealing shall be carried out by trained personnel and shall be achieved using heat-shrink caps and tubing. The shrinkable components must be coated with adhesive sealant.

Where a laid cable is found to have high moisture content due to inadequate sealing, the installer must remedy this. A work method statement for cable sealing, including this remediation work, shall be submitted by the installer for the approval of SA Power Networks' Project Manager.

All cable cutting and sealing processes shall be in accordance with the manufacturer's instructions including maintaining personal safety, safe operating procedures and shall be conducted only by suitably qualified cable installers.

Copies of the cable installer's qualifications/training may be requested by SA Power Networks. All cable ends whether located in the trench or on the cable drum are to be suitably sealed as soon as practical after the cable has been cut.

Cables shall not be cut using saws or other such hand tools which may result in metal filings contaminating the insulation layers of the cable.

13.4 Joint Bays

The joint bay reinforcement design must ensure that no steel completely encircles any conduit (such as by cutting 50mm section from reinforcing mesh under each penetration). Please also refer to **Section 11.2** , item **3**.

All straight joints or future joint locations are to be installed within an appropriate joint bay, consisting of concrete walls and floor.

The dimensions of joint bays shall be based on the following:

1. The number of cables;
2. Separation required between cables for jointing (eg joint offsets); and
3. Joint length.

A typical joint bay for a single 66kV circuit using 1600mm^2 Cu XLPE cables is 8.4m long and 2.6m wide with 200mm thick reinforced concrete walls and floor.

The height of the joint bay walls will vary depending on the cable's depth of burial, but should end 500mm below finished ground level and extend at least 500mm below the cable's outer sheath to provide room for jointers to perform their works.

Each joint bay shall be fitted with two sump pits, one at either end of the bay at the cable entry and exit points. Theses sumps shall be a minimum of 300mm long, 300mm wide and 600mm deep. The floor of the bay shall have a gradient of 1:100 and slope towards each of the sumps from the centre of the bay.

13.4.1 Joint Bay Locations

Joint bays shall be installed in locations where they will be readily accessible for conducting future repairs and preferably clear of driveways, intersections and other infrastructure (both above and below ground).

Joint bays shall not be installed within the carriageway of DPTI controlled roads unless approved by both DPTI and SA Power Networks. Where such approval is granted, the joint bay should be located in the kerbside lane and link box enclosures associated with the joint bay shall be preferably located at the back of kerb where possible.

13.4.2 Link Box enclosures

The link box enclosure associated with the joint bay should be manufactured from reinforced concrete fitted with a gatic cover / lid. The enclosure should be suitably dimensioned to accommodate those link boxes approved for use on SA Power Networks' network.

Link box enclosures shall be positioned such that the length of the bonding cable from the power cable joints to the link box is less than 10m unless otherwise approved by SA Power Networks. They should also be positioned to facilitate an orderly arrangement of cabling within the joint bay to allow for easy access for removal of backfill material.

Any lids or covers associated with link box enclosures shall open in a safe and accessible manner and not open onto the road or in the case of such enclosures within a road lane, shall open in the direction opposite to the flow of traffic, these lids should not open into adjacent lanes.

Connections between the link box enclosure and the joint bay shall be via 4 x 100mm PVC conduits encased in minimum 100mm all around conduits of 20MPa concrete. These conduits and associated concrete encasement, shall have a minimum of 150mm cover.

13.4.3 Cable and Joint Support

To prevent local heating of cables caused by eddy currents, clamps shall be either made of non-ferrous materials or where they are made from ferrous material, the two halves shall not touch at both sides, and shall be fixed together using non-ferrous bolts, nuts and washers. Suitable elastic softening which allows for normal heat expansion movement of the cable must be used between the cable clamps and the cable oversheath.

Cables and joints within joint bays shall be suitably supported and restrained to prevent movement during installation, reinstatement, future excavation or operationally (eg during faults). Such supports and associated clamps shall be constructed using galvanised mild steel.

13.4.4 Joint Bay Penetrations

To facilitate sealing and to reduce the possibility of future damage to the cable's outer sheath, the cables at the entry and exits of the conduits shall be suitably supported such that the cable axis and duct axis coincide.

In addition to the seal applied between the cable(s) outer sheath and the internal diameter of the conduits, a secondary seal shall be applied by taping or the use of heat shrink materials between the cable(s) and the protruding conduit.

All cables and associated conduits required to penetrate the joint bay should be made ideally using bell mouths. Any area between the penetration and the conduit entry should be sealed to prevent or limit the ingress of water into the joint bay. Where possible, penetrations should be cast in situ within the joint bay walls as per the joint bay design.

13.4.5 Backfilling of Joint Bays

Joint bays shall be backfilled with sand in layers no greater than 200mm having a TR value as specified within the design. The sand backfill shall be suitably compacted to achieve the required TR. Cover slabs and warning tapes shall also be installed. FTB shall not be used to backfill the joint bay.

13.5 Cable Terminations / Joints

There shall be joint bay and terminations scaffolding/enclosures installed that are designed to provide clean, tidy and safe working conditions during jointing/terminations.

Only those cable terminations / joints approved by SA Power Networks shall be installed on the network. Contact the relevant SA Power Networks Project Manager for a list of approved terminations and joints. Refer to **Table 15**.

Table 15
Joints and Terminations References

Description	SA Power Networks' Stock Item Number
Straight Joints	RN8025
Cross Bonding Joints	RN8026
Over/Under (Outdoor) Terminations	RN8041 (for 1600mm^2 Cable)
Gas Insulated Switchgear Terminations	Non-Stock Item

Notes:

1. SA Power Networks does not stock all types of joints and terminations.
2. Prior to use of any non-listed items in Table 15, it shall be specified with the project scope and will require approval from SA Power Networks' Project Manager.

13.6 Cable Guard

The relevant SA Power Networks Project Manager shall specify whether SA Power Networks or their contractor shall be responsible for mounting, terminating and clamping the cables, earthing and for the supply and fitting of a 3m high galvanized steel cable guard at the base of the over/under pole.

Refer to E-drawings E1511 series, **Appendix B**, for more details. Where possible, cables shall be installed on the pole so they are facing away from oncoming traffic.

13.7 Surge Arrestors

Surge arresters (Stock Item VX1160) are to be installed at each termination to protect the underground cable in the event of surges or injections from remote sources. These are to be mounted on the same support structure as the terminations. Refer to E drawing series E1510.

The earthing arrangements for both the termination and surge arrester shall be indicated on design drawings. Surge arrestor taps shall be kept as short as possible (refer to E1510 sheet 2.2).

13.8 Fibre Optic Cable Termination

Where fibre optics is included within the cable, they shall be terminated in a suitable junction box as specified by SA Power Networks. The junction box shall be mounted below the over / under termination frame unless otherwise specified.

Note: Do not bend the fibre optic cable below minimum bending radius (refer to cable manufacturer for details of specific cable).

Preference will be given to terminating all three phase cables' fibres in a manner suitable to enable their future use by a Distributed Temperature Sensing (DTS) system.

13.9 Sheath Voltage Limiters (SVL)

The 'Sheath Voltage Limiters' (SVL) (Non Stock Item) shall be compatible with the SA Power Networks preferred link boxes and acceptable sheath voltage limits**.** SA Power Networks does not stock SVL.

SVL shall be specified with the project scope and will require approval from SA Power Networks' Project Manager.

13.10 Link Boxes

Only those link boxes approved by SA Power Networks shall be installed on the network. The single point and cross bonding of cable sheaths shall be affected using approved link boxes located in pits on the footpath adjacent to the joint bay or on termination structures where applicable.

At over / under poles, earth links shall be mounted on the pole above the cable guard in a suitable approved box at a height between 3.6m and 4m above ground level (refer to E1510 Sheet 4).

Disconnecting link support insulators shall withstand 15kV DC for one (1) minute. Links shall be of tinned Copper and clearly labelled (on each side of the link) with the phase identification 'X', 'Y' and 'Z'.

A durable label shall be fixed to each link box lid showing a diagram of the link connection arrangement. Labels can be manufactured at SA Power Networks' Substation workshop, Marleston, for details contact 'Engraving and Label Technician' on (08) 8292 0257.

The metallic link box casing shall be connected to the joint bay or sealing end earthing electrode system. Where sheath voltage limiters (SVL) are installed in the link box, the SVL's earth connection shall be directly bonded to the earth bar (refer to E1510 Sheet 3.1).

Link boxes associated with joint bays shall be capable of facilitating either six (6) direct earth connections, six (6) earth connections via SVLs or a combination of three (3) direct connections and three (3) connections via SVLs.

All link boxes installed as part of a straight joint shall be installed in suitable concrete pits (Refer to **Section 13.4**), while those at the substation ends shall be stand mounted. All link boxes shall be manufactured using stainless steel.

Table 16
Link Box References

Application
Earthing Link Box with SVLs - Stand Mounted
Earthing Link Box without SVLs - Stand Mounted (ie Direct Earth Connection)
Double Earthing Link Box with SVLs - Pit Mounted
Double Earthing Link Box without SVLs - Pit Mounted (ie Direct Earth Connection)
Double Earthing Link Box with three SVLs/ three Earth Connections - Pit Mounted
Earthing link box with SVLs - stand / pole mounted
Earthing link box without SVLs - stand / pole mounted (ie direct earth connection)

Notes:

1. SA Power Networks does not stock Earthing Link Box with or without SVLs.
2. Prior to use of any non-listed items in Table 16, it shall be specified with the project scope and will require approval from SA Power Networks' Project Manager.

13.11 Polywater® Lubricant J

Polywater® Lubricant J is a high performance, clean, slow drying and water-based gel type lubricant. It provides maximum tension reduction in all types of cable pulling.

It is also recommended for long pulls; multiple-bend pulls and pulls in a hot environment as it dries to form a thin lubricating film which retains its lubricity for months after use.

SA Power Networks has approved the use of Polywater® Lubricant J (stock item-OC8051) and Polywater® Lubricant Pump with Conduit Adaptors (stock item-OC8052). However, similar or equivalent lubricant is also acceptable subject to the approval of SA Power Networks' Project Manager.

13.12 Electrical Works Forms

The TS105A (Forms) series assists in verifying all project works are completed to the required standards. TS105 Part C and TS105 Part D must be submitted at least 10 business days prior to commencement. As stated in TS105 Part D 'Index of Forms - Major Projects', the relevant electrical works construction forms shall be completed and submitted to SA Power Networks' representative. Refer to **Appendix F** for sample of forms.

13.12.1 Notification Form

The electrical contractor shall complete and submit form TS105 F1 'Authority to Proceed Request (ATP)' and TS105 F2 'Documentation - Check List' to the SA Power Networks representative at least 10 business days prior to commencement of any electrical works.

Electrical works shall not proceed until the responsible electrical contractor have received acknowledgement of receipt and approval of these forms from SA Power Networks' representative.

13.12.2 Compliance Form

For all projects with the electrical installation component, the form TS105 F3 'SA Power Networks' Electrical Infrastructure Works Compliance Form', or TS105 F4 'SA Power Networks' Partial Electrical Infrastructure Works Compliance Form' shall be completed and submitted to SA Power Networks' representative .

If the electrical contractor delays or does not submit these completed forms, then this may result in delays with energisation works.

14. Fabrication of Accessories

14.1 General

The equipment's accessories, fittings and connections supplied shall be entirely suitable for continuous operation under the conditions specified herein and shall include everything necessary for safe and convenient installation, operation, replacement (as required) and maintenance. The equipment shall be so constructed that:

1. It is not affected by normal handling during transport, installation, inspection and repair;
2. Maintenance can be carried out conveniently and safely; and
3. The design, materials and dimensions of all parts are such that the stresses to which they are subjected shall not render them liable to distortion or damage, under the most severe operating or fault conditions likely to be encountered in service.

14.2 Surface Protection

Unless otherwise specified, all metallic surfaces shall have a protective coating.
SA Power Networks encourages the use of non-corrodible materials. Where practicable all ferrous metal external surfaces shall be galvanized or stainless steel.

14.3 Painting

Where applicable, paint work shall be in accordance with AS/NZS 2312, unless otherwise specified. Non-ferrous metal surfaces to be paint finished, shall be prepared for painting in accordance with AS 1627.1.

15. Testing Works

The following tests (but not limited to) shall be conducted to ensure the integrity of the cable before, during and after installation. In addition, a phase rotation test shall be conducted on each circuit prior to being placed into service. All test reports including any certificate of test compliance shall be submitted to the relevant SA Power Networks Project Manager for verification.

15.1 Native Soil Test

The re-use of the native soil as a sand backfill material is prohibited unless otherwise specifically approved by SA Power Networks. Subject to the native soil testing report and if the native soil is approved for re-use by SA Power Networks, all large items such as rock, tree roots etc, should be removed and the ground reinstated according to the requirements of the relevant authority. The following requirements shall be met in conducting native soil testing:

1. SA Power Networks or its nominated contractor shall undertake all required soil testing along the route of the cable design to determine the thermal resistivity of the native soil at spacings and depths (nominated by the designer) necessary to undertake the cable design and determine the achievable cable ratings.
2. SA Power Networks reserves the right to request a native soil test certificate (as provided by a geo-technical consultant).
3. SA Power Networks or its contractor is responsible for performing these tests at adequate depths and levels of geo-technical testing to determine the existence and nature of any contaminants as well as the structure of the ground at the proposed installation depths.
4. Where trenchless techniques are required, the geo-technical report shall include an assessment of the native soil and an indication or recommendation as to its suitability to enable traditional trenchless techniques methods to be employed without resulting in any subsidence or whether an encasing pipe / sleeve needs to be inserted using micro-tunnelling or other techniques.

15.2 Waste and Contaminated Soil Test

The EPA (www.epa.sa.gov.au) has released guidelines for managing waste soil and site contamination, which shall be adhered to at all times. Waste and contaminated soil shall be tested and managed as per the EPA's compliance requirements. Refer to EPA's website for 'Standard for the production and use of Waste Derived Fill (WDF)' and 'Site Contamination' for more details.

Test results (as provided by a geo-technical consultant) may be required to be submitted to the relevant SA Power Networks Project Manager, before the commencement of work on the site or adoption of assets installed by third parties. Further information can be obtained by contacting the relevant SA Power Networks Project Manager.

Documented construction environmental and stakeholder risks, mitigation measures and responsibilities shall be completed and submitted to SA Power Networks in line with SA Power Networks 'EMS 5.3 Waste Soil Management Procedure'.

15.3 Sand Backfill Test

The following requirements shall be met in conducting sand backfill testing:

1. Sand backfill testing should occur for every delivery required on the site and be marked on the relevant drawing to indentify extent or required remediation.
2. Prior to use of any backfilling material, the contractor shall supply a sand backfill test report to the relevant SA Power Networks Project Manager, when requested. SA Power Networks reserves the right to ask for a backfilling sand test compliance certificate.
3. Before commencing the backfilling operations of any trench excavation, surplus-jointing materials, any waste materials, all rubbish including timber, foreign material, tree roots, rock, free water and slurry shall be removed from the trench.
4. Verification tests should be carried out on samples of the trench backfill (above cable envelope) material during installation to confirm compliance with the specification.

15.4 FTB Test

The following requirements shall be met in conducting FTB testing:

1. For each pour or at least daily a sample of the FTB shall be taken and submitted to SA Power Networks or a 'National Association of Testing Authorities, Australia' (NATA) approved laboratory for analysis to ensure its TR and strength properties conform to those specified within the design.
2. The location / extent of any pour utilising a given FTB sample should be recorded and shown / indicated on the 'As Constructed' drawings, together with the FTB sample's reference number / ID used by the relevant testing authority to enable determination of the cable route impacted by the FTB.
3. The test report shall also include the dates that the sample was taken and tested, the source of the FTB, the material designation, the location that the sample was taken from and its fully dried thermal resistivity value.
4. Where the results of the FTB tests suggest non-compliance to the requirements of the design, SA Power Networks may require removal and / or replacement of the affected portion of the installation (including conduits) where assessment deems that the required cable rating(s), strength (MPa) may not be achieved or where the FTB applied may have damaged the conduits.

15.5 Cable Tests

The cable shall be tested in accordance with AS/NZS 1429.2. Test certificates are required to be submitted for all tests performed on the equipment prior to the delivery of cables.

For type tests, a test assembly shall be prepared. This shall include at least 20m total length of cable between accessories, terminations and joints of the types proposed for the contract installation. The cable shall include a length which has been subjected to the bending test.

15.6 Insulation Resistance Test

15.6.1 Before Installation

An insulation resistance test of each core and each screen is to be carried out while still on the drums after delivery if the ends are accessible.

15.6.2 During Installation

An insulation resistance test of each core and each screen is to be carried out when it is laid in the trench or conduit and before the terminations are commenced.

15.6.3 After Installation

Insulation resistance tests shall also be taken of each cable section using a 2.5kV (minimum) megger. Minimum acceptable values shall be:

1. Outer serving (termite tapes to earth) 500 MΩ
2. Bedding for termite tapes (termite tapes to screen) 200 MΩ

Note: For (1) above the purchaser expects values in excess of 2000 MΩ and values less than this will require explanation and possible correction.

15.7 High Voltage Test

The cable system shall be subjected to power frequency withstand test for 24 hours. All cables should be 'Soaked' (ie energised for 24hours prior to being loaded).

15.8 Outer Serving High Voltage Test

The outer cable sheath of each cable shall be tested using a Megger with a test voltage of 10kV DC applied between metallic sheath and the earth/soil for one (1) minute. Leakage current values will be recorded at the start and end of one (1) min.

Sheath insulation resistance shall be checked at 2.5kV DC before and after the 10kV test. SVLs should be disconnected from cable sheath during this test.

Jointing operation shall start only after successful completion of the tests on all six (6) cable ends at each joint bay location.

15.9 Conductor and Screen Resistances

The conductor and screen resistances shall be measured to verify circuit continuity and compare results with calculated or design values.

15.10 Induced Voltage on Cable Screen

The Contractor shall carry out tests to verify the calculated induced screen standing voltages.

15.11 Sheath Voltage Limiters (SVL)

Prior to SVL test, ensure that all SVL are disconnected from the cable outer sheath.

Each sheath voltage limiter (SVL) shall be tested with 5kV DC applied between the earthing point of the link box and the metallic part of the SVL that was disconnected from the cable sheath.

Measure the leakage current through SVL during the 5kV DC test.

Measure the insulation resistance with a 2.5kV Megger tester after the 5kV DC test; minimum acceptable values shall be 100MΩ.

After the 5kV DC and insulation resistance tests, the capacitive current shall be safely discharged.

15.12 Earth Resistance Tests

After the installation of each joint bay electrode system by the contractor, standard earth resistance tests shall be carried out and the results of these tests shall be provided to SA Power Networks' Project Manager, for approval.

15.13 Verification of Screen Bonding for Cross-Bonded Arrangements

After installation of each cable section the contractor shall demonstrate that the cross bonding system is effective. This may be done by three phase current injection into the cable cores and measuring the corresponding sheath voltages and current at each sheath bonding position to ensure the correctness of the bonding connections.

Temporary redisposition of the bonding links to simulate erroneous bonding shall indicate the presence of substantial screen current. Note: Sheath Voltage Limiters (SVL) shall be temporarily disconnected. Voltages between screen and earth shall be measured and when corrected for the declared cable current rating shall not exceed the guaranteed levels.

The testing report shall include detailed schematic diagram of the testing assemblies, of recorded and calculated values and the statement of compliance with the stated current rating and losses.

15.14 Positive and Zero Phase Sequence Impedance

Tests shall be made to establish the positive and zero phase sequence impedances and verify the in-situ values where requested within the project specific cable specification.

15.15 Phase Rotation Test

A phase rotation test shall be conducted on each circuit prior to being placed into service.

15.16 Earthing and Bonding Connections

The contact resistance of the interface between the earthing or bonding lugs of joints, terminations, auxiliary equipment metal enclosures and local earthing mats shall be less than/or equal to 20 Micro Ohms (mΩ).

15.17 Continutity Test

For testing continuity of any integrated or separate optic fibres, contact SA Power Networks' Network Model-Network Telecommunications group for details on testing requirements. The results should be submitted to relevant SA Power Newtorks' Project Manager.

16. Materials

All materials used on the SA Power Networks 66kV network shall be those approved for use on the network at the time the design is performed. This is to ensure only appropriate equipment is installed on the network and to minimise the number of spares, tools and other equipment required to be held by SA Power Networks.

Where the use of a non-approved/non-listed item is proposed, this should be highlighted and approval sought from SA Power Networks' Manager Network Planning branch via SA Power Networks' designated Project Manager prior to procurement.

SA Power Networks reserves (at its absolute discretion) the right to reject such a proposal on the grounds of technical performance, logistics considerations (eg spare holdings) or any other reason.

16.1 Material Receipt

Prior to acceptance of any materials, they shall be checked to ensure compliance against the requirements of their appropriate specification.

Particular attention shall be paid to the cable's integrity. Where variance to the specification for any item is found, Network Planning shall be consulted prior to formal acceptance of the delivery from the manufacturer.

Where rejected by SA Power Networks (on reasonable grounds), all costs associated with the transport, handling, storage return and replacement of the equipment shall be borne by the material manufacturer / distributor.

17. Detailed Design Report

The detailed design report produced by the designer shall be provided to SA Power Networks detailing the following items:

1. Calculations (ie thermal analysis and thermal modelling etc) to support determination of the achievable cable rating (including a summary detailing the overall circuit's minimum cyclic and continuous ratings).
2. Results of thermal resistivity testing and sample location cross referenced to the route plan, (ie thermal resistivity investigations and subsequent analysis for native soils and trench backfill).
3. Trial hole survey locations and Route survey.
4. Where applicable, provide results of the geo-technical survey and testing performed including assessment of the types and quantum of contaminants as well as recommendations regarding the need or otherwise of an encasing pipe within the railway lines rail corridor to resist subsidence.

5. Where applicable, provide Geotechnical survey findings for the purpose of waste classification for disposal and soil composition for reuse.
6. Joint bay design.
7. 'For Construction' drawings detailing the route, installation method (eg open trench, trenchless), bore depth, bore pit locations, lubrication injection points and any existing vegetation affected, earth bonding arrangement etc. These drawings shall include trench cross sections and vertical profile details.
8. Cable installation details including cable lengths and drum details, hauling tensions etc.
9. Calculation of sheath induced voltage.
10. Where applicable, consider earth potential rise and LFI due to electro-magnetic fields near third party assets such as telecommunication, signalling cables and metallic pipes etc at the nominated cable installation depth(s).
11. Designs for power cables, bonding cables and accessories etc.
12. Cable and sheath bonding details.
13. Details of pre-commissioning tests to be conducted together with test method details and pass / fail criteria.
14. Photos (as appropriate).
15. Two (2) hard copies of the Design Report and one (1) soft copy are required.
16. Provision of design drawing(s) in A1 and A3 format. An AutoCAD version of all drawings is required showing cable route and alignment.

18. As Constructed Drawings

Provision of accurate 'As Constructed' drawing information is required to ensure that asset details and locations are available for future reference and to support SA Power Networks' relevant information systems, records and responsibilities including Geographical Information System (GIS) data, asset drawing records and 'Dial Before You Dig' responses. All drawings should comply with the requirements of TS099.

All 'As-Built' drawings are to be completed within six (6) weeks of the practical project completion date. Where those drawings submitted are deemed non-compliant with the requirements of TS099, the relevant contractor will be required to remediate the drawings to the satisfaction of SA Power Networks at their own expense.

The third party contractors engaged by SA Power Networks through a tender process, will be considered to have read and considered all costs associated with complying with SA Power Networks' drawing and documentation requirements within their offer.

19. Non Compliance

SA Power Networks may conduct audits and inspections to verify compliance with this document.

Non-compliance may result in one or all of the following:

1. Require the relevant contractor to re-perform or repair the works contracted for or pay SA Power Networks to engage an alternate contractor to undertake the remediation works required.
2. Issue of a directive to cease work and or removal of the offending person from the site.
3. Baning an offender from working near the SA Power Networks infrastructure until further notice.
4. Withdrawal of a company's endorsement with SA Power Networks (where presently approved).

20. Who You Should Talk To?

Customer Connections Information and Customer Solutions Managers:

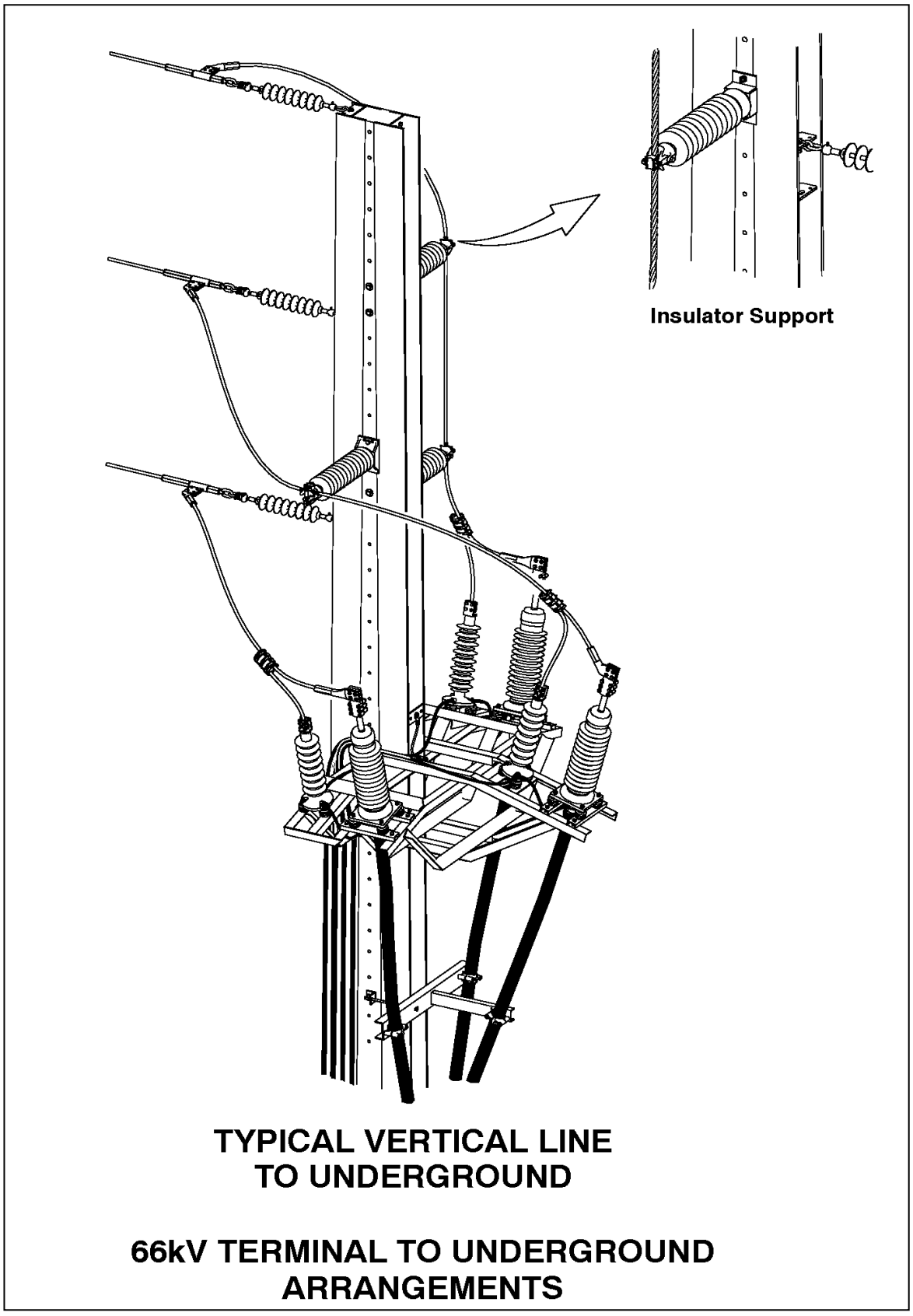
The SA Power Networks Customer Connections Information and Customer Solutions Managers contact details are available on internet, click here:
https://www.sapowernetworks.com.au/public/download/?id=221664

For Documentation Access:

For E-Drawings, AutoCAD standard templates and Instructional manuals, please contact 'Standards and Equipment Team' via Hotline on 8404 4200 or send an email to:
networkstandards@sapowernetworks.com.au.

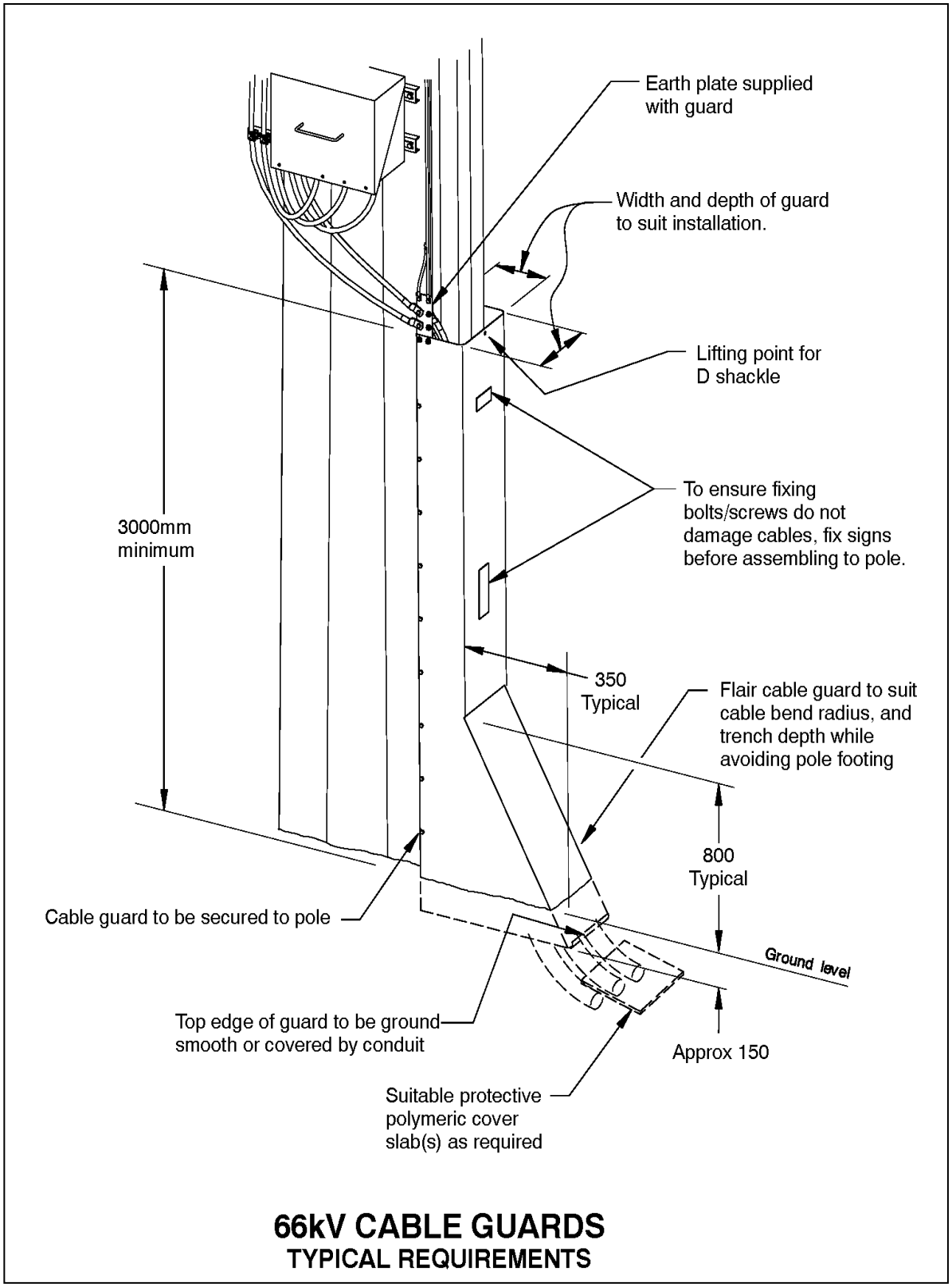
Appendices

A. Typical Over / Under Pole Vertical Arrangement



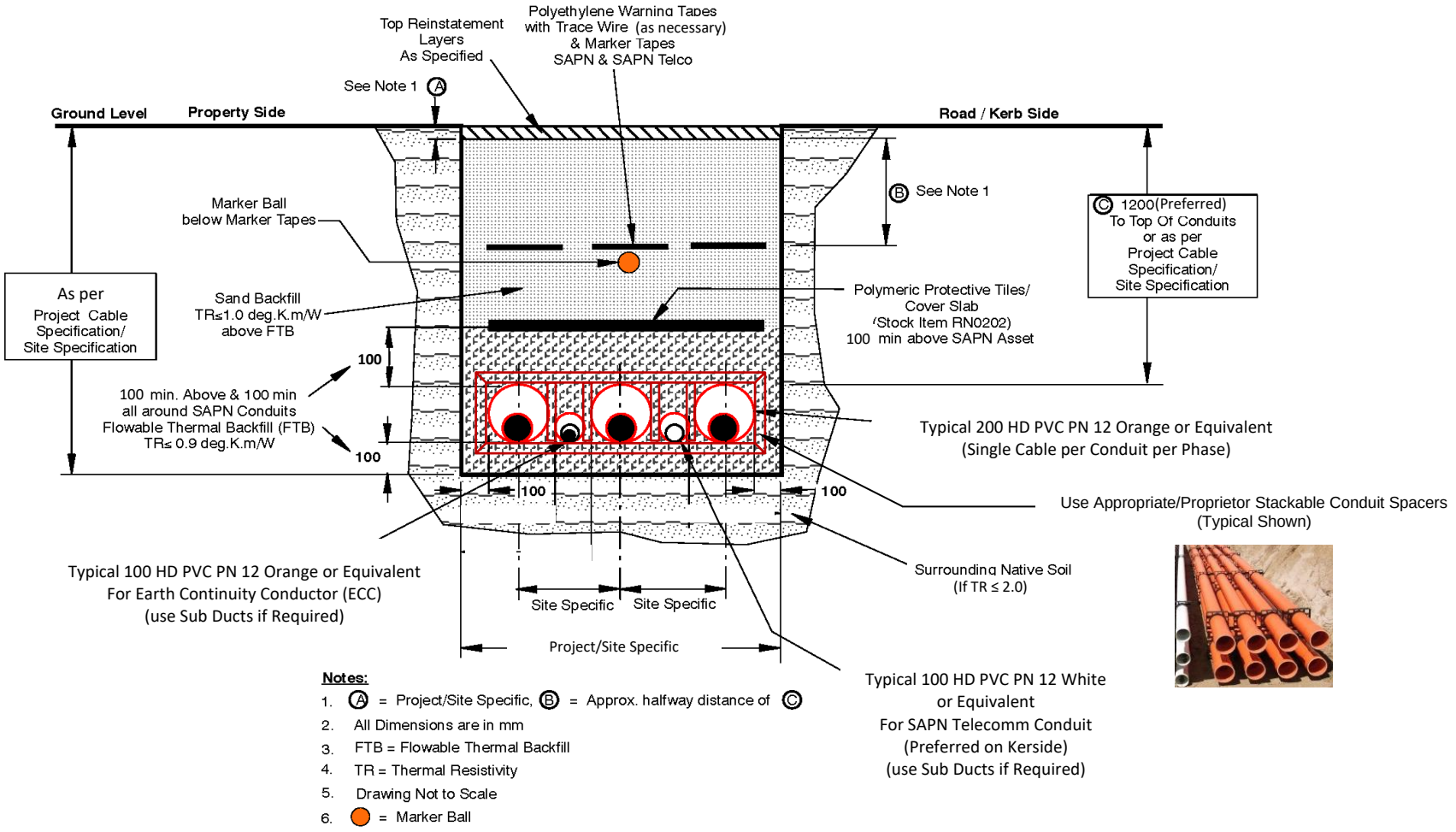
For more details Refer to E-drawings E1551 series.

B. Typical 66kV Cable Guard

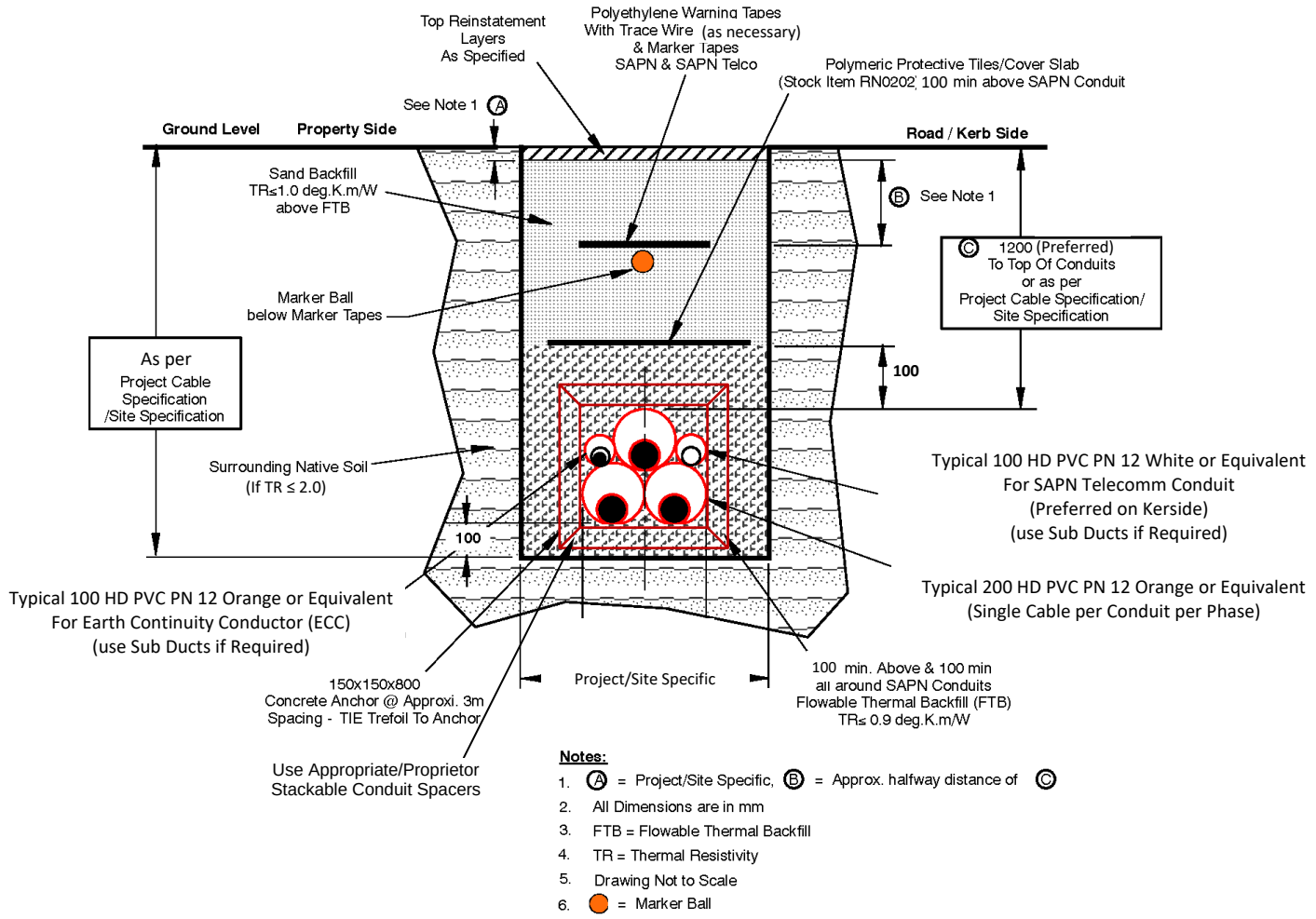


Refer to E-drawing E1511 series for more information.

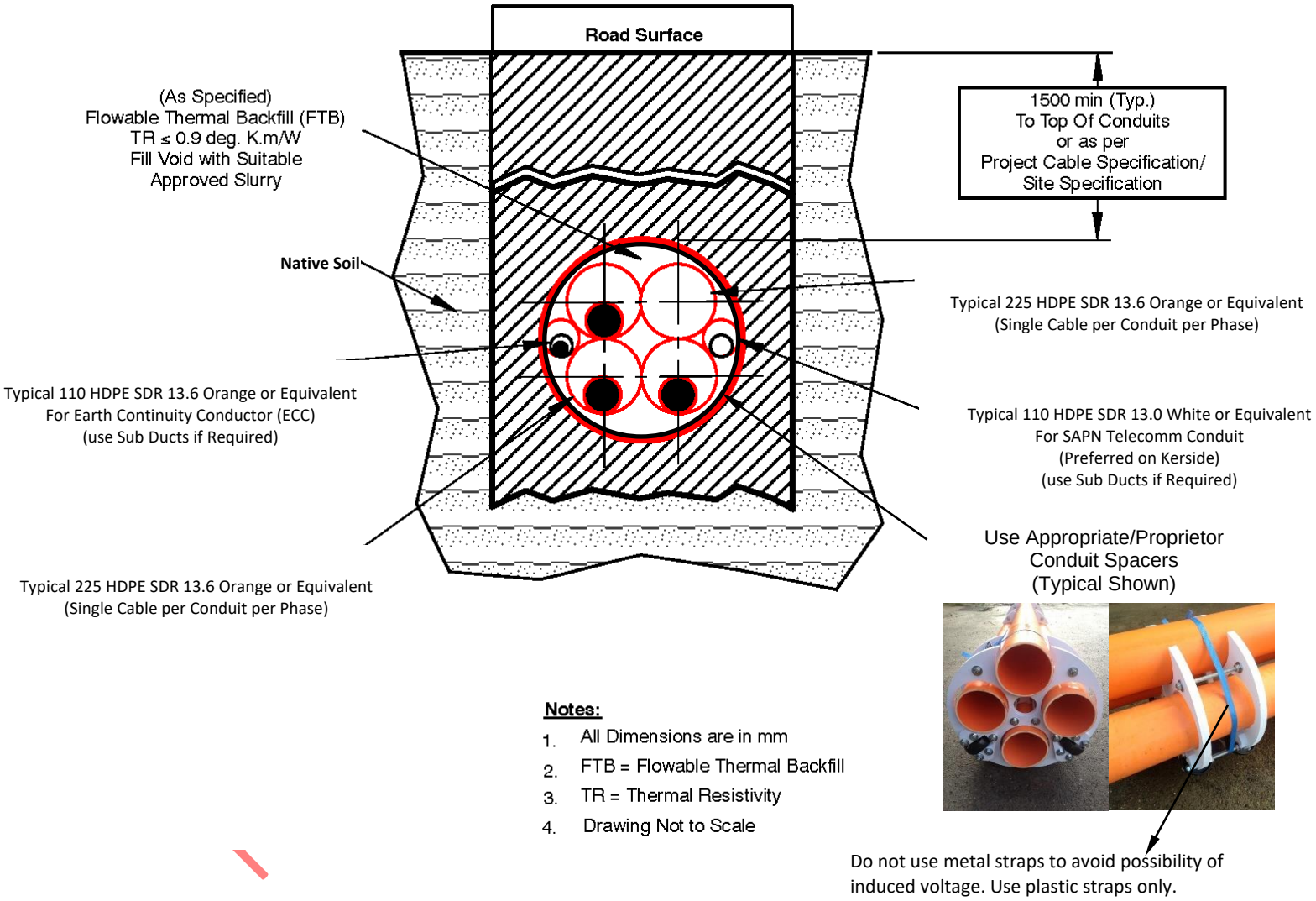
C. Typical Flat Arrangement



D. Typical Trefoil Arrangement



E. Typical Under Bore Arrangement



F. TS105 Forms: Samples Only

F.1 TS105 Part C: Project Details - Major Projects

Click here for the latest version of TS105 Part C

SA Power Networks

TS105 Part C: Project Details - Major Project Works

For Major Project Works	TS105 Part D must be submitted with this form at least 10 business days prior to commencement.

*Please fill in **SA Power Networks** Project Details:*			
Project/Job ID:		Project Date:	
Project/Job Name:		Stage:	
Customer/Applicant:			
Project Location:			
Depot Name:			
*Please fill in **SA Power Networks** Responsible Project Officer/Manager's Details:*			
Project Officer / Manager's Name:			
Contact Phone No:		Mobile No:	
Email Address:			
Additional Information/Comments: Use attachments if required.			

*Please fill in **Contractor's** Details:*			
Business Name:			
Representative's Name:			
Street Number:		Street Name:	
Suburb:		Post Code:	
Contact Phone No:		Mobile No:	
Email Address:			
*Please fill in **Secondary Contractor's** Details (If Applicable):*			
Business Name:			
Representative's Name:			
Street Number:		Street Name:	
Suburb Name:			
Contact Phone No:		Mobile No:	
Email Address:			

Sample Only

Note: This form shall be forwarded to either (A) and (B) SA Power Networks' Representatives as below:

(A)	To: The Civil Engineer (Team Leader - Major Projects) James Kokkinos - 0427 580 070	James.Kokkinos@sapowernetworks.com.au
and		
(B)	To: The Relevant SA Power Networks' Project Manager	

TS105 Part C	Authorised: Jehad Ali	Published: January 2019	Page 1 of 1

The use of this form is subject to the conditions stated in SA Power Networks' disclaimer section at the front of TS105A (Forms) document.

F.2 TS105 Part D: Index of Forms - Major Projects

Click here for the latest version of TS105 Part D

TS105 Part D: Index of Forms - Major Projects Works

For Major Project Works	TS105 Part C must be submitted with this form at least 10 business days prior to commencement.

Notes:
1. This form shall be used as a part of any Close Out log.
2. Please Tick to indicate which forms are Required and Supplied.
3. Also submit TS105 F-2 check list that is relevant to your specific project.

Civil Works Notification & Compliance Forms		'Tick' when Required	'Tick' when Supplied
TS105 C-1	SA Power Networks' Civil Infrastructure Works Notification Form		
TS105 C-2	SA Power Networks' Civil Infrastructure Works Compliance Form		

Electrical Works Compliance Forms		'Tick' when Required	'Tick' when Supplied
TS105 F-1	Authority to Proceed Request (ATP) - For Electrical Contractor		
TS105 F-2	Documentation - Check List		
TS105 F-3	SA Power Networks' Electrical Infrastructure Works Compliance Form		
TS105 F-4	SA Power Networks' Partial Electrical Infrastructure Works Compliance Form		

Note: This form shall be forwarded to either (A) and (B) SA Power Networks' Representatives as stated below:

(A)	To: The Civil Engineer (Team Leader - Major Projects) James Kokkinos - 0427 580 070		James.Kokkinos@sapowernetworks.com.au
and			
(B)	To: The Relevant SA Power Networks' Project Manager		

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F.3 TS105 C1: Civil Infrastrucutre Works Notification Form

Click here for the latest version of TS105 C1

SA Power Networks

TS105 C-1: SA Power Networks' Civil Infrastructure Works Notification Form

For Contestable Project Works (or) For Regulated Project Works	TS105 Part A and TS105 Part B must be submitted with this form at least 10 business days prior to commencement.
For Major Project Works	TS105 Part C and TS105 Part D must be submitted with this form at least 10 business days prior to commencement.

Notes:
1. The Civil Contractor must submit this form to SA Power Networks' Compliance Representative and the relevant Project Manager, to notify their intent of conducting civil works (eg Digging, Excavation, Trenching etc) on and/or around SA Power Networks' infrastructure.
2. Please refer to NICC404, TS085 and TS110 for requirements including any project specifications.

Please fill in your works details:	
Site Location:	
Site Reference No. (If applicable)	
Proposed Works Commencement Date:	
Proposed Works Completion Date:	
Description of Works (ie. nature of work intended to be carried out, any comments and or attachments etc.)	

Please fill in Civil Contractor's Details:			
Business Name:			
Representative's Name:			
Contact Phone No:		Mobile No:	
Email Address:			

SA Power Networks reminds you of your responsibilities with respect to the following areas:
1. You have read and understood all applicable NICC404, TS085 and or TS110, and any other project specific requirements.
2. You have consulted with our relevant Project Manager/Officer.
3. You have undertaken all reasonably practical measures to comply with SA Electricity Act 1996 & SA Electricity (General) Regulations 2012.
4. You have Safe Works Method Statement (SWMS) in place, which is a requirement for High Risk Construction Works as specified in SA WHS Act 2012 & SA WHS Regulations 2012.

Note: This form shall be forwarded to either (A) or (B) or (C), and (D) SA Power Networks' Representatives as below:

(A)	To: The Compliance Coordinator (Contestable Works)	Compliancegroup@sapowernetworks.com.au
or		
(B)	To: The Compliance Coordinator (Regulated Project Works) Rick Niutta - 0418 714 475	Rick.Niutta@sapowernetworks.com.au
or		
(C)	To: The Civil Engineer (Team Leader - Major Projects) James Kokkinos - 0427 580 070	James.Kokkinos@sapowernetworks.com.au
and		
(D)	To: The Relevant SA Power Networks' Project Manager	

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F.4 TS105 C2: Civil Infrastrucutre Works Compliance Form

F.4.1 TS105 C2: Page 1 of 2

Click here for the latest version of TS105 C2

TS105 C-2: SA Power Networks' Civil Infrastructure Works Compliance Form

For Contestable Project Works (or) For Regulated Project Works	TS105 Part A and TS105 Part B must be submitted with this form at least 10 business days prior to commencement.
For Major Project Works	TS105 Part C and TS105 Part D must be submitted with this form at least 10 business days prior to commencement.

Note: This form is for the Civil Contractor who has completed civil works eg. Digging, Excavation, Trenching etc. on and/or around SA Power Networks' infrastructure.

Please fill in your works details:	
Site Location:	
Site Reference No. (If applicable)	
Civil Works Completion Date:	
Description of Works (ie. nature of work intended to be carried out, any comments etc.)	

Please fill in Civil Contractor's Details:			
Business Name:			
Representative's Name:			
Contact Phone No:		Mobile No:	
Email Address:			

SA Power Networks reminds you of your responsibilities with respect to the following areas:

1. You have read and understood all applicable NICC404, TS085 and or TS110, and any other project specific requirements.
2. You have consulted with our relevant Project Manager/Officer.
3. You have undertaken all reasonably practical measures to comply with SA Electricity Act 1996 & SA Electricity (General) Regulations 2012.
4. You have Safe Works Method Statement (SWMS) in place, which is a requirement for High Risk Construction Works as specified in SA WHS Act 2012 & SA WHS Regulations 2012.

Note: This form shall be forwarded to either (A) or (B) or (C), and (D) SA Power Networks' Representatives as below:

(A)	To: The Compliance Coordinator (Contestable Works)		Compliancegroup@sapowernetworks.com.au
or			
(B)	To: The Compliance Coordinator (Regulated Project Works) Rick Niutta - 0418 714 475		Rick.Niutta@sapowernetworks.com.au
or			
(C)	To: The Civil Engineer (Team Leader - Major Projects) James Kokkinos - 0427 580 070		James.Kokkinos@sapowernetworks.com.au
and			
(D)	To: The Relevant SA Power Networks' Project Manager		

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Click here for the latest version of TS105 C2

TS105 C-2: SA Power Networks' Civil Infrastructure Works Compliance Form

Tasks to be completed by the Civil Contractor:		Tick 'ONE' (When Completed)			Date
		YES	NO	N/A	
I have read and understood all applicable NICC404, TS085 and/or TS110, and any other project specific requirements.					
I have appropriately searched and located other utilities/services.					
For Road Works on the DPTI Road.	I have submitted DPTI Notification Form Impacting DPTI Roads to DPTI.				
	I have attached a Copy of DPTI Letter of Confirmation for your reference.				
I have notified SA Power Networks - Compliance Coordinator for Civil Works program by submitting TS105 C-1 form a minimum of 10 business days prior to the work commencing.					
I have implemented all applicable NICC404, TS085 and/or TS110, and any other project specific requirements..					
I have ensured that all block and survey pegs that were disturbed because of Civil Works have been reinstated by Licensed Surveyor.					
Licensed Surveyor's Name:					
I have ensured that the reinstatement work is also satisfactory to Council/DPTI/other statutory authorities' specifications.					
I have noted/marked-up all actual site information stating all variances for trenching, conduiting, depths and layout etc. for developing 'As Installed' drawing plans.					
The 'As Installed' information is forwarded/presented to the Electrical Contractor/Designer.					
I have liaised and notified Electrical Contractor during and on the completion of Civil Works.					
I have also notified responsible SA Power Networks - Customer Solutions Manager/ Project Officer on completion of Civil Works.					

I the undersigned _____certifies that I have undertaken the installation and satisfied the requirement of any SA Power Networks' specification and that of DPTI, Council and any other Authority. All the information supplied in this form is filled in correctly to the best of my knowledge and understanding.

_____ _____ ___/____/_____

Name of Authorised Civil Representative Signature: Date:

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F.5 TS105 F1: Authority to Proceed (ATP) - For Electrical Contractor

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Click here for the latest version of TS105 F1

SA Power Networks

TS105 F-1: Authority to Proceed Request (ATP) - For Electrical Contractor

For Contestable Project Works (or) For Regulated Project Works	TS105 Part A and TS105 Part B must be submitted with this form at least 10 business days prior to commencement.
For Major Project Works	TS105 Part C and TS105 Part D must be submitted with this form at least 10 business days prior to commencement.

Note:
This form is for the Electrical Contractor who wishes to forward their request for Authority to Proceed for conducting electrical works on and or around SA Power Networks' infrastructure.

Please fill in your works details:	
Site Location:	
Site Reference No. (If applicable)	
Proposed Works Commencement Date:	
Proposed Works Completion Date:	
Description of Works (ie. nature of work intended to be carried out, any comments etc.)	

SA Power Networks reminds you of your responsibilities with respect to the following areas:

1. You have read and understood all applicable NIGC404, TS085 and or TS110, and any other project specific requirements.
2. You have consulted and confirmed our requirements with relevant Project Manager/Officer.
3. You have undertaken all reasonably practical measures to comply with SA Electricity Act 1996 and SA Electricity (General) Regulations 2012.
4. You have Safe Works Method Statement (SWMS) in place, which is a requirement for High Risk Construction Works as specified in SA WHS Act 2012 & SA WHS Regulations 2012.
5. SA Power Networks will not be able to issue the Authority to Proceed (ATP), if:
   5.1. the Proposed Dates as requested are not filled in; and
   5.2. for, the Contestable and Regulated Project Works, the following (a), (b) & (c) are not submitted:
      (a) Material Compliance,
      (b) Final Easement Plan, and
      (c) Public Lighting Tariff Acceptance by Council.
   5.3. for, Major Project Works, the following reports not submitted:
      (a) Manufacturer's, Supplier and or Installer's Material Compliance
      (b) Constructor's Installation and Testing Plan, and
      (c) For Construction drawings.
6. the Contestable Electrical Works test cannot be booked with our Compliance Group, if the following (a) & (b) are not submitted:
      (a) A copy of the external Authority to Proceed, and
      (b) For Construction drawings.

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Click here for the latest version of TS105 F1

TS105 F-1: Authority to Proceed Request (ATP) - For Electrical Contractor

Materials:

Please note that the following materials will not be sourced from SA Power Networks and will require confirmation from SA Power Networks that the materials to be installed meet the Specification.

For, Major Project Works, attach Manufacturer's, Supplier's and or Installer's Material Compliance report.

1.		5.	
2.		6.	
3.		7.	
4.		8.	

Cables:

Please find following details for Cables that are required by SA Power Networks for issuing an approval.

For, Major Project Works, attach Manufacturer's, Supplier's and or Installer's report.

1.	Cable Manufacturer/Supplier's Name:		
2.	Drum Numbers for Traceability Purposes:		
3.	Manufacturer/Supplier's Verification of Compliance to SA Power Networks Current Technical Standards:	Provided	Not Provided
4.	Test Certificates for Each Drum of Cable Satisfies Current AS/NZS Standards:	Provided	Not Provided

Performance Bond Details:

Critical Dates for the Vesting:

	Responsible Group	Work Required	Proposed Dates (Required)
1.	Contractor	Notification sent to Compliance Coordinator that work is commencing on site. 10 working days notice is required.	
2.	Contractor/ SA Power Networks	The acceptance of the TS105 F-3 SA Power Networks' Electrical Infrastructure Works Compliance Form in accordance with the Construction Terms.	
3.	Applicant/ SA Power Networks	Applicant has satisfied other conditions for vesting (Transfer of Title) as set out in the Construction Terms.	

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Click here for the latest version of TS105 F1

TS105 F-1: Authority to Proceed Request (ATP) - For Electrical Contractor

Note: This form shall be forwarded to either (A) or (B) or (C), and (D) SA Power Networks' Representatives as below:

(A)	To: The Compliance Coordinator (Contestable Works)	Compliancegroup@sapowernetworks.com.au
or		
(B)	To: The Compliance Coordinator (Regulated Project Works) Rick Niutta - 0418 714 475	Rick.Niutta@sapowernetworks.com.au
or		
(C)	To: The Civil Engineer (Team Leader - Major Projects) James Kokkinos - 0427 580 070	James.Kokkinos@sapowernetworks.com.au
and		
(D)	To: The Relevant SA Power Networks' Project Manager	

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F.6 TS105 F2: Documentation - Check List

F.6.1 TS105 F2: Page 1 of 2

Click here for the latest version of TS105 F2

SA Power Networks

TS105 F-2: Documentation - Check List

For Contestable Project Works (or) For Regulated Project Works	TS105 Part A and TS105 Part B must be submitted with this form at least 10 business days prior to commencement.
For Major Project Works	TS105 Part C and TS105 Part D must be submitted with this form at least 10 business days prior to commencement.

Note: This form is for the Electrical Contractor who has completed (Full and or Partial) electrical works on and or around SA Power Networks' infrastructure.

General Information Required	'Tick' when Required	'Tick' when Supplied	Notes
Relinquished Access Permits & Folder:			
Non-Compliance Notice:			
Charge Order Form: Out or Hours Cost:			
Charge Order Form: Equipment:			
Charge Order Form: Re-Inspection:			
Authority to Proceed:			
Concrete Cart-Note:			
Material Lists:			
Incident Report:			
As Cons Plans (eg 1 + 1 for Each T/F & S/C):			
Civil Compliance:			
Site Condition Compliance as per Current TS/Specs:			

SA Power Networks' Use Only	'Tick' when Required	'Tick' when Supplied	Notes
Contractor/Constructor Order Number:			
Switching Program Sheets (NSP/LSP/SSP etc.):			
Documentation to the relevant SA Power Networks' PM/NPO:			
Document to Operations Supervisor – External Works:			
Write Up Job Report:			
Drawings/Documents to Facilities Records Team via email assetforms@sapowernetworks.com.au:			
Where TS105 F-6 is required, notify Network Protection Team via email NP.ProtectionandControl@sapowernetworks.com.au:			
Summary of Direct Work Authority (DWA) to Connect:			
Documentation to Contractor:			
Copy of Compliance Certificate (CCC) to File:			

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TS105 F-2: Documentation - Check List

Note: This form shall be forwarded to either (A) or (B) or (C), and (D) SA Power Networks' Representatives as below:

(A)	To: The Compliance Coordinator (Contestable Works)	Compliancegroup@sapowernetworks.com.au
or		
(B)	To: The Compliance Coordinator (Regulated Project Works) Rick Niutta - 0418 714 475	Rick.Niutta@sapowernetworks.com.au
or		
(C)	To: The Civil Engineer (Team Leader - Major Projects) James Kokkinos - 0427 580 070	James.Kokkinos@sapowernetworks.com.au
and		
(D)	To: The Relevant SA Power Networks' Project Manager	

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F.7 TS105 F3: Electrical Infrastrucutre Full Works Compliance Form

F.7.1 TS105 F3: Page 1 of 2

Click here for the latest version of TS105 F3

SA Power Networks

TS105 F-3: SA Power Networks' Full Electrical Infrastructure Works Compliance Form

For Contestable Project Works (or) For Regulated Project Works	TS105 Part A, TS105 Part B and TS105 F-2 must be submitted with this form at least 10 business days prior to commencement.
For Major Project Works	TS105 Part C, TS105 Part D and TS105 F-2 must be submitted with this form at least 10 business days prior to commencement.

Note: This form is for the Electrical Contractor who has completed (Full) electrical works on and or around SA Power Networks' infrastructure.

Please fill in your works details:	
Site Location:	
Site Reference No. *(If applicable)*	
Electrical Works Completion Date:	
Description of Works *(ie. nature of work intended to be carried out, any comments etc.)*	

Specifically note that SA Power Networks may not be able to accept this form as your Certificate of Electrical Compliance, if you have not satisfied the following requirements:

1. You have complied with our requirements and any other project specifications.
2. You have consulted and confirmed our requirements with relevant Project Manager/Officer.
3. You have undertaken all reasonably practical measures to comply with SA Electricity Act 1996 and SA Electricity (General) Regulations 2012.
4. You have Safe Works Method Statement (SWMS) in place, which is a requirement for High Risk Construction Works as specified in SA WHS Act 2012 & SA WHS Regulations 2012.

I _____ being the primary electrical contractor/constructor for the installation of the Works for the above project hereby certifies that the electricity Works have been completed as follows:

(1) The "As constructed" drawing is: _____ Revision: _____
(2) All electrical infrastructures associated with the Works that is to be vested/connected to the SA Power Networks has been installed to the relevant standards and specifications and are as shown on the "As Constructed" Plan. The required numbers of copies are attached.
(3) All Network Access Permits (NAPs) are relinquished (completed).
(4) All HV & LV switches, LV fuses and Open points are as shown on the "As Constructed" Plan.
(5) All Earths have been removed.

YES	NO	
If 'NO', to 2, 3 4 or 5, please provide full details.		

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Click here for the latest version of TS105 F3

TS105 F-3: SA Power Networks' Full Electrical Infrastructure Works Compliance Form

I, further certify that:

(1) Electrical testing and other documentation relevant to this project have been satisfactorily completed and detailed on the attached "Certificate of Tests", and
(2) The "Civil Works Compliance Form" is attached (if applicable), and
(3) While transfer of title has not necessarily taken place between the Applicant and SA Power Networks, the Works are considered to be electrified. Any access to the Works by a contractor from the date of this certificate will require an access permit.
(4) I authorise our _____ Rolling Bond / _____ Restricted Works Bond to be utilised as the Performance Bond for this project.

Name of Authorised Representative _____ Signature: _____ Date: ___/___/_____

SA Power Networks' Use - further action/recommendations (if applicable):

Name of Compliance Coordinator/PM _____ Signature: _____ Date: ___/___/_____

Note: This form shall be forwarded to either (A) or (B) or (C), and (D) SA Power Networks' Representatives as below:

(A)	To: The Compliance Coordinator (Contestable Works)	Compliancegroup@sapowernetworks.com.au
or		
(B)	To: The Compliance Coordinator (Regulated Project Works) Rick Niutta - 0418 714 475	Rick.Niutta@sapowernetworks.com.au
or		
(C)	To: The Civil Engineer (Team Leader - Major Projects) James Kokkinos - 0427 580 070	James.Kokkinos@sapowernetworks.com.au
and		
(D)	To: The Relevant SA Power Networks' Project Manager	

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F.8 TS105 F4: Electrical Infrastrucutre Partial Works Compliance Form

F.8.1 TS105 F4: Page 1 of 2

Click here for the latest version of TS105 F4

SA Power Networks

TS105 F-4: SA Power Networks' Partial Electrical Infrastructure Works Compliance Form

For Contestable Project Works (or) For Regulated Project Works	TS105 Part A, TS105 Part B and TS105 F-2 must be submitted with this form at least 10 business days prior to commencement.
For Major Project Works	TS105 Part C, TS105 Part D and TS105 F-2 must be submitted with this form at least 10 business days prior to commencement.

Note: This form is for the Electrical Contractor who has completed (Partial) electrical works on and or around SA Power Networks' infrastructure.

Please fill in your works details:	
Site Location:	
Site Reference No. *(If applicable)*	
Electrical Works Completion Date:	
Description of Works *(ie. nature of work intended to be carried out, any comments etc.)*	

Specifically note that SA Power Networks may not be able to accept this form as your Certificate of Electrical Compliance, if you have not satisfied the following requirements:

1. You have complied with our requirements and any other project specifications.
2. You have consulted and confirmed our requirements with relevant Project Manager/Officer.
3. You have undertaken all reasonably practical measures to comply with SA Electricity Act 1996 and SA Electricity (General) Regulations 2012.
4. You have Safe Works Method Statement (SWMS) in place, which is a requirement for High Risk Construction Works as specified in SA WHS Act 2012 & SA WHS Regulations 2012.

I _____ being the primary electrical contractor/constructor for the installation of the Works for the above project hereby certifies that the electricity Works have been completed as follows:

(1) The "As constructed" drawing is: _____ Revision: _____
(2) All electrical infrastructures associated with the Works that is to be vested/connected to the SA Power Networks has been installed to the relevant standards and specifications and are as shown on the "As Constructed" Plan. The required numbers of copies are attached.
(3) All Network Access Permits (NAPs) are relinquished (completed).
(4) All HV & LV switches, LV fuses and Open points are as shown on the "As Constructed" Plan.
(5) All Earths have been removed.

YES	NO	
If 'NO', to 2, 3 4 or 5, please provide full details.		

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Click here for the latest version of TS105 F4

TS105 F-4: SA Power Networks' Partial Electrical Infrastructure Works Compliance Form

I, further certify that:

(1) Electrical testing and other documentation relevant to this project have been satisfactorily completed and detailed on the attached "Certificate of Tests", and
(2) The "Civil Works Compliance Form" is attached (if applicable), and
(3) While transfer of title has not necessarily taken place between the Applicant and SA Power Networks, the Works are considered to be electrified. Any access to the Works by a contractor from the date of this certificate will require an access permit.
(4) I authorise our _____ Rolling Bond / _____ Restricted Works Bond to be utilised as the Performance Bond for this project.

Name of Authorised Representative _____ Signature: _____ Date: ___/___/_____

SA Power Networks' Use - further action/recommendations (if applicable):

Name of Compliance Coordinator/PM _____ Signature: _____ Date: ___/___/_____

Note: This form shall be forwarded to either (A) or (B) or (C), and (D) SA Power Networks' Representatives as below:

(A)	To: The Compliance Coordinator (Contestable Works)	Compliancegroup@sapowernetworks.com.au
or		
(B)	To: The Compliance Coordinator (Regulated Project Works) Rick Niutta - 0418 714 475	Rick.Niutta@sapowernetworks.com.au
or		
(C)	To: The Civil Engineer (Team Leader - Major Projects) James Kokkinos - 0427 580 070	James.Kokkinos@sapowernetworks.com.au
and		
(D)	To: The Relevant SA Power Networks' Project Manager	

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G. Waste Soil Management Procedure - Summary

This Appendix is an extract from the SA Power Networks' internal environmental document 'Waste Soil Management Procedure' (ie EMS Procedure 5.3), which is derived from the SA EPA Standard for the production and use of Waste Derived Fill. Please contact the SA Power Networks' Environment Branch on 08 8404 5888, to obtain a copy of these documents and or for any further assistance.

SA Power Networks undertakes a large range of activities which may generate soil that needs to be removed from the location that was excavated. The following **key questions** may provide a starting point in making judgment in dealing with contaminated soil.

1. Is the soil coming from a site associated with a Potentially Contaminating Activities (PCA), for example around a transformer or from a substation?
   (a) YES - If the material is coming from a PCA site it shall be tested for its disposal suitability. If testing (refer to Notes) confirms that the material is either Waste Fill or Intermediate Waste Soil, it shall be transported in EPA licensed vehicles, each load will require a transport certificate and be disposed at EPA approved facility for recycling or disposal.
   (b) NO - refer to question 2.

2. Is the volume of soil from a project site OVER 100 tonnes?
   (a) YES - If the volume is greater than 100 tonnes, the material shall be tested and assessed (refer to Notes) by an EPA approved consultant (eg Enviropacific Services, BlueSphere Environmental, McMahon Services or URS) prior to transportation to an EPA approved recycling or disposal facility.
   (b) NO - If the volume of soil is less than 100 tonnes and passes an olfactory and visual inspection the material can be reused onsite or transported to any EPA approved recycling or disposal facility. Refer to 'Standard for the production and use of Waste Derived Fill (WDF)' and 'Site Contamination' for EPA's compliance requirements.

Notes:

1. If after testing, the material is classified as a Low-Level Contaminated soil then it shall be disposed-off at either TPI Inkerman, IWS at Dublin or Southern Waste at Maslin Beach.
2. The reuse at another site of any soil from a PCA site (even if the soil is assessed as Waste Fill) is not recommended until assessed by a suitably qualified auditor/consultant prior to transport for reuse. Soil that passes an olfactory and visual inspection may be reused at the site where the activity is taking place without additional testing.
3. Test results shall accompany any material transported.
4. All soil that is removed from the SA Power Networks' sites or third-party sites shall meet EPA's compliance standards.
5. Organisational and individual penalties may apply for non-compliance under the EPA Act.

H. Definitions

AC	Alternating current
AS/NZS	Australia and New Zealand Standards published by Standards Australia.
Bonding	Low resistance (impedance) electrical-conductor joint that utilises long lifetime (> 30 years), pressure or welded bond point connection design.
Circuit	Any number of conductors connected together for the purpose of carrying current.
CMEN	'Common Multiple Earth Neutral', which has a neutral that is common to the HV (high voltage) and LV (low voltage) systems and is continuous back to the substation earth. Where as **Local CMEN** system is only used in an isolated location, where the neutral is not connected back to the substation earth. Refer to TS109 for more information.
Cable System	The cable system includes components such as power cables, cable joints, cable terminations, cable accessories etc, which forms part of the SA Power Networks infrastructure, in connection with electrical sub-transmission and distribution network, and in particular will form the underground portion between the locations as specified.
Cable Joint	Joints are used to join two cables. They are generally grouped by their type, and are sized according to the voltage and cable size.
Cable Termination	Terminations are used to close off the end of a cable (underground). **Note:** Cable Termination (RAYCHEM type) specified in E-drawings E4053 series is only intended for use in emergency replacement applications. For any other applications, written approval from MNP shall be obtained.
Conduit	Conduits are PVC or HDPE tubes the primary purpose of which is to protect an underground cable from physical or water damage.
Contractor	A third party contractor and their sub-contractor who performs works (eg Design / Construction / Testing) on the SA Power Networks infrastructure.
DC	'Direct Current'.
Distribution Network	Any plant, equipment, structure, pole, building, conductor, cable, fixture, attachment or other thing that comprises part of the infrastructure that SA Power Networks utilises to provide distribution connection services below 66kV.
DNSP	'Distribution Network System Provider'.
DPTI	'Department of Planning Transport and Infrastructure'. Visit http://www.dpti.sa.gov.au/.
DTS	'Distributed Temperature Sensing'.

H1: Definitions (Continued)

Easement (Electricity)	An electricity easement is the right held by a DNSP to control the use of land near above-ground, underground power lines and substations. It holds this right to ensure the landowner's safety and to allow DNSP staff access to work on the power assets at all times.
ECC	'Earth Continuity Conductor'.
Electricity Infrastructure	Can mean any one or all of the following: (a) electricity generating plant (b) powerlines (c) substations for converting, transforming or controlling electricity (d) equipment for metering, monitoring or controlling electricity (e) any wires, equipment or other things (including tunnels and cavities) used for, or in connection with, the generation, transmission, distribution or supply of electricity; (f) anything declared by regulation to form part of electricity infrastructure, but does not include anything declared by regulation not to form part of electricity infrastructure
EPR	Earth Potential Rise
FTB	'Flowable Thermal Backfill'.
GIS	'Geographical Information System'.
GPR	Ground Penetrating Radar
HD	Heavy Duty
HDPE	High Density Poly Ethylene
HV (High voltage)	Electricity at a voltage exceeding 1,000 V alternating current (AC) or 1,500 Volts direct current (DC).
Joint Bay	An enlarged section of excavated trench, in which cables are jointed, and which is backfilled at the completion of the jointing work.
Landowner	The landowner is the person or entity that is the registered proprietor / owner of the land as recorded at the Lands Titles Office. All easement agreements shall be with the landowner.
LD	Light Duty
LFI	'Line Fault Indicator'.
LV (Low Voltage)	Exceeding 50 Volts AC or 50 Volts ripple free DC but not exceeding 1000 Volts AC or 1500 Volts DC
MNP	The SA Power Networks Manager Network Planning.

H2: Definitions (Continued)

MEN	Multiple earthed neutral is also known in EIC 60364 as a TC-N-S earthing system. Part of the system used a combined PEN (protective earth – neutral) conductor, which is at some point split up into separate PE and N lines. The combined PEN conductor typically runs between the transformer/supply neutral and the entry point into the building and may be earthed at numerous points. The PEN conductor is only separated into distinct PE and N conductor at the installation switchboard. In the SA Power Networks MEN system, this LV earthing/neutral system is kept distinctly separate from the HV earthing systems.
PCA	Potentially Contaminated Activities
PE	Poly Ethylene
PP	Poly Propylene
Project Manager	The SA Power Networks Network Project Manager, Delivery Project Manager, Network Project Officer, Network Service Officer, Customer Service Officer, Strategic Project Manager or any Officer / Supervisor who is ultimately responsible for the management of a project.
PVC	Poly Vinyl Chloride
RMS	'Root Mean Square'.
Shall	'Mandatory'.
SWL	Safe Working Load
SVL	'Sheath Voltage Limiter'.
Sub-Transmission Networks	66kV lines in the case of SA Power Networks. Any plant, equipment, structure, pole, building, conductor, cable, fixture, attachment or other thing that comprises part of the infrastructure that SA Power Networks utilises to provide 66kV connection services.
Surge Arrestor	A surge arrestor is an equipment asset that is used to protect the network from higher than expected voltages caused by lightning. They are generally found within zone substations or on poles mounted equipment.
Terms and Conditions	The SA Power Networks publication Terms and Conditions for External Contractor Construction, as amended from time to time.
TR	Thermal Resistivity

H3: Definitions (Continued)

Works:	
Planned	The works, which has followed the normal planning process, prior to work commencing, ie where the worksite has been physically inspected and assessed, in advance of the work crew, arriving on site.
Unplanned	Any urgent works where there has not been a reasonable opportunity to follow normal planning processes prior to work commencing. This includes works where the supervisor has not physically inspected the workplace or where a work crew has come across a scope of work requiring action during the normal course of their duties.
Emergency	Where a crew is dispatched to the worksite, in response to an immediate threat/danger to an individual, the public, or the infrastructure.

I. References

The following listed documents are for additional information but may not be a conclusive list and other documentation may be required on a project specific basis. Refer to the following SA legislative acts and regulations, SA Electricity Code, the SA Power Networks publications, relevant AS/NZS and ENA standards for more detail.

Please note: It's your responsibility to ensure you have complied with all relevant standards and you have used the latest version. For civil contractors conducting regular civil works for any the SA Power Networks installations, there is a E Drawings Group: 40 - Civil Construction available on request, which detail many project specific aspects of civil works that may not be detailed in this standard.

South Australian Legislations

- Electricity Act 1996 and Electricity (General) Regulations 2012
- Electricity (Principles of Vegetation Clearance) Regulations 2010
- Environment Protection Act 1993 and Environment Protection Regulations 2009
- Development Act 1993 and Development Regulations 2008
- Telecommunications Act 1997 and Telecommunications Code of Practice 1997
- Work Health & Safety Act 2012 and Work Health & Safety Regulations 2012

Essential Services Commission of South Australia (ESCOSA) Codes

- SA Electricity Distribution Code (EDC)

Energy Networks Association (ENA) Publications

- ENA NENS 03: National Guidelines for Safe Access to Electrical and Mechanical Apparatus
- ENA NENS 04: National Guidelines for Safe Approach Distances to Electrical and Mechanical Apparatus

Australian Energy Market Commission (AEMC) Publications: National Electricity Rules (NER)

The Department of Planning Transport and Infrastructure (DPTI) Publications

The Office of Technical Regulator (OTR) Publications

SA Power Networks' Documents:

Manuals:

Manual 14	Safety, Reliability, Maintenance & Technical Management Plan
E Dwgs Group 40	Civil Construction Manual

Technical Standards & NICCs:

NICC400	Information for an applicant undertaking a contestable extension
NICC401	Information on Network Design and Installation by an External Contractor
NICC404	Working in the Vicinity of the SA Power Networks Infrastructure - Network Access Permit Process
TS099	Distribution and Sub-Transmission CAD Drafting Standards
TS102	Easement standard for distribution networks
TS109	Earthing of the Distribution Network

Relevant E Drawing Series - Eg E1511 series

Standards Australia Publications:

AS 1141.11.1/Amdt 2	2016	Methods for sampling and testing aggregates Part 11.1: Particle size distribution sieving method
AS 1289.3.3.1	2009	Methods of testing soils for engineering purposes Part 3.3.1: Soil classification tests - Calculation of the plasticity index of soil
AS 1319	1994	Safety signs for the occupational environment
AS 1345	1995	Identification of the contents of pipes, conduits and ducts
AS 1428 (Set)	2010	Design for access and mobility set
AS 1742.13	2009	Manual of uniform traffic control devices Local area traffic management
AS 1931.2	1996	High-voltage test techniques measuring systems
AS 2067	2016	Substations and high voltage installations exceeding 1kV AC.
AS 2419.1	2017	Fire Hydrant Installations Part 1: System design, installation and commissioning
AS 3798/Amdt 1	2008	Guidelines on earthworks for commercial and residential developments
AS 4139	2003	Fibre reinforced concrete pipes and fittings
AS 4292.2	2006	Rail safety management - track, civil and electrical infrastructure
AS 4678/Amdt 2	2008	Earth-retaining structures
AS 4799	2000	Installation of underground utility services and pipelines within railway boundaries
AS 60038	2012	Standard voltages
AS 60068.1	2003	Environmental testing, Part 1: General and guidance
AS/CA S009	2013	Installation requirements for customer cabling (Telecommunications Wiring Rules)
AS/NZS 1477	2017	PVC pipes and fittings for pressure applications
AS/NZS 2032		Installation of PVC pipe systems
AS/NZS 2053.1	2016	Conduits and fittings for electrical installations Part 1: General requirements
AS/NZS 2648.1	1995	Underground marking tape, Part 1: Non-detectable tape
AS/NZS 3000	2018	Electrical Installations (known as the wiring rules)
AS/NZS 3500 (Set)	2015	Plumbing and Drainage Set (Parts 0-4)
AS/NZS 3845.1	2015	Road safety barrier systems and devices Part 1: Road safety barrier systems
AS 3865-1991/Amdt 1	2003	Calculation of the effects of short-circuit currents
AS 3996	2006	Access covers and grates
AS/NZS 1429.2	2009	Electric Cables-Polymeric Insulated – for Working Voltages above 19/33 (36)kV up to and including 87/150 (170)kV
AS/NZS 4026	2008	Electric cables - for underground residential distribution systems
AS/NZS 4130/Amdt 1	2009	Polyethylene (PE) Pipes for Pressure Applications
AS/NZS 5100 Series	2017	Bridge design
AS/NZS ISO 14001	2016	Environmental Management Systems - Requirements with guidance for use
AS/NZS ISO 31000 (Set)	2013	Risk Management Set - Principles and Guidelines. (AS/NZS 4360 is superseded in 2004)
G591	2006	Telecommunications in Road Reserves Operational Guidelines for Installations - Industry Guideline

International Standards:

ASTM STP1331	1998	The Design and Application of controlled low-strength materials (flowable fill)
IEC 60255.1	2009	Measuring Relays and Protection Equipment Part 1: Common requirements
IEC 60287.1.3	2002	Electric cables - Calculation of the current rating. Part 1-3: Current rating equations (100 % load factor) and calculation of losses - Current sharing between parallel single-core cables and calculation of circulating current losses
IEC 60853-2 - Amdt 1	2008	Calculation of the cyclic and emergency current rating of cables. Part 2: Cyclic rating of cables greater than 18/30 (36) kV and emergency ratings for cables of all voltages
IEEE 442	2017	Guide for Thermal Resistivity Measurements of Soils and Backfill Materials
IEEE C37.90.1	2012	Standard Surge Withstand Capability Tests for Relays and Relay Systems Associated with Electric Power Apparatus

ENA Standards:

ENA EG0	2010	Power System Earthing Guide: Part 1: Management Principles
ENA EG1	2006	Substation Earthing Guide