Standard

Underground Installation Configurations for High Voltage and 1500 V dc Cables

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Preface

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

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

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

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

This document forms part of the suite of transport standards and sets out the requirements for underground installations of high voltage and 1500 V dc cables.

This standard is developed from RailCorp standard EP 20 00 04 02 SP Underground Installation Configurations for High Voltage and 1500 V dc Cables, version 2.1.

This standard supersedes the RailCorp standard EP 20 00 04 02 SP and is a first issue.
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1. Introduction

TfNSW has a high voltage distribution network that supplies electricity to the traction substations, railway stations as well as other elements of the RailCorp network. Feeders of this high voltage distribution network consist of both cables and overhead conductors with nominal voltages of between 11 kV and 132 kV. Small number of feeders with a nominal voltage of 2 kV is still present in the existing network. These feeders are gradually being phased out. Cables with rated voltage 6.6 kV are also used as positive and negative feeders in the 1500 V dc traction system of RailCorp network.

Apart from RailCorp network, high voltage cables of other organisations may also be installed within the rail corridor.

2. Purpose

This document aims to set out the requirements for underground installations of high voltage and 1500 V dc cables for RailCorp network.

2.1 Scope

This document sets out the requirements for underground installations of high voltage ac cables with a nominal voltage up to 66 kV and 1500 V dc cables within the RailCorp network.

Installation within the rail corridor of high voltage cables that are not part of RailCorp network shall comply with the requirements of AS 4799 and ESC 540 Service Installations within the Rail Corridor.

This document does not cover the following:

- ground line troughing (GLT) installations, which is covered in EP 20 00 00 03 SP Above Ground Cable Installation Systems
- transition arrangements between underground and above ground cable installations, which is covered in EP 20 00 04 04 SP Ground Entry Arrangements
- cable pits, which is covered in EP 20 00 04 05 SP Cable Pits
- requirements for cables with a nominal voltage higher than 66 kV

2.2 Application

This document applies to underground installation of high voltage and 1500 V dc cables for all new work, as well as alterations to existing installations. For alterations to existing installations, the requirements of this document are applicable to the extent of new construction only. Alterations to 2 kV cables shall comply with the requirements of this document for 11 kV cables.
This document applies to the underground installation of high voltage and 1500 V dc cables within RailCorp network's system substations.

This document is not applicable to maintenance repairs to existing cable routes.

3. **Reference documents**

**Australian standards**

- AS/NZS 1477:2006 PVC pipes and fittings for electrical installation
- AS/NZS 1906.1:2007 Retroreflective materials and devices for road traffic control purposes – Retroreflective sheeting
- AS/NZS 2053.2:2001 Conduits and fittings for electrical installations – Rigid plain conduits and fittings of insulating material
- AS 2067-2008 Substations and high voltage installations exceeding 1 kV a.c.
- AS/NZS 2648.1:1995 Underground marking tape – Non-detectable tape
- AS/NZS 4130:2009 Polyethylene (PE) pipes for pressure applications
- AS 4702-2000 Polymeric cable protection covers
- AS 4799-2000 Installation of underground utility services and pipelines within railway boundaries
- AS 5488-2013 Classification of subsurface utility information (SUI)
- AS/CA S009:2013 Installation requirements for customer cabling (Wiring rules)

**TfNSW standards**

- EP 20 00 00 03 SP Above Ground Cable Installation Systems
- EP 20 00 04 01 SP Cable Route Selection
- EP 20 00 04 04 SP Ground Entry Arrangements
- EP 20 00 04 05 SP Cable Pits
- EP 20 00 04 06 SP Underground Cable – Location Recording
- ESC 215 Transit Space
- ESC 540 Service Installations within the Rail Corridor
- T HR TE 01001 ST Communication Outdoor Cabling
- SPC 207 Track Monitoring Requirements for Undertrack Excavation
- SPG 0705 Construction of Cable Routes and Signalling Civil Works
Other reference documents

Australasian Society for Trenchless Technology Guidelines for Horizontal Directional Drilling, Pipe Bursting, Microtunnelling and Pipe Jacking

CIGRE TB194 Construction, laying and installation techniques for extruded and self contained fluid filled cable systems

ESAA C(b)2-1989 Guide to the Installation of Cables Underground


Roads and Maritime Services (RMS) QA Specification RMS M209 – Road Openings and Restoration

4. Terms and definitions

The following definitions apply in this document:

AEO Authorised Engineering Organisation

ASA Asset Standards Authority

TfNSW Transport for New South Wales

5. General requirements

Cables with a higher nominal voltage shall be installed at a depth greater than those with a lower nominal voltage.

Trenches shall not be covered until after location recording in accordance with EP 20 00 04 06 SP Underground Cable – Location Recording has been made.

Illustrations of typical installation configurations are included in Appendix A.

5.1 Installations outside rail corridor

Installation of high voltage and 1500 V dc cables within a registered easement of TfNSW shall comply with the requirements for installations within the rail corridor.

Elsewhere, underground installations of high voltage and 1500 V dc cables outside of rail corridors shall follow the NSW Streets Opening Conference Guide requirements for high voltage cables and the requirements of the controlling authorities of the area. Agreement shall be obtained from the relevant controlling authorities for any deviation from the requirements.

Installation of high voltage and 1500 V dc cables under roads controlled by the Roads and Maritime Services (RMS) shall comply with the requirements of RMS Quality Assurance Specification M209.
6. **Minimum depth of installation**

For direct laid systems, the depth of installation is the vertical distance from the ground level to the top of the cable. For duct laid systems, the depth of installation is the vertical distance from the ground level to the top of the duct.

Within the rail corridor, the minimum depth of installation of high voltage and 1500 V dc underground cables and their enclosures shall comply with AS 4799.

Within system substations, high voltage and 1500 V dc cable installations shall comply with AS 2067.

Outside of the rail corridor, the minimum depth of installation of high voltage and 1500 V dc cables shall follow the *NSW Streets Opening Conference (SOC) Guide* requirements for high voltage cables and the requirements of the controlling authorities of the area.

Where high voltage and 1500 V dc cables are installed by trenchless technology, the top of the cable duct shall be at a depth of not less than 1 m from ground level.

The minimum depths of installation for high voltage and 1500 V cables are summarised in Table 1 and Table 2.

**Table 1 - Minimum depths of installation for high voltage and 1500 V cables within rail corridor**

<table>
<thead>
<tr>
<th>Location</th>
<th>Minimum depths of installation</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>At undertrack crossings</td>
<td>2000 mm from top of rail</td>
<td>Per AS 4799</td>
</tr>
<tr>
<td>Within system substations</td>
<td>750 mm</td>
<td>Protected; per AS 2067</td>
</tr>
<tr>
<td></td>
<td>900 mm</td>
<td>Unprotected; per AS 2067</td>
</tr>
<tr>
<td>Elsewhere</td>
<td>1000 mm</td>
<td>Per AS 4799</td>
</tr>
<tr>
<td></td>
<td>500 mm</td>
<td>Reduced depth of installation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Not to be constructed by trenchless technology</td>
</tr>
</tbody>
</table>
Table 2 - Minimum depths of installation for high voltage and 1500 V cables outside rail corridor

<table>
<thead>
<tr>
<th>Location</th>
<th>Nominal voltage (kV)</th>
<th>Minimum depths of installation</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>State roads controlled by Roads and Maritime Services</td>
<td>All</td>
<td>1200 mm</td>
<td>Unprotected; see RMS M209</td>
</tr>
<tr>
<td></td>
<td>All</td>
<td>1000 mm</td>
<td>Protected; sleeved within concrete encasement; see RMS M209</td>
</tr>
<tr>
<td>Regional and local roads controlled by councils</td>
<td>HV up to 22 kV, 1500 V dc</td>
<td>750 mm</td>
<td>Installation by trenching; see NSW Streets Opening Conference Guide</td>
</tr>
<tr>
<td></td>
<td>33 kV and above</td>
<td>900 mm</td>
<td>Installation by trenching; see NSW Streets Opening Conference Guide</td>
</tr>
<tr>
<td></td>
<td>All</td>
<td>1000 mm</td>
<td>Installation by trenchless technology</td>
</tr>
<tr>
<td>Footways</td>
<td>HV up to 22 kV, 1500 V dc</td>
<td>600 mm</td>
<td>Installation by trenching; see NSW Streets Opening Conference Guide</td>
</tr>
<tr>
<td></td>
<td>33 kV and above</td>
<td>900 mm</td>
<td>Installation by trenching; see NSW Streets Opening Conference Guide</td>
</tr>
<tr>
<td></td>
<td>All</td>
<td>1000 mm</td>
<td>Installation by trenchless technology</td>
</tr>
</tbody>
</table>

6.1 Reduced depth of installation

Where obstructions are present in the cable route and it is not reasonably practicable to remove the obstructions, high voltage and 1500 V dc cables may be installed at a reduced depth, provided that it satisfies all of the following conditions:

- the cables are laid in ducts
- the minimum depth of installation is 500 mm
- cable protection covers are provided
- adequate mechanical protection is provided around the ducts to prevent damage from excavation as well as mechanical loads at the surface; where such protection is provided by encasing the ducts in concrete, the concrete encasement shall extend beyond the edge of the outermost duct by at least 100 mm at the top and bottom and 75 mm on each side. Cable protection covers may be omitted if the thickness of concrete encasement above the top layer of ducts is 300 mm or more
- additional warning labels shall be installed at intervals of not more than 3 m on the surface along the entire length with reduced depth of installation
- other provisions as required by the controlling authority of the area
7. **Cable protection covers**

Polymeric cable protection covers to AS 4702 or approved equivalent shall be provided above the bedding layer around cables and their enclosures.

Cable protection covers shall be located directly above and overlap each cable or duct by not less than 50 mm on each side.

7.1 **Additional protection for direct buried cables**

For direct buried cables, cable protection covers shall also be provided between cables of different circuits and between cables and other services.

7.2 **Protection of cables in a duct bank**

Where cables are installed in ducts in a shared trench arrangement and where ducts of other services are installed directly above the high voltage and 1500 V dc cable ducts, the arrangement is deemed to provide adequate protection for the high voltage and 1500 V dc cables. The protection arrangement for the duct bank shall then be determined by the requirements of the services occupying the top row of ducts. Refer to SPG 0705 *Construction of Cable Routes and Signalling Civil Works* for cable protection arrangements for shared trenches with signals and communications.

8. **Warning marker tapes**

Orange warning marker tapes that comply with AS/NZS 2648.1 shall be installed above the cable protection covers. The warning marker tapes shall cover all areas directly above the cable protection covers.

Where cable protection covers are omitted for configurations with reduced depth of installation, the warning marker tapes shall cover all areas directly above the concrete encasement. Warning marker tapes may be omitted for configurations with reduced depth of installation if the concrete encasement is extended to the ground level.

9. **Separation from other cables and services**

Separation refers to the shortest distance measured between edges of cable ducts and edges of cables for direct buried cables.

Separation distances greater than the minimum requirements may be required when the following are considered:

- requirements of the controlling authority of the assets involved
- maintenance and safeworking arrangements of the assets involved
- mutual heating effects on cable ratings
• risk of damage to cables as a result of fault conditions of other cables and services

Other cables and services that have additional separation requirements include the following:
• services that are not part of RailCorp network
• other high voltage cables
• low voltage cables
• signalling cables
• communication cables

9.1 Separation from cables and services that are not part of RailCorp network

The separation between high voltage and 1500 V dc cables from cables and services that are not part of RailCorp network shall not be less than 300 mm.

9.2 Separation from RailCorp network cables and services

Separation requirements exist between high voltage and 1500 V dc cables and other RailCorp network cables and services. The RailCorp network cables include the following:
• other high voltage and 1500 V dc cables
• low voltage cables
• signalling cables
• communications cables
• other services

9.2.1 Separation from other high voltage and 1500 V dc cables

The minimum separation between high voltage and 1500 V dc cables of different circuits shall be 150 mm horizontal and 225 mm for direct buried cables. For cables in ducts, the minimum separation between ducts shall be 50 mm.

Where a design proposes to have high voltage and 1500 V dc cables of different circuits separated by a distance of less than 1000 mm, the designer shall assess the risk to network reliability caused by the failure of more than one circuit from a single event. The design configuration shall be approved by the relevant configuration control board.

9.2.2 Separation from low voltage cables

Minimum separation from low voltage cables shall be 150 mm horizontal and 225 mm vertical for direct buried cables. For cables in ducts, the minimum separation between the ducts shall be 50 mm.
9.2.3 Separation from signalling cables

Separation from signalling cables shall comply with the requirements of SPG 0705 Construction of Cable Routes and Signalling Civil Works.

9.2.4 Separation from communication cables

Separation from communication cables shall comply with the requirements of T HR TE 01001 ST Communication Outdoor Cabling and AS/CA S009.

9.2.5 Separation from other services

The separation between high voltage and 1500 V dc cables and other services such as gas and water shall not be less than 300 mm.

10. Distributed temperature sensing fibre optic cables and pilot wire cables

Where distributed temperature sensing fibre optic cables and pilot wire cables for a high voltage feeder are installed along the same route of the power cables, they are considered to be part of the high voltage cable circuit. The separation requirements between power and communication cables do not apply to these cables.

Where the power cables are installed in ducts, a separate duct shall be provided for the pilot wire cable.

Pilot wire cables shall be installed below the associated power cables.

11. Cable route markers within the rail corridor

Cable route markers shall be provided in accordance with AS 4799 for installation within the rail corridor. The following requirements shall also be satisfied:

- Markers shall be located to satisfy the clearance requirements of ESC 215 Transit Space. In yard areas, markers shall not obstruct footpaths, walkways or vehicle access ways.
- Marker plates shall be made from Class 1 retro-reflective sheeting with yellow background in accordance with AS/NZS 1906.1.

11.1 Cable route markers outside of the rail corridor

Cable route markers shall be provided in accordance with AS 4799, except for the following:

- the minimum distance between consecutive markers may be more than 200 m, but not less than the line of sight
- the heights of markers above ground level and their orientation may be varied to suit local conditions
12. **Direct laid system**

Cables directly buried in a trench shall be buried in clean sand. The clean sand shall provide bedding at the bottom and across the entire width of the trench in order to achieve the following:

- the distance between the bottom of the trench and the bottom of cables is 150 mm minimum
- the thickness of the clean sand above the top of cables is 100 mm minimum
- the outermost edge of cables is located at a distance of at least 100 mm from the side of the trench

Where there is a risk of erosion, a 14:1 sand cement mix may be used instead of clean sand.

Cable protection covers shall be placed immediately above the bedding.

On top of the cable protection covers natural backfill may be used.

Outside of the rail corridor, the top of the trench shall be restored in accordance with the requirements of the controlling authority of the area.

Unless otherwise specified in design, single core high voltage ac cables shall be installed in close trefoil formation. Justification shall be provided in the design documentation if other arrangements are used.

Illustrations of typical direct laid system configurations are provided in Appendix A.

13. **Duct laid system**

Cables shall be enclosed in ducts at the following installations:

- undertrack crossings
- crossings of main roads
- installations using trenchless technology

High voltage cables of different circuits shall not be installed within the same duct. 1500 V dc positive cables of different feeders shall not be installed within the same duct. 1500 V dc negative cables may be installed within the same duct.

Single core high voltage ac cables shall be installed with one of the following configurations:

- all cores of the same circuit are in close trefoil formation within one duct
- each core is installed in a separate duct, with the ducts arranged in a trefoil formation as far as practicable; the trefoil formation shall be maintained when any one of the cables is replaced by a new one in the spare duct

Ducts with cables shall not be filled with grouts.
Illustrations of typical duct laid system configurations are provided in Appendix A.

13.1 Properties of ducts

Ducts shall be rigid unplasticised polyvinyl chloride (UPVC) orange heavy duty conduits to AS/NZS 2053.2 or AS/NZS 1477 class PN12, except that polyethylene (PE) pipes to AS/NZS 4130 may be used where ducts are installed by trenchless technology.

Ducts shall be impervious to water, smooth on the inside and chemically inert.

13.1.1 Duct entries

Duct entries into pits or other structures shall be provided with bellmouths. Alternatively, type-approved cable entry systems may be provided at duct entries.

13.2 Minimum duct diameter

The internal diameter of a duct shall at a minimum comply with the following:

- 1.7 times the cable diameter for a duct containing a single cable
- 3 times the cable diameter for a duct with up to 3 cables in the duct
- 3.5 times the cable diameter for a duct with 4 cables in the duct

Small ducts and clearances may be used with approval of the design and cable installation methodology by the appropriate design authority.

13.3 Provision of spare ducts

Spare ducts shall be provided for future use.

The minimum number of spare ducts for each high voltage circuit shall be 30% of the total number of ducts occupied by cables of the circuit, with at least one for each circuit. Where a pilot wire cable is installed for the circuit, a separate spare duct shall be provided for the pilot wire cable.

The minimum number of spare ducts for 1500 V dc cables shall be 30% of the total number of ducts occupied by 1500 V dc positive and negative cables, with at least one spare duct.

Spare ducts shall be sealed with type-approved sealers.

Ducts shall be allocated such that spare ducts are at or above the levels of ducts containing cables of the same circuit.
13.4 Arrangement of ducts in a trench

Ducts shall be embedded in 14:1 sand cement mix.

The sand cement mix shall provide bedding at the bottom and across the entire width of the trench in order to achieve the following:

- the distance between the bottom of the trench and the bottom of ducts is 100 mm minimum
- the thickness of the sand cement mix above the top of ducts is 100 mm minimum
- the outermost edge of ducts is located at a distance of at least 75 mm from the side of the trench

Cable protection covers shall be placed immediately above the bedding.

On top of the cable protection covers natural backfill may be used. Outside of the rail corridor, the top of the trench shall be restored in accordance with the requirements of the controlling authority of the area.

Ducts shall be arranged with a minimum separation of 50 mm. Spacers shall be provided to maintain the arrangement of the duct bank along the cable route.

Appropriate conduit bends shall be used to ensure that the minimum cable bending radius is not exceeded.

13.5 Ducts installed by trenchless technology

Where ducts are installed by trenchless technology, the voids between ducts shall be filled with pumpable slurry.

Where an encasing pipe is used, the void between the encasing pipe and the bored hole shall be filled with pumpable slurry.

Details of the pumpable slurry shall be specified by the designer after consideration of the thermal and mechanical strength requirements of the installation.

The ducts shall be of sufficient strength to withstand the heat from the curing of the slurry.

Ducts shall be arranged with a minimum separation of 50 mm.

Spacers and suitable restraining devices shall be provided to maintain the arrangement of the duct bank along the cable route.

Ducts shall be installed with a minimum depth of 1.0 m.

Cable protection covers and warning marker tapes are not required for cable installations using trenchless technology.

Trenchless technology shall not be used for areas with reduced depth of installation.
Where trenchless technology is used, the following shall be complied with:

- the selected technology shall provide for accurate location recording of the underground installation
- a geographical investigation shall be done in accordance with Australasian Society for Trenchless Technology Guidelines for Horizontal Drilling, Pipe Bursting, Microtunnelling and Pipe Jacking

### 13.6 Undertrack crossings

Undertrack crossings shall comply with the requirements of AS 4799 and ESC 540 Service Installations within the Rail Corridor. Track monitoring shall comply with SPC 207 Track Monitoring Requirements for Undertrack Excavation.

Metallic encasing pipe and metal reinforced concrete encasing pipe shall not be used within one kilometre of electrified areas.

The voids between ducts within the encasing pipe and between the encasing pipe and the bored hole shall be filled with pumpable slurry.

The ducts shall be of sufficient strength to withstand the heat from the curing of the slurry.

Details of the pumpable slurry shall be specified by the designer after consideration of the thermal and mechanical strength requirements of the installation.

Spacers and suitable restraining devices shall be provided to maintain the arrangement of the ducts through the undertrack crossing.

Illustrations of typical undertrack crossing duct arrangements within an encasing pipe are provided in Appendix A.

### 14. As-built design documentation

The location and installation configuration of underground cables shall be surveyed and recorded in accordance with EP 20 00 04 06 SP Underground Cable – Location Recording.

The records shall be included in the as-built design documentation of the project.
Appendix A – Typical installation configurations

The figures provided below are illustrations of typical underground installations for high voltage and 1500 V dc cables.

Figure 1 - Typical direct laid configuration with single cable
Figure 2 - Typical direct laid configuration with multiple 1500 V dc negative cables

Figure 3 - Typical direct laid configuration with cables of different circuits run in parallel
Figure 4 - Typical direct laid configuration with cables crossing

Figure 5 - Typical duct laid configuration
Figure 6 - Typical cross section of a 16 duct, bored undertrack crossing

Figure 7 - Typical cross section of a five duct, bored undertrack crossing