

Railway Signalling Cables





Engineering Standard

Rail Commissioner

SG4-DOC-000455

Document Control

Document Status

Document Owner: Director, Asset Management			
Action	Name	Signature	Date
Prepared By:	Name: Philip Keany Title: Signals Inspector		7/09/2016
Reviewed By:	Name: Kevin Johnson Title: Team Leader Communications Engineering		8/19/2016
	Name: Oluwole Odusanya Title: Team Leader Signals Engineering		08/19/2016
Approved By:	Name: Mayank Jain Title: Unit Manager Signals and Communications Engineering		12/19/2016
Document Review Schedule: This document is due for review every 5 years or as required.			

Document Amendment Record

Revision	Change Description	Date	Prepared	Reviewed	Approved
1	Initial Issue	September 2016	Philip Keany	Kevin Johnson Oluwole Odusanya	Mayank Jain

TABLE OF CONTENTS

1. Introduction.....	6
2. Purpose	6
3. Scope.....	6
4. Related Documents	6
5. References	6
6. Acronyms	6
7. Definitions	7
8. Types of cables.....	7
9. General requirements.....	7
9.1. Environmental conditions	7
9.2. Suitability of use	7
9.3. Marking on cables	8
9.4. Cable drums.....	9
9.4.1. Labelling.....	9
10. Testing.....	10
11. Test certificates	11
12. Manufacturers quality accreditation.....	11
13. Warranty guarantee	11
14. Power Cables	12
14.1. Construction of the Cable	12
14.2. Conductors.....	12
14.3. Core Insulation	13
14.4. Sheath.....	13
14.5. Identification	13
15. Multi Core Signalling Cables.....	13
15.1. Construction of the Cable	13
15.2. Conductors.....	14
15.3. Core Insulation	14
15.4. Sheath.....	14
15.5. Nylon Covering.....	14
15.6. Outer Sacrificial Sheath.....	15
15.7. Length	15
15.8. Identification and Marking of Cable.....	15
15.9. Identification of cores.....	15
15.10. Marking on Drums	15
16. Twisted Pair Cables.....	15

16.1. Conductors.....	15
16.2. Wire Insulation.....	16
16.3. Sheath.....	16
16.4. Identification.....	16
17. Traction Bonding Cables	16
17.1. Conductors.....	16
17.2. Sheath.....	17
17.3. Identification.....	17
18. Track Connection Cables.....	17
18.1. Construction.....	17
18.2. Conductors.....	17
18.3. Insulation.....	18
18.4. Reels.....	18
18.5. Identification.....	18
19. Quad Axle Counter Cables.....	18
19.1. Conductors.....	18
19.2. Core Insulation.....	18
19.3. Screen.....	19
19.4. Sheath.....	19
19.5. Identification.....	19
20. Internal Cabling	19
20.1. Conductor.....	19
20.2. Core Insulation (Type 2 Conductors).....	19
20.3. Identification (Type 1 & Type 2 Conductors).....	20
21. SSI Data Cables	20
21.1. Conductors.....	20
21.2. Core Insulation.....	20
21.3. Moisture Barrier.....	20
21.4. Sheath.....	20
21.5. Identification.....	20
21.6. Electrical Characteristics.....	20
22. Optical Fibre Cables	21
22.1. Identification.....	23
23. Non Optical Communication Cables	23
23.1. General cable route - Direct Buried.....	23
23.1.1. Moisture Barrier.....	24
23.2. General cable route - Installed inside conduit.....	24
23.2.1. Moisture Barrier.....	24

23.3. Transmission and signalling limits 24

23.4. Factory Testing..... 24

 23.4.1. Dielectric Strength..... 24

 23.4.2. Insulation Resistance 24

 23.4.3. Mutual Capacitance and Capacitance Unbalance 24

 23.4.4. Installed Capacitance Unbalance 25

APPENDIX – Cable characteristics.....26

1. Introduction

The Department of Planning, Transport and Infrastructure (DPTI) owns, operates and maintains the Adelaide Metropolitan Passenger Rail Network (AMPRN). This standard forms part of the engineering management system used to ensure safety and customer service levels are efficiently and effectively supported. This standard also provides minimum requirements for signalling cables to minimize the risk of asset failures and of harm to personnel working with, or in the vicinity of, signalling cables.

2. Purpose

The purpose of this standard is to specify the requirements for designing, procuring and storing signalling cables on the AMPRN.

3. Scope

This standard applies to all signalling cables used on the AMPRN.

4. Related Documents

DOCUMENT NAME	DOCUMENT NUMBER
Pit and Conduit Standard for Signalling and Communication Cables	PTS-MS-10-SG-STD-00000094

5. References

- AS/CA S008:2010 Requirements for customer cabling products
- AS 1125:2001 – Conductors in insulated electric cables and flexible cords
- AS1660.1:1998 – Test methods for electric cables, cords and Conductors and Metallic Components
- AS/NZS 2857:1996 – Timber drums for insulated electric cables and bare conductors
- AS/NZS 3808:2000 – Insulating and sheathing materials for electric cables
- AS/NZS 5000.1:2003 – Electric Cables – Polymeric insulated – For working voltages up to and including 0.6/1 (1.2) kV
- AS 5000.3 – Polymeric insulated – Multicore control cables
- AS/RISSB 7663:2012 – Railway Infrastructure - Signal Cables
- AS 1049.1-2014: Telecommunication Cables – Insulation, Sheath and Jacket – Materials.
- AS/NZS ISO 9001:2008 : Quality Management Systems - Requirements
- BR 1932 – Twin data link type polyethylene insulated and polyethylene sheathed cable for railway signalling (Network Rail UK)

6. Acronyms

ACRONYM	FULL NAME
AC	Alternating Current
AMPRN	Adelaide Metropolitan Passenger Rail Network
ARS	Adelaide Railway Station
DC	Direct Current
DPTI	Department of Planning, Transport and Infrastructure
MPM	Multi-Processor Module
NATA	National Association of Testing Authorities
OCC	Operations Control Centre
SASD	Safety and Services Division
PVC	Poly Vinyl Chloride, a type of insulating material
RISSB	Railway Industry Safety and Standards Board

SSI	Solid State Interlocking
TFM	Trackside Function Module
UL	Underwriters Laboratories
UV	Ultraviolet

7. Definitions

TERM	DEFINITION
Cable	An insulated conductor within a conductive sleeve covered by an insulating sheath. The conductor and sleeve form the two conductors of the one circuit.
Core of cable	The conductor with its insulation but not including any protective covering.
Cable Pair	Two conductors within a cable that are twisted throughout the length of the cable.
Manufacturer	An entity that makes and assembles signalling cable.
Non-Hygroscopic	Applied to a material, means that the material, after being preconditioned in an oven for 24 ± 1 h at 50°C and allowed to cool in a desiccator, does not absorb more than 5 percent by weight of moisture during a 48h treatment in humidity of 95 percent at a temperature of 20 ± 5°C.
Signalling System	A system which provides a means of safety regulating the movement of trains on a railway through the use of appropriate technology.
Solid State Interlocking (SSI)	A first generation processor based system for controlling the interlocking between points and signals, as well as communication with line side signalling functions using a high integrity microprocessor based technology both for the central interlocking (multi-processor module – MPM) and for the trackside controls (trackside function modules – TFM's)

8. Types of cables

Signalling cables cover a diverse range of applications and installation environments. This standard considers the following generic types:

1. Power cables (external)
2. Multi - core cables (external)
3. Twisted pair cables (external)
4. Traction bonding cables
5. Track connection cables
6. High frequency track circuit cables
7. Quad axle counter cables
8. Internal cabling
9. SSI data cables
10. Fibre optic data cables
11. Communication cables

9. General requirements

9.1. Environmental conditions

Signalling cables shall be suitable for the following environmental conditions:

1. Relative Humidity up to 100%.
2. Total immersion in water, acidic solutions with low concentration, salty media.
3. Exposure to toxic materials, dirt, dust, grease, oil, hazardous gases that may be found within the railway corridor.
4. Abrasion as a result of vibration and shock.
5. Temperature range of -10°C to +90°C.
6. Direct exposure to UV radiation.

9.2. Suitability of use

Signalling cables are required for normal railway use at the following nominal potential:-

- 660V AC unearthed
- 110V AC unearthed
- 50V DC unearthed
- 24V DC unearthed

Conditions for normal use are as follows:

1. Cables suitable for outdoor use:
 - Laid directly in the ground, ash ballast or concrete at the side of and under the railway tracks without protective covering of any kind.
 - Laid in PVC under-ground conduit at the side of and under railway tracks.
 - Laid in galvanised steel, PVC or concrete ducts.
 - Exposed direct to atmospheric conditions at rail level or at the tops of poles where it will be joined to aerial cables.
 - Subjected to acids and salts which may be present in concrete structures and soils.
 - Subjected to insect attack (termites in particular)
2. Cables suitable for indoor use:
 - Laid indoors in steel cable trays, concrete or PVC ducts.
 - Exposed to atmospheric conditions including indirect sunlight and the various substances present in industrial and seaside areas.
3. Cables suitable for laying directly on the ground:
 - Subjected to vibration from passage of trains and mechanical abrasion due to dragging equipment, movement of personnel, tools, material, equipment including rubber tired mobile machinery, etc.
 - Subjected to oils and fuels from trains and trackside equipment.
 - Subjected to insecticides and herbicides from trackside spraying.
 - Subjected to temperature rise due to the sun heating the rock ballast.

9.3. Marking on cables

Cables shall be identified on their outer sheath with information at 500mm intervals in characters not less than 3mm high. On cables less than 6mm in diameter the supplier shall indicate the height of lettering that can be applied. Lettering shall be not less than 1.8mm in height.

The information shall include:-

1. Manufacturer's name or identifying initials.
2. Year of manufacture.
3. The type and size of cable.
4. The inscription "RAILWAY – SIGNALS"

In addition to the above, cables shall be marked at 1000 mm intervals on the outermost sheath or covering of the cable with the progressive length starting from the inner end on the drum.

Length marking shall be in a contrasting colour to the outer sheath colour and numerals shall be 5mm in height.

On cables less than 9mm in overall diameter the progressive length marking is not required unless otherwise requested.

Marking on cables may be waived in emergency situations with approval from DPTI Signals Engineering

9.4. Cable drums

Use of cable drums is an acceptable method for protecting signalling cables in transit or storage. Cable drums shall be constructed in a manner that minimizes:

1. the occupational safety risk during handling;
2. the risk of damage to the cable; and
3. the risk of damage to the drum.

Signalling cables shall be transported and stored on wooden cable drums conforming to AS/NZS 2857:1996 *Timber drums for insulated electric cables and bare conductors*.

It shall also comply with the requirements listed below:

1. Cable drum width shall not exceed 1000mm.
2. Cable drum diameter shall not exceed 1800mm.
3. Cable drums shall be marked with a distinctive arrow on each side of the drum indicating the direction in which the drum must be rotated when being rolled from one location to another.
4. Cable shall be tightly coiled on the drum to prevent movement of the coils during transport and handling.
5. Cable ends shall be secured to prevent movement of the coils during transport and handling.
6. Timber battens shall be secured around the drum perimeter, in accordance with AS/NZS 2857:1996 *Timber drums for insulated electric cables and bare conductors*.
7. As an alternative to timber battens, on drums of diameter less than 750mm and width less than 500mm, a corrugated polypropylene continuous sheet with one steel strap shall be used.
8. On drums of width less than 900mm and of gross weight less than 1 tonne, two steel straps shall be provided.
9. On drums of width greater than 900mm or of gross weight greater than 1 tonne, three steel straps shall be provided.
10. A minimum of 500mm of the inner length of cable shall be brought out and firmly clamped to facilitate testing, and this end shall be carefully protected from damage during transport and handling.
11. The cable outer end shall be firmly clamped in position, and the position clearly marked on the drum.
12. The cable ends shall be protected to prevent the ingress of moisture to the cable.
13. Cable drum gross weight shall not exceed 2.1 tonne.
14. DPTI - Signals Engineering shall approve the packaging arrangements for smaller sizes of signalling cables and wires that may be suitable for shrink-wrapped spools.
15. Any alternative means of transportation or storage shall be approved by the DPTI - Signals Engineering.

9.4.1. Labelling

Identification of cable stored on cable drums ensures efficient material management and identification of the correct type.

Every reel of cable shall have the following information clearly and indelibly marked on its side; nail on tags shall not be permitted. Printed weatherproof labels as approved by the DPTI - Signals Engineering may be used.

These shall be stapled to the drum using staples that do not penetrate completely through the flange of the drum and shall include the following information:

1. The type of cable, type of insulation and description of constructed layers of the cable.
2. The number of cores or pairs
3. The size of the conductor(s).
4. The conductor material.
5. Length of cable.
6. Manufacturer name.
7. Manufacture date.
8. The phrase "Railway – Signals".
9. Drum weight.
10. Rated Voltage
11. A specific number that allows the cable to be tracked through the manufacturing process and tested by the supplier.
12. A unique number to identify it easily and track its usage from a cable register (Which will track where it is used and how much)

The information on the cable drum shall not fade.

10. Testing

The manufacturer shall perform type tests in accordance with AS/NZS 5001:2005 *Electric Cables – Polymeric insulated – For working voltages up to and including 0.6/1 (1.2) kV*, AS 1660.1:1998 *Test methods for electric cables, cords and conductors* and AS/CA S008:2010 *Requirements for customer cabling products*, on samples of insulation material, and insulated core and sheath material as applicable. Type test certificates from a NATA or equivalent laboratory approved for such tests must be available.

10.1. Conductor tests

Conductors shall meet the requirements of AS 1125:2001 *Conductors in insulated electric cables and flexible cords*. The resistance of each conductor shall be recorded.

10.2. Insulation tests

Insulation shall meet the requirements of AS/NZS 3808:2000 *Insulating and sheathing materials for electric cables*. Insulation resistance shall be recorded between:

- cores
- cores and screen / shield
- cores and earth (if applicable)
- screen / shield and earth (if applicable)
- pairs (if applicable)

10.3. Sheath tests

Sheaths shall meet the requirements of AS/NZS 3808:2000 *Insulating and sheathing materials for electric cables*.

10.4. Spark tests

Spark tests (as applicable) shall be performed on:

- insulated cores
- separation layers
- sheath over metallic layers

To pass the test, there shall be no breakdown of insulation.

10.5. High voltage tests

High voltage tests shall be performed in accordance with the requirements of AS/NZS 5001:2005 *Electric Cables – Polymeric insulated – For working voltages up to and including 0.6/1 (1.2) kV*. To pass the test, there shall be no breakdown of insulation.

11. Test certificates

Each drum of cable shall be delivered with a test certificate attached. Copies of all test certificates shall be sent to DPTI the purchaser.

Test certificates shall include at least the details shown below:

- test certificate number and cable identification drum number
- description of the cable
- relevant DPTI / Contractors order number and company works codes
- conductors resistance tested (or corrected) at 20°C
- high voltage test and duration
- spark test on cores
- insulation resistance as applicable:
 1. between cores
 2. between cores and earth
 3. between pairs (if applicable)
- core numbering test (for multi-conductor cables)

In the case of optical fibre cable, the test certificates shall include, as a minimum, the details shown below:

- test certificate number and cable identification drum number
- description of the cable
- relevant DPTI / Contractors order number and company works codes
- overall end-to-end loss of the cable

12. Manufacturers quality accreditation

The Manufacturer shall be quality accredited to produce cables under a Quality Assurance system which addressed the requirements of AS/NZS ISO 9001:2008, or a recognised equivalent.

A nominated DPTI - Signals Engineering representative shall have such access to the works of the Manufacturer as is reasonable and necessary to determine the quality of the material and workmanship and to audit the Manufacturers Quality System.

Manufacturers shall supply the representative with complete details of the cable offered. Any component of the cable not mentioned in the specification shall be fully detailed regarding type, composition, dimensions, tolerances and minimum thickness of materials used.

13. Warranty guarantee

The manufacturer shall guarantee that the insulation resistance when measured with an insulation tester with applied voltage of 500V DC shall be not less than the values indicated below.

Cable type	Insulation Resistance @ 20°C			
	Core-Core or wire-wire (MOhm.Km)	Core-Earth or wire-earth (MOhm.Km)	Core-Screen* (MOhm.Km)	Screen*-Earth (MOhm.Km)
Multi-conductor				
New Cables	60	60	60	5
After 10 Years	40	40	40	2
Single conductor				
New cables		10	5*	5*
After 10 years		5	2*	2*

* - Whenever applicable (either the shield or screen).

The manufacturer shall guarantee that the cable meets this requirement for a period of 10 years from dispatch of the cable. Where the insulation resistance of the materials used is temperature dependent the manufacturer shall indicate the temperature correction required to convert measured readings to a standardized reading at 20°C.

The manufacturer shall undertake to replace at his expense any length which fails to withstand these tests or give satisfactory service during the period. This obligation does not extend to cable which has been subject to misuse, negligence, or accident after delivery.

Manufacturers shall indicate their agreement to guarantee the cable for 10 years against damage by ants and termites; or otherwise the period they will guarantee the cable against such an attack.

14. Power Cables

14.1. Construction of the Cable

Power cable specifications will vary according to their application. The requirements listed in this section are limited to single core double insulation (SDI) or 2-core 0.6/1kV applications, typically used for local signalling power distribution on voltages up to 650V AC.

The 2-core cable shall be constructed of conductors individually insulated with PVC laid up in an outer PVC sheath. The 2-core cable shall be assembled into a flat or circular configuration from two individually insulated cores.

The cores of the two (2) core cable shall be identified by the colour of the insulation. One (1) core having black insulation and the second (2) core having red insulation.

14.2. Conductors

Each conductor must be continuous, without weld, splice or joint throughout its entire length and shall comply with AS/RISSB 7663:2012 *Railway Infrastructure - Signal Cables* – Section 2.3.1.

Conductor Size
7/0.85 mm
7/1.04 mm
7/1.35 mm
7/1.70 mm
19/1.35 mm
19/1.53 mm
19/1.78 mm

Conductors shall be soft drawn standard annealed copper wire conforming to AS 1125 *Conductors in insulated electric cables and flexible cords*.

14.3. Core Insulation

Each core shall be insulated to a minimum of V-90 PVC, conforming to AS/NZS 5000.1:2005 (an alternative is X-90 polyolefin).

To minimise the risk of error in connecting the cable the following shall apply:

- for single core cables, the core insulation shall be coloured black or red;
- for 2-core cables, the insulation on one core shall be coloured red, the other shall be coloured black

14.4. Sheath

A 5V-90 PVC inner concentric sheath shall be provided, conforming to AS/NZS 5000.1:2005. The sheath should be coloured black.

A nylon jacket shall be supplied to provide an insect resistant barrier for the cable sheath. The nylon jacket shall be type 11 or type 12 nylon, applied smoothly, closely and evenly over the sheath.

A 5V-90 PVC outer concentric sheath shall be provided, conforming to AS/NZS 5000.1:2005. The sacrificial outer sheath shall be coloured orange.

14.5. Identification

In addition to the requirements of Section 9.3 within this document, the power cable shall be identified with the following information:

- the phrase "Signalling Power",
- the number, size and stranding of conductors.

15. Multi Core Signalling Cables

Multi-Core cable specifications will vary according to their application. The requirements listed in this section are limited to non-twisted pair and non-fire safe applications, typically used for external trackside circuitry in non-CBI applications.

15.1. Construction of the Cable

These multi-core cables shall be used on voltages up to 110V AC.

The cable shall be constructed of conductors individually insulated with PVC laid up in a PVC sheath covered with a nylon covering and outer PVC sacrificial sheath. The number and size of conductors specific to DPTI are tabulated in Table 1.

AS/RISSB 7663:2012 Section 2.4.1 contains other conductor configurations suitable for use on the AMPRN.

No jute, fabric, fibrous or hygroscopic material shall be used.

Except in the case of a single core (if any) placed in the centre, the cores shall be laid up helically into a tight cylindrical form, with a length of lay such as to ensure good construction. Adjacent layers shall alternate in lay direction and the length of lay shall differ by at least 15mm. The distinctively numbered cores shall be laid-up sequentially starting from the centre of the cable and the numbering in all layers shall be in the same rotational sequence.

The 10+2 core shall be manufactured of a centre pair of 7/1.70 mm conductors around which the remaining ten (10) 7/0.85 mm conductors shall be laid concentrically with a length of lay to produce a compact and symmetrical cable.

The 10+2 core shall be manufactured of a centre pair of 7/1.70 mm conductors around which the remaining ten (10) 7/0.50 mm conductors shall be laid concentrically with a length of lay to produce a compact and symmetrical cable.

Any necessary filling shall consist of soft black PVC or any non-hygroscopic material as approved by DPTI - Signals Engineering.

An inert tape shall be bound around the outer layer of the conductors for physical separation from the sheath and to hold the conductors in position and the cable circular.

15.2. Conductors

Each conductor shall be un-tinned, soft drawn annealed copper wire to *AS 1125:2001 Conductors in insulated electric cables and flexible cords*.

Each conductor must be continuous, without weld, splice or joint throughout its entire length. The size of conductors is tabulated in Table 1.

Table 1

No. Cores	Conductor Size
2+10	7/1.70mm+7/0.85mm
2+10	7/1.70mm+7/0.50mm
8	7/0.85mm
8	7/0.5
6	7/0.85
4	7/0.85

15.3. Core Insulation

Each core shall be insulated with V-90 PVC, in accordance with *AS/NZS 5000.1:2005* (an alternative is X-90 polyolefin). The insulation on each core shall be coloured natural or white.

Each core shall be identified in accordance with, *AS/NZS 5000.3:2003* with core numbering starting from "one" and with black identification letters.

15.4. Sheath

A 5V-90 PVC concentric sheath shall be provided, in accordance with *AS/NZS 5000.1:2005*.

The sheath should be coloured black.

15.5. Nylon Covering

A nylon jacket shall be supplied to provide an insect resistant barrier for the cable sheath. The nylon jacket shall have the following features:

- be coloured black;
- be type 11 or type 12 nylon;
- be applied smoothly, closely and evenly over the sheath.
- The minimum radial thickness of the sacrificial sheath should be 1mm.
- The sacrificial outer sheath shall be coloured black.

15.6. Outer Sacrificial Sheath

The nylon covering is to be covered with an outer sacrificial sheath coloured black of 5V – 90 PVC for mechanical protection of the nylon. The radial thickness of the sheath shall not be less than 1 mm at any point and as per *AS/NZS 5001:2005 Electric Cables – Polymeric insulated – For working voltages up to and including 0.6/1 (1.2) kV*.

15.7. Length

The nominal length shall be:

1. 1000 meters for cables up to and including 20 conductors (excluding 10+2 core cable)
2. 500 meters for 10+2 core cables and cables larger than 25 conductors.

The nominal tolerance shall be +/- 10 meters for all sizes.

15.8. Identification and Marking of Cable

In addition to the requirements of Section 9.3 within this document, the multi-core cable shall be identified with the following information:

- the phrase "Signalling Multi",
- the conductor size and stranding;
- the number of cores.

15.9. Identification of cores

In all other cables the cores shall be indelibly marked every 50 mm throughout the entire length of the cable in both numerals and words. The cores shall be consecutively numbered, starting from the centre of the cable in the inner layer with number "one 1" and finishing at the outer layer. The numbering in each layer shall always be in the same rotational sequence. The numbers and words shall be greater than 2.0 mm in height, coloured black and clearly legible.

15.10. Marking on Drums

Marking on drums shall be done as per Section 9.4 within this document.

16. Twisted Pair Cables**16.1. Conductors**

Specific communication cables for DPTI - Signals Engineering see Section 23

For twisted-pair cables, the acceptable number of conductors is:

- 2
- 4
- 6
- 8
- 12
- 24

Acceptable conductor sizes and strands shall be not less than:

- 1/1.38mm
- 7/0.5mm

The preferred conductor size and strands should be 7/0.5mm.

Conductors shall be plain annealed copper, conforming to *AS1125:2001*

The preferred conductor shall be plain annealed copper, conforming to *AS 1125:2001*.

16.2. Wire Insulation

Each wire shall be insulated with V-90 PVC, in accordance with *AS/NZS5000.1:2005* (an alternative is X-90 polyolefin).

The Manager Signals Engineering shall document the minimum required insulation thickness.

Each pair shall be uniquely numbered, starting from "1", with 2mm high text.

Additionally, each pair should be uniquely numbered, starting from "one", with 2mm high text.

For multi-core twisted pair cables the following shall apply:

- For every pair, one wire's insulation shall be coloured natural or white, the other black; the black wire shall be numbered in white numbers, the other core in black numbers.
- For other twisted pair cables, the Manager Signals Engineering shall document the identification colours for the pairs.

16.3. Sheath

A 5V-90 PVC concentric sheath shall be provided, in accordance with *AS/NZS5000.1:2005*.

The sheath should be coloured black.

A nylon jacket shall be supplied to provide an insect resistant barrier for the cable sheath.

The nylon jacket shall have the following features:

- be coloured black;
- be type 11 or type 12 nylon;
- be applied smoothly, closely and evenly over the sheath.

A sacrificial outer sheath can protect the cable's nylon jacket during installation.

The cable shall be supplied with a PVC sacrificial outer sheath, conforming to *AS/NZS5000.3:2003*.

The sacrificial outer sheath shall be coloured black.

16.4. Identification

In addition to the requirements of Section 9.3 within this document, the twisted pair cable shall be identified with the following information:

- the phrase "Signalling Multi – Twisted Pair",
- the conductor size and stranding,
- the number of pairs.

17. Traction Bonding Cables

In addition to the requirements of section 9.1, traction bonding cables shall withstand direct exposure to UV radiation.

17.1. Conductors

Acceptable conductor sizes shall be limited to:

- 608/0.5mm Copper,
- 962/0.5mm Copper,

925/0.5mm Aluminium,
1525/0.5mm Aluminium.

Copper Traction Bonding Cables shall:
be annealed and un-tinned;
have no non-metallic material present in the conductor;
not have the strands lubricated.

17.2. Sheath

As specified in *AS/RISSEB 7663:2012 Signalling Cables – Section 2.6.3*, the insulation and the conductor shall be separated by a “Mylar” barrier tape wound on the conductor.

The sheath shall be coloured orange.

Copper Traction Bonding Cables insulating material shall have the following properties:

- Type HD-90-CSP insulation, or equivalent;
- Conform to AS5000 mechanical requirements.

Aluminium Traction Bonding Cables insulating material shall have the following properties:

- Type R-90-CSP insulation or equivalent;
- Conform to AS5000 mechanical requirements.

17.3. Identification

In addition to the requirements of Section 9.3 within this document, the traction bonding cable shall be identified with the following information:

- the phrase “Traction Bonding”,

18. Track Connection Cables

This cable shall consist of a single flexible multi-strand UV stabilised conductor with insulation rated at 0.6/1kV. This cable is generally referred to as Welding Cable in the electrical industry. The cable is required for electrical connections between individual rails of railway lines and terminal and terminal points clear of the track and will carry control circuit current for the detection of trains and trams and the consequent operation of the signalling system.

18.1. Construction

Cable shall be constructed to ensure the greatest possible protection against abrasion and penetration due to dragging equipment, movement of personnel tools, material and equipment and the use of track maintenance equipment.

18.2. Conductors

Specific cable for DPTI - Signals Engineering

The conductor shall be flexible plain annealed copper wire stranding in accordance with *AS1125:2001*. The size of the conductors shall be 1121/0.20 mm. The nominal cross section area per core shall be 35 mm²

The conductor shall be flexible plain annealed copper wire stranding in accordance with *AS1125:2001*. The size of the conductors shall be 513/0.20 mm. The nominal cross section area per core shall be 16 mm²

18.3. Insulation

Specific cable for DPTI - Signals Engineering

- 35mm² track cable
 - The radial thickness of the insulation shall be 1.1 mm and the thickness of the sheath shall be 1.5 mm. The insulating material used shall be PVC complying with AS 3808 - V90 HT and AS/NZS 5000.
 - The sheath shall be Nitrile – Butadiene – PVC Copolymer.
 - It shall be UV stable and highly flexible.
- 16mm² track cable
 - The radial thickness of the insulation shall be 1.0 mm and the thickness of the sheath shall be 1.3 mm. The insulating material used shall be PVC complying with AS 3808 - V90 HT and AS/NZS 5000.
 - The sheath shall be Nitrile – Butadiene – PVC Copolymer.
 - It shall be UV stable and highly flexible.

18.4. Reels

The cable shall be delivered in lengths of 100 meters.

The reels shall be of sturdy construction and shall protect the cable in transit.

18.5. Identification

Specific cable for DPTI - Signals Engineering

The cable outer sheath is coloured orange or black; these specific cables do not have the phrase "Track Connection" marked on the sheaths, this cable is a multipurpose cable used for industry and not specifically made for railway.

In addition to the requirements of Section 9.3 within this document, the track cable may be identified with the following information:

- the phrase "Track Connection".

This phrase "Track Connection" can be omitted from this cable as it is not specifically made for railways.

19. Quad Axle Counter Cables

In addition to the requirements of section 9.1, quad axle counter cables shall withstand direct exposure to UV radiation.

19.1. Conductors

Acceptable conductor sizes shall be limited to:

7/0.5mm.

Quad Axle Counter Cables shall be constructed from plain annealed copper conforming to AS1125:2001.

Quad Axle Counter Cable conductors are arranged in a star-quad construction.

19.2. Core Insulation

The insulation on each conductor shall have the following properties:

- V90 PVC (an alternative is X-90 polyolefin), conform to *AS1049.1-2014*.

- Within the star quad construction, one pair shall have one conductor insulation coloured blue, the other conductor insulation coloured white.
- Within the star quad construction, one pair shall have one conductor insulation coloured black, the other conductor insulation coloured red.

19.3. Screen

A flexible metal tape or braided screen with a drain wire shall be incorporated, conforming to *AS/CA S008:2010*.

19.4. Sheath

A 5V-90 PVC concentric inner sheath shall be provided, in accordance with *AS/NZS5000.1:2005*.

A nylon jacket shall be supplied to provide an insect resistant barrier for the cable sheath. The nylon jacket shall have the following features:

- be coloured black;
- be type 11 or type 12 nylon
- be applied smoothly, closely and evenly over the sheath

A sacrificial outer sheath is provided to protect the cable's nylon jacket during installation.

The cable shall be supplied with a PVC sacrificial outer sheath, conforming to *AS/NZS5000.3:2003*.

The outer sheath shall be coloured either: black, or blue.

19.5. Identification

In addition to the requirements of Section 9.3 within this document, the quad axle counter cable shall be identified with the following information:

- the phrase "Quad AxleC", or "AS/RISSB 7663 Quad AxleC"..

20. Internal Cabling

This single conductor cable shall be used on voltages up to 110 V.A.C.

This cable shall consist of a single flexible multi-strand conductor double insulated with an inner insulation of polythene and an outer insulation of PVC

20.1. Conductor

The conductor shall be made up of twenty four (24) strands of 0.2 mm (0.75 mm²) tinned annealed copper wires.

20.2. Core Insulation (Type 2 Conductors)

- The insulation shall be a minimum of V-90 PVC in accordance with *AS/NZS5000.1:2005* (an alternative is X-90 polyolefin).
- The insulation shall be formulated to minimize the potential for plasticiser to seep out from the cable ends.
- The colour of the insulation shall be black.
- The sheath shall be a minimum of V-90 PVC.
- The colour of the sheath shall be black.
- A sacrificial outer sheath can protect the cable's nylon jacket during installation.
- The cable should be supplied with a PVC sacrificial outer sheath, conforming to *AS/NZS5000.3:2003*.

20.3. Identification (Type 1 & Type 2 Conductors)

In addition to the requirements of Section 9.3 within this document, the internal cabling shall be identified with the following information:

- the phrase "Internal", or "AS/RISSB 7663 Internal"

21. SSI Data Cables

Solid State Interlocking (SSI) Data Cable is used exclusively for forming data link connections with Solid State Interlocking configurations.

SSI Data Cables shall be generally in accordance with *BR 1932 Specification for Twin data link type polyethylene insulated and polyethylene sheathed cable for railway signalling*.

- SSI Data Cables shall as a minimum comply with *AS/CA S008:2010 Requirements for customer cabling products*

SSI Data Cables shall be a twin (one pair) cable.

21.1. Conductors

The conductors shall be 1.27mm plain annealed copper conforming to *AS1125:2001*.

The conductors shall be paired with a lay length of 150mm

21.2. Core Insulation

- Each core shall be insulated with V105 PVC, in accordance with *AS1049.1-2014*
- The insulation on one core shall be coloured red; the other shall be coloured blue.
- The pair insulation shall be polypropylene UL style 1589.
- The pair insulation shall have a minimum average diameter of 7mm.

21.3. Moisture Barrier

- The pair shall be enclosed with a helically wrapped aluminium / polyester tape.
- The tape shall have a minimum average thickness of 0.35mm, comprising an aluminium layer of nominal thickness 0.15mm.

21.4. Sheath

- A V-105 PVC outer sheath shall be provided, in accordance with *AS/NZS5000.1:2005*.
- The outer sheath shall be coloured black.
- A nylon jacket shall be supplied to provide an insect resistant barrier for the cable sheath.
- The nylon jacket shall have the following features:
 - be type 11 or type 12 nylon;
 - be applied smoothly, closely and evenly over the sheath
- The nylon jacket shall be coloured black.
- A sacrificial outer sheath can protect the cable's nylon jacket during installation.
- The cable should be supplied with a PVC sacrificial outer sheath, conforming to *AS/NZS5000.3:2003*.

21.5. Identification

In addition to the requirements of Section 9.3 within this document, the SSI data cable shall be identified with the following information:

- the phrase "SSI Data", or "AS/RISSB 7663 SSI Data".

21.6. Electrical Characteristics

- Characteristic impedance of 100ohms + 10% at 10 MHz.
- Nominal Capacitance: 100 pF/m.

- Conductor resistance: maximum average 14 ohms/km at 20°C.
- Capacitance between each conductor and moisture barrier shall be balanced within 4p/Fm.

22. Optical Fibre Cables

Fibres within the cable shall meet the requirements below:

- The fibre attributes of the cable shall comply with ITU-T G.652 D
- The cable shall not contain any metallic material
- The cable shall contain insect and rodent resistant layers.

The cable shall be supplied according to the general requirements specified in the following table:

Table 2

Manufacturing Standards	All components forming the completed cable shall be manufactured and tested to the applicable Australian and/or international standards generally accepted for the manufacture of comparable cables supplied for telecommunications use, except where specifically modified or excluded by the requirements of this Technical Specification.
General Requirements	The cable design, construction processes and materials used shall be such that the requirements of this Specification should be capable of being met for an anticipated service installation life of at least 25 (twenty-five) years, when the cable is installed in the Rail environment and in accordance with the installation practices recommended by the manufacturer.
Installed Cable Temperature Range	-10°C to +60°C
Optical Fibre Attenuation	The attenuation of the coated optical fibre at the nominated wavelengths shall not vary from the value measured at 20°C over the Installed Cable Temperature Range.
Attenuation Degradation of any fibre due to mechanical stress from expansion / contraction of the cable	Shall not be greater than 3% referred to the attenuation measured at 20°C.
Quality	Manufacturers and suppliers of cable shall have a Quality Assurance system covering the design, manufacture and supply of telecommunications cables. The Quality Assurance system shall be accredited to AS/NZS ISO9001 by an internationally recognised Quality Accreditation Agency.
Length	No joints on drum.

Cable Identification	<p>Each cable shall contain the following minimum information on the Label:</p> <ul style="list-style-type: none"> • Unique cable identification number (to be able to identify the manufacturer, the purchase order, batch, drum, cable type and number) • Manufacturer Name • Date of Manufacture • Cable Part Number • Cable Type and number of Cores • The word "COMMUNICATIONS" • The name of the end user "DPTI" <p>Cable Length markers commencing at 000 at the inner end of the cable as drummed at 1m spacing</p> <p>Standards compliance e.g. AS/CA S008:2010, and for LSZH the relevant fire rating standards.</p> <p>Information shall be indelibly marked onto the outer sheath of the cable with letters not less than 3mm at intervals not exceeding 1m in contrasting colour to the sheath.</p>
Cable Drums	<p>Shall be supplied coiled on drums in accordance with AS/NZS 2857:1996.</p> <p>Inner and outer end shall be easily accessible and identifiable for testing purposes. Enough length shall be easily accessible for stripping and termination.</p>

Single Mode Optic Fibre (SMOF) shall be manufactured and supplied to the SMOF Electrical & Mechanical Specification as identified in the following table:

Table 3

Manufacturer	Corning (or Similar)			
Type	<p>SMOF</p> <p>The optic fibre cable shall support operation at 1310, 1550 and 1625 nm.</p>			
Compliance	Conform to ITU-T Recommendation G652.D and Appendices except where modified within this Specification.			
Performance Requirements	Attenuation, Chromatic Dispersion and Polarisation Mode Dispersion in accordance with ITU-T Recommendation G652.D.			
Average Attenuation (dB/km)	1310 nm	0.36	1550 nm	0.22
Maximum Attenuation in any Drum Length (dB/km)	1310 nm	0.40	1550 nm	0.30
Chromatic Dispersion Maximum in any Drum Length (ps/km/nm)	1310 nm	6	1550 nm	17
Polarisation Mode Dispersion (ps/km-2)	0.20			

Maximum Link Design Value PMDQ		
Optical Fibre Colour	As per as per AS/CA S009:2013 Table B.7.	
Number of fibres per tube	6 for cables of 48 cores or less. 12 for cables with core count greater than 48	
Tube Colour	As per as per AS/CA S009:2013 Table B.7.	
Minimum Bend Radius	No Load	To be specified by supplier
	Full Load	To be specified by supplier
Nominal Outside Diameter	To be specified by supplier	
Approximate Cable Mass	200 kg/km or less	
Crush Resistance	Long Term	Not Less than 1kN/100 mm
	Short Term	Not Less than 2kN/100 mm
Central Strength Member	To be specified by supplier, non-metallic.	
Fibre Stress Relief	Loose Tube design with non-metallic central strength member and Tubing Gel.	
Moisture Exclusion	Manufactured to prevent ingress and/longitudinal flow of moisture through the cable for the installed environment.	
Core Wrapping	A helical wrap shall be applied over the cable core assembly.	
	Nominal Thickness	25 microns
	Nominal Overlap	20%
Rip Cords	The cable shall contain at least one ripcord under each sheath for easy sheath removal.	
Insect Resistant Layer	To be specified by supplier	
Rodent Resistant Layer	To be specified by supplier	
Primary Outer Sheath	High Density Polyethylene over the cable core in accordance with AS 1049.1-2014.	
	To be specified by supplier	
Low Smoke Halogen Free/ Low smoke Zero Halogen (LSZH)	Specific lengths of cable may be required for use in environments such as tunnels.	
	These lengths of cables shall be manufactured with an additional LSZH sheath.	

Current data sheets for fibre utilised on Seaford line can be provided by DPTI - Signals Engineering

22.1. Identification

Surface printing includes sequential marking at one-meter intervals.

23. Non Optical Communication Cables

23.1. General cable route - Direct Buried

The main cable shall consist of polythene insulated 1.27mm diameter copper conductors with moisture barrier, polythene sheath, galvanised tape armoured overlapped and PVC

outer sheath suitable for direct burial generally in accordance with *AS1049.1-2014*. Local cables shall be of identical construction but provided with 0.9mm diameter copper conductors and unarmoured.

23.1.1. Moisture Barrier

The moisture barrier shall consist of a polythene / aluminium laminate longitudinally lapped or a suitable compound filling as approved by DPTI - Signals Engineering between the insulated conductor spaces. Where compound filling is used this shall not cause premature ageing of the conductor insulation.

23.2. General cable route - Installed inside conduit

The main cable shall consist of polythene insulated 1.27mm diameter copper conductors with moisture barrier, polythene sheath, galvanised tape armoured overlapped and PVC outer sheath suitable for direct burial generally in accordance with *AS1049.1-2014*. Local cables shall be of identical construction but provided with 0.9mm diameter copper conductors and unarmoured.

23.2.1. Moisture Barrier

The moisture barrier shall consist of a hard jacketed combined Nylon bonded to Polyethylene longitudinally lapped or a suitable compound filling as approved by DPTI - Signals Engineering between the insulated conductor spaces. Where compound filling is used this shall not cause premature ageing of the conductor insulation.

23.3. Transmission and signalling limits

The transmission and signalling limits for individual circuits are respectively an attenuation loss of 10dB at 1600 Hz and a loop resistance of 1000 ohms not including terminating devices. The circuits shall be loaded as required to meet these limits.

23.4. Factory Testing

The cable lengths shall be factory tested in accordance with the following:

23.4.1. Dielectric Strength

High voltage tests on each cable length shall be carried out as follows:

Wire to all other wires	5 kV DC
Outer sheath to screen	14 kV DC

23.4.2. Insulation Resistance

Insulation resistance tests shall be made with not less than 500V DC.

Insulation resistance of each conductor in the cable measured with all other conductors joined together to the metallic screen if provided and earth shall not be less than 16,000 mega-ohm/km after electrification for one minute at not less than 20°C.

23.4.3. Mutual Capacitance and Capacitance Unbalance

The mutual capacitance and capacitance unbalance shall be measured at a frequency of 1kHz. All conductors other than those under test shall be connected to the metallic shield/moisture barrier if provided. The number of pairs to be tested shall be 20 per cent of the total or twenty pairs, whichever is the greater except where otherwise specified. In every length of cable the average mutual capacitance of pairs shall lie within 44nF/km + 4 per cent for main type and within 44 to 52nF/km for local types.

The deviation of each reading of mutual capacitance from the average shall not exceed 8 per cent for each length.

The measured capacitance unbalance are to be corrected as follows, lengths less than 100m to be considered as 100m.

Pair-Pair: The measured values to be divided by

$$\frac{1}{2} \left(\frac{L}{500} + \sqrt{\frac{L}{500}} \right)$$

Pair-Earth: The measured values to be divided by

$$\frac{L}{500}$$

Where L is the length of the cable under test in metres.

Capacitance unbalance measured in picofarads for each 500m length should not exceed:

Table 4

	Main		Local	
	Average	Max	Average	Max
Between pairs in same quad	30	100	125	750
Between any pair and earth	120	500	200	750
Between pairs in different quads	20	100	-	125

23.4.4. Installed Capacitance Unbalance

Pair capacitance unbalance for loaded sections shall not be greater than 300 pF. This shall be accomplished by cable balancing if necessary.

Table 5 - Typical Communication Cable types installed.

No. Pairs	Conductor Size
36 pair	0.9
30 pair	0.9
20 pair	0.9
12 pair	1.27
10 pair	7/0.32
6 pair	0.9
2 pair	1.27

APPENDIX – CABLE CHARACTERISTICS

CABLE CHARACTERISTICS									
	Cable	Nominal Thickness	Nominal Thickness	Nominal Thickness	Nominal Overall	Maximum Conductor	AS1125:2001 Nominal	Mutual Capacitance	Characteristic Impedance
		Insulation (mm)	Sheath (mm)	Nylon (mm)	Diameter (mm)	Resistance (Ω/km)	Resistance (Ω/km)	(pF/m at 10kHz)	(Ω at 10Mhz)
1	Power Cables (External), 1core, 7/0.85mm	1.0	1.4	0.3	8.1 ± 0.2	6.0	4.61	-	-
2	Power Cables (External), 2 core, 7/0.85mm	1.0	1.4, 1.4	0.3	16.3 ± 0.4	6.0	4.61	-	-
3	Power Cables (External), 1core, 7/1.70mm	1.0	1.4	0.3	10.6 ± 0.3	1.5	1.15	-	-
4	Power Cables (External), 2 core, 7/1.70mm	1.0	1.4, 1.4	0.4	21.6 ± 0.6	1.5	1.15	-	-
5	Power Cables (External), 1core, 19/1.78mm	1.4	1.4	0.3	15.2 ± 0.4	0.495	0.387	-	-
6	Power Cables (External), 2 core, 19/1.78mm	1.0	1.4, 1.4	0.4	30.3	0.495	0.387	-	-
7	Multi-Core Cables (External), 6core, 7/0.5mm	0.8	2.0, 3.0	0.4	21.2 ± 0.6	-	-	-	-
8	Multi-Core Cables (External), 15core, 7/0.5mm	0.8	2.0, 3.0	0.4	26.5 ± 0.7	-	-	-	-
9	Multi-Core Cables (External), 25core, 7/0.5mm	0.8	2.0, 3.0	0.5	30.6 ± 0.9	-	-	-	-
10	Multi-Core Cables (External), 50core, 7/0.5mm	0.8	2.0, 3.0	0.5	37.5 ± 1.1	-	-	-	-
11	Twisted Pair Cables (External)	-	-	0.5 ± 0.1	-	-	-	-	-
12	Traction Bonding Cables, 608/0.5mm	3.5 minimum	-	-	-	0.22	-	-	-
13	Traction Bonding Cables, 962/0.5mm	3.5 minimum	-	-	-	0.16	-	-	-
14	Traction Bonding Cables, 925/0.5mm	3.5 minimum	-	-	26.8 ± 0.7	0.205	-	-	-
15	Traction Bonding Cables, 1525/0.5mm	3.5 minimum	-	-	32.3 ± 0.7	0.124	-	-	-
16	Track Connection Cables, 84/0.3mm	3.5 minimum	-	-	-	3.0	-	-	-
17	Track Connection Cables, 7/19/0.26mm	ASC81	-	-	-	28.0 ± 1.5	-	-	-
18	High Frequency Track Circuit Cables	0.8	2.0 ± 0.3	0.5 ± 0.1	-	-	-	-	-
19	Quad Axle Counter Cables	-	-	0.2	-	-	-	-	-
20	Internal Cabling, 7/0.4mm	0.7	-	0.15 (+0.15, -0.05)	2.9	-	-	-	-
21	Internal Cabling, 24/0.20mm	0.5 minimum	0.4 minimum	-	2.95 ± 0.15	-	-	-	-
22	Internal Cabling, 32/0.20mm	0.8 minimum	2.0 minimum	-	2.95 ± 0.15	-	-	-	-

23	SSI Data Cables	0.8	5.0	0.5	19.0	14.0	-	≤ 55	100 ± 10
24	Composite barrier gate cable 7/1.70mm+7/0.85mm	1.0mm (minimum)	1.8mm (minimum)	0.5mm	33.3mm	DC 1.15. AC 1.3999			
25	Composite point machine cable 7/1.70mm+7/0.50mm	1.0mm (minimum)	1.8mm (minimum)	0.5mm	30.5mm	DC 1.15. AC 1.3999			
26	Multi-Core Cables 8core, 7/0.85mm	1.0mm (minimum)	1.8mm (minimum)	0.5mm	25.1mm	DC 4.61. AC 5.606			
27	Multi-Core Cables 8core, 7/0.50mm	1.0mm (minimum)	1.8mm (minimum)	0.5mm					
28	Multi-Core Cables 6core, 7/0.85mm	1.0mm (minimum)	1.8mm (minimum)	0.5mm	23.8mm	DC 4.61. AC 5.606			
29	Multi-Core Cables 4core, 7/0.85mm	1.0mm (minimum)	1.8mm (minimum)	0.5mm					
30	35mm track cable	1.1mm	1.5mm	-	13.6mm	DC 0.536			
31	16mm track cable	1.0mm	1.3mm	-	10.3mm	DC 1.16			