# Master Specification
# Part RD-ITS-C3

## Telecommunications Cabling

**September 2024**

Government of South Australia
Department for Infrastructure and Transport

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# Document Information

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| 1 | Clarifications to local area network cable/port testing requirements in section 5.3.2. | 05/07/2024 |
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# Document Management

# Contents

# RD-ITS-C3 Telecommunications Cabling

## 1 General

a) This Master Specification Part sets out the requirements for the design, supply, installation, and testing of telecommunications cabling used for intelligent transport systems (ITS) including:

i) the documentation requirements, as set out in section 2;

ii) the requirements for the supply of telecommunications cabling, as set out in section 3;

iii) the requirements for the installation of telecommunications cabling, as set out in section 4;

iv) the testing and commissioning requirements, as set out in section 5;

v) the signal grounding system requirements, as set out in section 6;

vi) the cable labelling system requirements, as set out in section 7;

vii) the cable schedule requirements, as set out in section 8; and

viii) the Hold Point requirements, as set out in section 9.

b) Without limiting the Contractor's obligation to comply with the Contract Documents, the Contractor must ensure that the design, supply, installation, and testing of telecommunications cabling for ITS also complies with:

i) RD-EL-C3 "Supply and Installation of Conduits and Pits";

ii) RD-ITS-S1 "General Requirements for the Supply of ITS Equipment";

iii) RD-ITS-C1 "Installation and Integration of ITS Equipment"; and

iv) PC-CN1 "Testing and Commissioning".

c) This Master Specification Part applies to all telecommunications cabling used for ITS together with all supporting systems including PMCS networks and fire control systems and applies to both surface roadside environments and Tunnels.

d) The design, supply, installation and testing of telecommunications cabling for ITS must comply with the Reference Documents, including:

i) AS 1768 Lightning protection;

ii) AS/NZS 3000 Electrical installations (known as the Australian/New Zealand Wiring Rules);

iii) AS/NZS 3013 Electrical Installations - Classification of the fire and mechanical performance of wiring system elements;

iv) AS 60529 Degrees of protection provided by enclosures (IP Code);

v) AS/CA S008 Requirements for customer cabling products;

vi) AS/CA S009 Installation requirements for customer cabling (Wiring Rules);

vii) AS 11801 Information technology — Generic cabling for customer premises;

viii) AS/NZS 14763.3 Information technology - Implementation and operation of customer premises cabling, Part 3: Testing of optical fibre cabling (ISO/IEC 14763-3:2014, MOD);

ix) Department Road Design Presentation Standards (available from: https://dit.sa.gov.au/standards/standards_and_guidelines);

x) IEC 60793-2-50 Optical fibres - Part 2-50: Product specifications - Sectional specification for class B single-mode fibres;

xi) IEC 61300-3-35 Fibre optic interconnecting devices and passive components - basic test and measurement procedures: Examinations and measurements - visual inspection of fibre optic connectors and fibre-stub transceivers;

xii) AS 11801 Information technology — Generic cabling for customer premises;

xiii) ISO/IEC 14763-3 Information technology - Implementation and operation of customer premises cabling - Part 3: Testing of optical fibre cabling;

xiv) ITU-T G.650.3 Test methods for installed single-mode optical fibre cable links;

xv) ITU-T G.651.1 Characteristics of a 50/125 µm multimode graded index optical fibre cable for the optical access network;

xvi) ITU-T G.652 Characteristics of a single-mode optical fibre and cable;

xvii) ITU-T-Recommendation L.36 Series L: Single-mode fibre optic connectors - construction, installation and protection of cables and other elements of outside plant; and

xviii) Telecommunications Cabling Provider Rules 2014 (made by the Australian Communications and Media Authority under subsection 421(1) of the *Telecommunications Act 1997* (Cth)).

# 2 Documentation

## 2.1 Design Documentation

In addition to the requirements of PC-EDM1 “Design Management”, the Design Documentation must:

a) comply with the requirements of the following standards:

i) AS 11801 Information technology — Generic cabling for customer premises; and

ii) ISO/IEC 14763-3 Information technology - Implementation and operation of customer premises cabling - Part 3: Testing of optical fibre cabling; and

b) include a cable installation and labelling plan as a part of the Detailed Design which complies with the requirements of sections 7 and 8.

## 2.2 Construction Documentation

In addition to the requirements of PC-CN3 “Construction Management”, the Construction Documentation must also include:

a) quality assurance documentation from the manufacturer of the cable, patch cord or pigtail as evidence of conformance with the requirements of section 3.3.5b)i);

b) details of additional connector colour coding as required by section 3.3.5b)ii);

c) evidence of ACMA cabling registration for telecommunications cabling installers and supervisors as required by section 4.1c);

d) locations of remake loops, as required by section 4.2d); and

e) test equipment calibration certificates, as required by section 5.1b)ii).

## 2.3 Quality Management Records

In addition to the requirements of PC-QA1 “Quality Management Requirements” or PC-QA2 “Quality Management Requirements for Major Projects” (as applicable), the Quality Management Records must include:

a) the ACMA TCA1 Forms, as required by section 5.1d);

b) all records relevant to the telecommunications cabling, as required by RD-ITS-S1 “General Requirements for the Supply of ITS Equipment”;

c) drawings, diagrams, and circuits of the actual telecommunications cabling installation which must comply with the Department Road Design Presentation Standards, including DP018 Intelligent Transport System (ITS); and

d) the location of all remake loops, including the pits containing remake loops being labelled as such in the As-Built Records.

# 3 Telecommunications cabling

## 3.1 General

The Contractor must ensure that:

a) all cables are installed in accordance with manufacturer’s requirements, including ensuring that:

i) the maximum draw strain is not exceeded;

ii) the minimum bending radius is not exceeded at any time;

iii) the maximum vertical rise of the cable is not exceeded in the design or during installation; and

iv) where vertical cables require permanent support, that such support is included in the installation;

b) all telecommunications cabling to be installed in Tunnels and in any other situation required by applicable Laws, are of the low smoke zero halogen (LSZH) type cable compliant with AS/NZS 3013 Electrical Installations - Classification of the fire and mechanical performance of wiring system elements;

c) all cables used for ITS to be installed in locations where they will be normally exposed to sunlight have a UV stable outer jacket;

d) all cables potentially subject to long term immersion in ground water (e.g. cables installed within underground conduits) are of the gel filled or water blocked type;

e) multi-core optical fibre trunk cables use colour coded tubed internal bundle construction;

f) all fibre optic cables feature a central straining member to enable the cables to be drawn into conduits without damage to the internal cores or bundles;

g) all cable outer sheaths are of a material that is resistant to attack by rodents, vermin or insects; and

h) each fibre bundle and core carries permanent identification marking or colour coding.

## 3.2 Twisted - pair copper cables

### 3.2.1 General

The Contractor must ensure that twisted pair copper cables forming part of the telecommunications cabling used for ITS comply with the requirements of this section 3.2.

### 3.2.2 Local area network cables

The Contractor must ensure that cables intended for local area networks comply with the following requirements:

a) the cables must be of balanced, twisted pair construction (shielded or unshielded);

b) the cables must comply with the requirements of:

i) AS/CA S008 Requirements for customer cabling products; and

ii) AS 11801 Information technology — Generic cabling for customer premises;

c) for network connections up to a speed of 1 Gbps, the cables must be certified to a minimum of category 6;

d) for network connections at speeds greater than 1 Gbps, the cables must be certified to a minimum of category 6A;

e) the cables must terminate in:

i) purpose-designed break-out enclosures; or

ii) patch panels using insulation displacement connector terminations rated to the same category as the cable;

f) the cables must be terminated at both ends using the 568A standard pin-out;

g) where installed via underground conduit networks all network cables must be gel filled or water blocked;

h) where installed within a road Tunnel environment (whether within underground conduit or on cable tray or ladder) then cables must be gel filled or water blocked and must be of LSZH construction compliant with AS/NZS 3013 Electrical Installations - Classification of the fire and mechanical performance of wiring system elements; and

i) standard cables must not be used in either roadside or Tunnel environments where long term immersion in ground water is likely.

### 3.2.3 Patch panels - local area network cables

The Contractor must ensure that the patch panels used to terminate local area network cables in accordance with section 3.2.2e)ii) comply with the following requirements:

a) the patch panels must be suitable for the type and number of cables and cores being terminated;

b) the patch panels must have a means of positively securing and supporting the cables such that no strain is placed on the terminations either:

i) during installation;

ii) after installation; or

iii) during maintenance operations;

c) patch cables must not be routed across cabinet door hinge points;

d) for network connections up to a speed of 1 Gbps, the patch panel connectors must be certified to a minimum of category 6;

e) for network connections at speeds greater than 1 Gbps, the patch panel connectors must be certified to a minimum of category 6A; and

f) all patch panel ports must be clearly labelled:

i) using indelible labels appropriate for both the patch panel and the installation environment, such that the purpose for or service connected to each port can be clearly identified; and

ii) adopting a labelling legend that:

A. complies with the Principal's labelling standards (refer Appendix 1: Cable labelling example); and

B. must be included on the cable schedule as required by section 8.

### 3.2.4 Coaxial cables - radio frequency (RF) applications

The Contractor must ensure that co-axial cables for RF applications comply with the following requirements:

a) the coaxial cables must have a characteristic impedance (Zo) to match the Zo of the connected equipment;

b) the coaxial cables must have a minimum shield coverage of 98%;

c) the coaxial cables must be selected to minimise losses at the operating frequency; and

d) the coaxial cables must have an ambient air operating temperature range of -15ºC to +55ºC.

### 3.2.5 Coaxial cable connectors

The Contractor must ensure that co-axial cable connectors comply with the following requirements:

a) coaxial cable connectors must be of a type designed for the cable being terminated;

b) coaxial cable connectors must have a return loss of greater than 26 dB;

c) coaxial cable connectors must have a characteristic impedance matching the cable;

d) coaxial cable connectors must be installed to the cable in accordance with the manufacturer's instructions, using the manufacturer's recommended tools; and

e) where coaxial connectors or cables are placed in adverse environmental conditions, the coaxial cable connectors must be selected and treated in accordance with Best Industry Practice to ensure protection against expected environmental conditions.

### 3.2.6 Serial data cables

The Contractor must ensure that:

a) cables used for RS422 or RS485 serial data connections have the following characteristics:

   i) be of shielded, twisted pair construction;

   ii) minimum shield coverage of 95%;

   iii) characteristic impedance (Zo) of 120 Ω; and

   iv) attenuation (dB/30 m) <= 0.600 dB at 1 MHz;

b) RS232 serial connections are only used if they are for connections between equipment located within the same equipment rack or enclosure;

c) cables used for RS232 serial data connections comply with the following requirements:

   i) the cables must be factory manufactured;

   ii) the cables must be of shielded construction;

   iii) the cables must use:

      A. moulded connectors; and

      B. strain relief;

   iv) connectors must match the port they are plugged into, including:

      A. being of the correct gender; and

      B. having the correct number and layout of pins;

   v) adaptors (e.g. 9-pin to 25-pin) or "gender changers" must not be used;

   vi) the cables must have all necessary pins connected through end-to-end; and

   vii) if "Null Modem" cables are required, then they must be clearly labelled as such;

d) where installed in underground conduits (within either Tunnels or the roadside environment) cables must be gel filled or water blocked; and

e) where utilised within Tunnels, cables:

i) are gel filled or water blocked;

ii) feature LSZH flame resistant construction compliant with AS/NZS 3013 Electrical Installations - Classification of the fire and mechanical performance of wiring system elements; and

iii) include vermin and insect repellent sheathing material.

### 3.2.7 Copper communications cable joints

a) Subject to section 3.2.7b), the Contractor must not use joints in copper communication cables.

b) Where joints in copper communication cables are necessary and no other alternative exists, the Contractor must ensure that the copper communication joints comply with the following requirements:

i) the joints must be located within a communications pit;

ii) the joints must be suitable for underground installation;

iii) only joints or connectors appropriate for the cable type may be used;

iv) the joints must be housed in suitable, re-enterable joint enclosures rated to a minimum IP rating of IP67 in accordance with the requirements of AS 60529 Degrees of protection provided by enclosures (IP Code);

v) the joints must be purpose-made and installed in accordance with the manufacturer's instructions; and

vi) only non-corroding fittings and fasteners may be used in the enclosures required by section 3.2.7b)iv).

c) The Contractor must ensure that all copper communications cable jointing works are performed by personnel suitably trained and experienced in such jointing techniques.

## 3.3 Optical fibre data communications cables

### 3.3.1 General

a) The Contractor must ensure that optical fibre cables forming part of the telecommunications network used for ITS telecommunications purposes comply with the requirements of this section 3.3.

b) The Contractor must ensure that:

i) single mode optical fibre (SMOF) cable is used for all new installations; and

ii) multi-mode fibre is only used when extending existing multi-mode installations, where the existing multi-mode installations are not being replaced.

### 3.3.2 Single-mode cable

The Contractor must ensure that all SMOF cables satisfy the following requirements:

a) the cables must be non-armoured;

b) the cables must be type OS2 and conform to the requirements of:

i) ITU-T G.652 Characteristics of a single-mode optical fibre and cable; and

ii) IEC 60793-2-50 Optical fibres - Part 2-50: Product specifications - Sectional specification for class B single-mode fibres;

c) the cables must have the following characteristics:

i) core diameter of 9 μm;

ii) cladding diameter of 125 μm;

iii) coating diameter of 250 μm;

iv) maximum attenuation per kilometre at 1 310 nm optical frequency must be 0.4 dB/km; and

v) maximum attenuation per kilometre at 1 550 nm optical frequency must be 0.3 dB/km;

d) fibres must be enclosed by a silicone composite resin material enclosed within colour coded loose tubes formed around a non-metallic central strength member;

e) solid polyethylene fillers must form part of the cable to produce a circular cable and each fibre within a tube must be individually coloured in accordance with the requirements of AS/CA S008 Requirements for customer cabling products; and

f) outer sheaths must be vermin and insect resistant and LSZH where utilised within Tunnels.

### 3.3.3 Multi-mode cable

The Contractor must ensure that all multi-mode optical fibre cables satisfy the following requirements:

a) the cables must be non-armoured;

b) the cables must be type OM3 and conform to the requirements of ITU-T G.651.1 Characteristics of a 50/125 μm multimode graded index optical fibre cable for the optical access network;

c) the cables must have the following characteristics:

i) core diameter of 50 ± 3 μm;

ii) cladding diameter of 125 ± 2 μm graded index; and

iii) coating diameter of 250 μm;

d) fibres must be embedded within a silicone composite resin material and mechanically enclosed within colour-coded loose tubes formed around a central strength member;

e) solid polyethylene fillers must form part of the cable to produce a circular cable and each fibre within a tube must be individually colour coded in accordance with the requirements of AS/CA S008 Requirements for customer cabling products; and

f) the cables must have the following signal transmission characteristics:

i) maximum attenuation of 3.5 dB/km at 850 nm;

ii) maximum attenuation of 1.0 dB/km at 1 310 nm;

iii) not less than 500 MHz transmission bandwidth at 850 nm;

iv) not less than 500 MHz transmission bandwidth at 1 310 nm; and

v) numerical aperture 0.2 ± 0.015.

### 3.3.4 Fibre optic break out trays

The Contractor must ensure that all fibre optic break out trays (FOBOTs) meet the following requirements:

a) the FOBOTs must be 19” rack mounted within appropriate equipment cabinets (refer TUN-ME-DC4 “Tunnel Equipment Cabinets” and RD-ITS-S3 “ITS Enclosures”);

b) where 19” rack mount facilities are not available, the FOBOTs must be:

i) DIN rail mount; or

ii) surface mount,

as appropriate for the relevant enclosure;

c) the FOBOTs must only use SC/AP connectors;

d) the FOBOTs must provide for sufficient clearance from the SC/AP connectors to all other surfaces (including cabinet doors) to ensure that patch cables connecting to the FOBOT are not improperly bent, stressed or damaged;

e) the FOBOTs must be:

i) suitable for housing fusion splices;

ii) suitable for loose tube and riser cable installation;

iii) protected against entry of vermin (i.e. “vermin-proof”), including providing for rear or side cable entry as appropriate; and

iv) be appropriately installed in the enclosure or cabinet to ensure that fibre can be installed in compliance with its minimum bending radius;

f) all connectors or ports on the FOBOTs must be clearly labelled using a labelling system appropriate for the FOBOTs and the installation environment such that the purpose for, or service connected to, each port is clearly identified; and

g) the labelling legends required by section 3.3.4f) must:

i) comply with the labelling specifications detailed in section 7; and

ii) be included on the splicing schedule required by section 8b).

### 3.3.5 Optical fibre connectors and pigtails

a) The Contractor must ensure that all fibre optic connectors and pigtails meet the following requirements:

i) optical fibre pigtails terminating optical fibre cables entering equipment enclosures must not be directly connected to equipment;

ii) all incoming and outgoing optical fibres must be terminated in appropriate FOBOTs in accordance with section 3.3.4;

iii) optical fibre connectors on patch cables and connectors to FOBOTs must be guaranteed for a minimum of 500 operations (connect / disconnect cycles);

iv) optical fibre connectors on patch cables and connectors to FOBOTs must meet or exceed the performance standards specified in ITU-T-Recommendation L.36 Single-mode fibre optic connectors - construction, installation and protection of cables and other elements of outside plant;

v) all unused female optical fibre connectors on patch cables and connectors to FOBOTs must have dust caps fitted;

vi) optical fibre connectors on patch cables and connectors to FOBOTs must be colour coded according to the type of connector end-face finish as follows:

A. angle physical contact connectors must have a green body;

B. physical contact connectors must have a blue body;

C. additional colour coding must be in accordance with the requirements of Telcordia GR-326 as set out in Appendix 1 of ITU-T Rec L.36 Single-mode fibre optic connectors - construction, installation and protection of cables and other elements of outside plant;

D. insertion loss must be as specified in Table 9-1 of ITU-T-Recommendation L.36 Single-mode fibre optic connectors - construction, installation and protection of cables and other elements of outside plant, Grade B or Grade C; and

E. return loss must be as specified in Table 9-2 of ITU-T-Recommendation L.36 Single-mode fibre optic connectors - construction, installation and protection of cables and other elements of outside plant, Grade 1 (angle physical contact connectors) or Grade 2 (physical contact connectors).

b) The Construction Documentation must:

i) include quality assurance documentation from the manufacturer of the patch cord or pigtail as evidence of conformance with the requirements of section 3.3.5a)iv); and

ii) include details of additional colour coding adopted in accordance with section 3.3.5a)vi).

### 3.3.6 Optical fibre patch leads

The Contractor must ensure that all optical fibre patch leads meet the following requirements:

a) the optical fibre patch leads must be suitable to connect all equipment to the FOBOT; and

b) the optical fibre patch leads must:

i) be a minimum of 2 m in length;

ii) have connectors matching those in the FOBOTs and the equipment to be connected, including end finish, such as:

A. angle physical contact connectors must only be mated to angle physical contact connectors; and

B. physical contact connectors must only be mated to physical contact connectors; and

iii) the connectors required by section 3.3.6b)ii)A must comply with section 3.3.5.

### 3.3.7 Cable management

a) The Contractor must provide appropriate methods of cable management for all telecommunications cables within enclosures such that they are:

i) properly secured;

ii) neatly and properly routed; and

iii) protected from damage during normal operation and maintenance of the equipment.

b) The Contractor must ensure that there is no unsecured, loose, or poorly installed cabling within enclosures or cable management systems.

c) The Contractor must ensure that telecommunications cable separation or segregation is maintained at all times during normal operation as required by the Reference Documents, including:

i) AS/CA S009 Installation requirements for customer cabling (Wiring Rules); and

ii) AS/NZS 3000 Electrical installations (known as the Australian/New Zealand Wiring Rules).

d) Data communications cabling, whether fibre or copper, must not be installed within conduit or pit networks serving electrical power circuit cabling.

e) When installed upon mixed service cable ladders or trays, appropriate segregation barriers must be used.

f) Within buildings where fire-rated cable restraints are not required, cables must be restrained with reusable cable restraints.

### 3.3.8 Optical fibre cable joints and splices

The Contractor must ensure that all optical fibre cable joints and splices comply with the following requirements:

a) all optical fibre cable joints must:

   i) use fusion splices;

   ii) use splice protectors; and

   iii) be held in a purpose made splice organiser;

b) all optical fibre cable joints must be made in accordance with the manufacturer's instructions;

c) all optical fibre cable splices must have an insertion loss of 0.3 dB or less;

d) all optical fibre cable splicing must be carried out in accordance with the instructions of both the:

   i) cable manufacturer; and

   ii) splicer manufacturer;

e) all optical fibre splicing must be:

   i) performed by persons suitably trained and experienced in such splicing and jointing techniques; and

   ii) undertaken only by, or under the direct supervision of, a person or persons holding an ACMA cabling registration, with the appropriate endorsements for the type of works being performed;

f) individual splice attenuation must be recorded on the Contractor’s inspection and test certificate (ITC);

g) all optical fibre cable housings located in pits must:

   i) be suitable for underground installation where long-term immersion in ground water is possible;

   ii) have an openable waterproof cover seal; and

   iii) be designed and installed so as to ensure the water-tightness of the incoming cable to the splice joint enclosure body;

h) optical fibre cable splice enclosures must:

   i) not be left “free floating” in pits;

   ii) be mounted to the long side of the pit using a purpose-made bracket; and

   iii) be uniquely numbered;

i) all fittings and fastenings must be non-corrosive; and

j) fastener threads must be treated with a suitable anti-seize compound.

# 4 Installation of telecommunications cables

## 4.1 General

a) The Contractor must ensure that the installation of telecommunications cables complies with this Master Specification Part and the requirements of:

   i) RD-ITS-C1 “Installation and Integration of ITS Equipment”; and

   ii) RD-EL-C3 “Supply and Installation of Conduits and Pits”.

b) The Contractor must ensure that the installation of telecommunications cabling is undertaken only by, or under the direct supervision of, a person or persons holding an ACMA cabling registration, with the appropriate endorsements for the type of cabling being performed.

c) The Contractor must provide evidence of ACMA cabling registration for installers or supervisors as required by:

i) section 3.3.8e)ii);

ii) section 4.1b); and

iii) section 5.1c),

to the Principal as part of the Construction Documentation, prior to commencement of the relevant cabling installation work or testing (as applicable).

d) The Contractor must ensure that the installation of the telecommunications cables complies with the following:

i) telecommunications cables must be:

A. installed as a continuous run with no unnecessary joins; and

B. enclosed by conduit throughout;

ii) where only non-metallic cables (e.g. optical fibres) are installed in a conduit run (e.g. a single conduit running to an equipment cabinet) with no other metallic cables running alongside either in the same or adjacent conduits, a tracer wire must be installed in the conduit along with the non-metallic cable to facilitate future cable location;

iii) the Contractor must confirm that the conduits are suitable for cable installation prior to hauling the cable (pigged and confirmed free of construction detritus, debris and sharp edges generally);

iv) the Contractor must provide and install a polypropylene or equivalent rot-proof draw cord of 5 kN breaking load in each conduit in parallel with cable installation;

v) the draw cord ends must be secured within the pits to which the conduit is terminated;

vi) no cables may be left exposed at the end of any work period; and

vii) in the event of any cable damage during installation, the whole of the particular length of cable concerned must be removed, replaced and re-spliced and tested prior to system commissioning.

e) Immediately following installation, all cables are identified at all jointing and termination points in accordance with the requirements of section 7:

i) for copper cables, all unused cores must be:

A. clearly identified (i.e. with cable number); and

B. terminated with each core occupying a separate terminal;

ii) for backbone optical fibre cable, all unused cores must be spliced through end to end;

iii) for optical fibre spur cables, each unused core must be coiled within a fibre splice cassette in the joint and the FOBOTs;

iv) the draw cords:

A. must not be used for hauling the cable; and

B. must only be used to pull through a purpose-made braided cable hauling rope;

v) the cable hauling rope required by section 4.1e)iv)B must be attached to the cable by the method approved by the cable manufacturer;

vi) a swivel must be attached between the cable hauling rope required by section 4.1e)iv)B and the point of attachment to the cable;

vii) cables must be hauled using a dynamic mechanical winch fitted with a clutch properly adjusted to ensure that the maximum hauling tension for the cable (as specified by the cable manufacturer) is not exceeded at any time;

viii) the hauling tension must be continuously monitored by the Contractor during the hauling operation;

ix) if the maximum hauling tension, as specified by the cable manufacturer, is exceeded:

A. the hauling must stop immediately;

B. the cable must be inspected and tested for damage; and

C. the Contractor must immediately notify the Principal of the event, the results of the inspection and testing, and the action taken to identify and rectify the cause of the excess hauling tension. The notification and provision of information to the Principal constitutes a **Hold Point**. Hauling must not recommence until this Hold Point is released;

x) bell mouths must be fitted in compliance with specification RD-EL-C3 “Supply and Installation of Conduits and Pits”, prior to the commencement of cable installation;

xi) the bell mouths required by section 4.1e)x) must remain in place after installation;

xii) cable hauling “slippers” must be used during hauling;

xiii) where intermediate pits exist in the cable route, the cable must be installed through each chamber in one operation;

xiv) cable guides must be used to support the cables in all intermediate pits;

xv) all cables must be lubricated during installation using a water based biodegradable lubricant which is specified by the cable manufacturer as being suitable for this purpose;

xvi) sufficient length of cable at each end must be allowed for correct termination at the termination location and any subsequent maintenance activities;

xvii) cable ends must be temporarily sealed using a method approved by the cable manufacturer against the ingress of moisture when termination does not proceed immediately following installation;

xviii) the bend radius for the cable, as specified by the cable manufacturer, must not be exceeded at any time; and

xix) where optical fibre breakout is required:

A. only the fibre cores to be spurred off may be jointed; and

B. all other cores must remain intact.

f) All cable and conduit entries (including spare conduits) to buildings and equipment cabinets must be sealed to prevent entry of vermin, water, dirt, and debris.

g) Cable installation must be designed to prevent the accumulation of water, dirt, and debris.

h) Where cable systems are to provide redundancy, they must be installed in geographically separated locations (i.e. separate Tunnels or separate trenches) or where such separation is not feasible as agreed by the Principal, a minimum horizontal separation of 2 m minimum must be maintained.

i) Protection against electrical transients must be provided where copper cabling is installed.

j) Where the Contract Documents specify protection against lightning strikes is required, protection against lightning strikes must be provided in accordance with AS 1768 Lightning protection.

## 4.2 Remake loops - copper cables

The Contractor must ensure that:

a) for all cables exceeding 50 m in length:

i) 5 m remake loops are provided at all joint and termination points; and

ii) additional 5 m remake loops are provided for every 500 m of cable length;

b) the remake loops required by section 4.2a) are installed in appropriately sized pits, such that;

i) the minimum bending radius of the cable is not exceeded; and

ii) sufficient cable is available for re-termination if and when required;

c) cables entering a control room or building must be provided with additional 5 m remake loops as close as practicable to the building entry; and

d) the location of all remake loops must be included in the Construction Documentation, including the pits containing remake loops being labelled as such in the Design Drawings.

## 4.3 Remake loops - fibre optic cables

The Contractor must ensure that:

a) fibre optic cables are installed with 30 m remake loops between:

i) each pair of splice joints, located as near as practical to mid-way between the splice joints;

ii) splice joints and equipment enclosures; and

iii) splice joints and building entry points;

b) remake loops are to be coiled in suitable pits of minimum P7 size, ensuring that the minimum bending radius of the cable is not exceeded; and

c) in addition to the requirements of section 4.3a), 15 m of optical fibre cable is left coiled at or near each splice joint.

# 5 Testing and commissioning

## 5.1 General

a) The testing and commissioning of telecommunications cabling used for ITS must be undertaken in accordance with the requirements of PC-CN1 “Testing and Commissioning”.

b) The Contractor must ensure that prior to testing in accordance with this section 5:

i) the correct functioning and current calibration of all test equipment is demonstrated; and

ii) copies of current calibration certificates for test equipment are provided to the Principal as part of the Construction Documentation.

c) The Contractor must ensure that testing is carried out by appropriately trained and qualified personnel who hold an ACMA cabling registration, with the appropriate endorsements for the type of testing being performed.

d) The Contractor must ensure that:

i) all test results, including the tester’s cable registration number, are submitted to the Principal within 5 days of the tests being concluded;

ii) following the completion of each package of cable installation, splicing and testing work, the installation must be certified by the tester as required by section 5.1c) as being compliant using an ACMA TCA1 Form (one for each separate package of work) within 10 Business Days of the completion of the cable installation, splicing and testing work; and

iii) each ACMA TCA1 Form completed pursuant to section 5.1d)ii), is submitted to the Principal as part of the Quality Management Records within 10 Business Days of completion of the testing.

## 5.2 Optical fibre testing

a) The Contractor must ensure that:

i) optical fibre cabling is tested in accordance with the requirements of ITU-T G.650.3 Test methods for installed single-mode optical fibre cable links;

ii) before each mating operation, optical fibre connectors are inspected, cleaned and classified in accordance with the requirements of IEC 61300-3-35 Fibre optic interconnecting devices and passive components - basic test and measurement procedures: Examinations and measurements - visual inspection of fibre optic connectors and fibre-stub transceivers;

iii) any failure or abnormality identified during cable testing is:

A. reported in accordance with section 5.2b) and as a Non-Conformance; and

B. rectified;

iv) following rectification pursuant to section 5.2a)iii)B:

A. the failed test must be repeated; and

B. sufficient testing must be undertaken to verify that no previously passed cabling has been adversely affected during rectification;

v) the completed optical fibre cable system is tested:

A. including splices and through connectors in both directions;

B. using a bidirectional optical time-domain reflectometer (OTDR) test at:

I. 1,310 nm, 1550 nm and 1,625 nm optical wavelengths for single mode fibre; or

II. 850 nm and 1,300 nm wavelengths for multi-mode fibre;

vi) all testing of optical fibre is carried out using a launch cable between the optical time-domain reflectometer and the fibre under test and a receive cable at the far end;

vii) launch cable and receive cable connectors must be matched to those of the fibre under test;

viii) testing of unconnected fibre ports or fibre cores is undertaken as permanent link tests (i.e. minus the patch cables);

ix) during equipment commissioning for fibre cores that are to be connected to equipment, channel tests for total overall insertion loss (including the patch cables that will connect to the equipment) are performed using a calibrated fibre optic power meter set for the transmission wavelength of the small form factor pluggable port or fibre port, as follows:

A. measure and record the power output from the equipment fibre port or small form factor pluggable port module;

B. inspect, clean and connect the patch cable between the equipment just tested and the specified local FOBOTs port;

C. using the same power meter, measure and record the received power output from the patch cable to be connected to the equipment at the other end of the circuit; and

D. the total insertion loss must be as specified in section 5.2a)ix);

x) once successfully tested, the patch cables must remain connected to the patch panel ports on which they have been tested and certified;

xi) all spare “dark fibre” (unspliced fibre ends) must be tested using “bare end” tests and then capped;

xii) dust caps must be refitted to all unmated connectors immediately after a successful test;

xiii) the optical time-domain reflectometer parameters are set such that the residual noise on the trace is less than 0.05 dB;

xiv) the attenuation of each fibre channel satisfies the following levels:

A. for fibre runs longer than 5 km, the attenuation must be less than 1.0 dB/km total loss including all splices, connectors, pig tails and patch leads;

B. for fibre runs shorter than 500 m, the attenuation must be less than 3 dB total loss;

C. for fibre runs between 500 m and 5 km, the attenuation must be less than the values shown in Appendix 2: Total fibre loss (dB) and slope (dB/km) for fibre spurs 500 m to 5 km; and

D. in any case, the total loss of the fibre channel must be within the link budget specifications specified in the Design Report or Contract Documents;

xv) the loss of each splice (dB) must satisfy the following levels:

A. for backbone fibres and spurs longer than 5 km, must be less than 0.3 dB per splice (bidirectional average); and

B. for fibre spurs to devices (shorter than 5 km), must be less than 0.3 dB per splice (bidirectional average);

xvi) the loss of each mated connector pair must be less than 0.5 dB per connector pair;

xvii) the return loss of each mated connected pair equal to or greater than 60 dB for each connector pair;

xviii) the cable must not have a difference between end-to-end attenuation exceeding 0.5 dB/km for any fibre core between the same 2 locations; and

xix) the following details are recorded with respect to each fibre optic test:

A. the name and, if relevant, Subcontractor details, of the person performing the tests;

B. the time and date of the test;

C. details of the cable being tested (as shown on the cable label and relevant drawings);

D. test equipment manufacturer, model, serial number, and calibration date;

E. details of launch cable (manufacturer, serial number if applicable, length, type of connectors);

F. the core number, tube, colour, patch panel number and patch panel port of each core being tested;

G. length of each fibre core under test (m);

H. attenuation of each fibre channel (noting that attenuation greater than the levels specified in this section constitutes a test fail result, which must be reported in the test);

I. loss of each splice (dB);

J. distance to each splice (m);

K. loss of each mated connector pair; and

L. return loss of each mated connector pair.

b) The Contractor must submit test results to the Principal within 5 days of the completion of testing. Submission of test results constitutes a **Hold Point**. Connection of the equipment must not take place until this Hold Point is released.

## 5.3 Copper cable testing

### 5.3.1 General

a) The Contractor must test the continuity of each core of a copper communications cable immediately following installation.

b) The Contractor must comply with the following testing requirements following completion of installation and jointing of copper communications cables:

i) continuity tests must be carried out on all copper conductors to check there are no “shorts”, “opens” or transitions;

ii) the Contractor must rectify any failures identified during the continuity testing undertaken pursuant to section 5.3.1b)i) prior to commencement of the remaining tests required by this section 5.3.1b);

iii) the loop resistance for each pair must be measured using a “GP” core identification test set (or similar) and appropriately recorded; and

iv) insulation resistance tests:

A. must be carried out using a Megger (or similar) with equipment disconnected or unplugged;

B. measurements must not be less than 10 MΩ (at 20º C) at 250 V DC after one minute; and

C. must be applied between:

I. “A” and “B” legs; and

II. “A” and “B” and earth,

respectively.

c) The Contractor must submit test results to the Principal within 5 days of completion of testing. Submission of test results constitutes a **Hold Point**. Connection of the equipment must not take place until this Hold Point is released.

d) All failures must be reported as a Non-Conformance, rectified and retested in accordance with this section 5.3.1.

### 5.3.2 Local area network cables

a) The Contractor must ensure that local area network cables are tested using a purpose-designed local area network cable analyser in accordance with the requirements of AS 11801 Information technology — Generic cabling for customer premises.

b) For cables/ports where equipment is being connected as part of the Works or Temporary Works, the Contractor must undertake channel testing to:

i) class EA (minimum), including all patch cables, for category 6 or 6A local area network cables; and

ii) class F (minimum), including all patch cables, for category 7 local area network cables.

c) Once successfully tested in accordance with section 5.3.2b), the patch cables must remain connected to the patch panel ports on which they have been tested and certified. If patch cables are disconnected and reconnected, the Contractor must repeat the tests for those patch cables and ports in accordance with section 5.3.2b).

d) For cables and ports where equipment is not being connected as part of the Works or Temporary Works, such as spare ports, the Contractor must undertake permanent link testing to:

   i) class EA (minimum) for category 6 or 6A local area network cables; and

   ii) class F (minimum) for category 7 local area network cables.

e) The Contractor must ensure that the following information is recorded for each local area network cable tested:

   i) the name and if relevant, Subcontractor details of the person performing the tests;

   ii) the time and date of the test;

   iii) details of the cable being tested (as shown on the cable label and relevant drawings);

   iv) details of the test equipment, including:

      A. manufacturer;

      B. model;

      C. serial number; and

      D. calibration date;

   v) wire map test result;

   vi) resistance (by pair);

   vii) length (by pair);

   viii) propagation delay (by pair);

   ix) delay skew (by pair);

   x) insertion loss (by pair);

   xi) return loss (by pair);

   xii) NEXT (Near End Cross Talk);

   xiii) PS-NEXT (Power Sum Near End Cross Talk);

   xiv) ACR-N (Attenuation to Cross-talk Ratio - Near End);

   xv) ACR-F (Attenuation to Cross-talk Ratio - Far End);

   xvi) PS-ACR-N (Power Sum - Attenuation to Cross-talk Ratio - Near End);

   xvii) PS-ACR-F (Power Sum - Attenuation to Cross-talk Ratio - Far End); and

   xviii) FEXT (Far End Cross Talk).

f) The Contractor must provide all test results to the Principal within 5 days of completion of testing. Submission of test results constitutes a **Hold Point**. Connection of the equipment must not take place until this Hold Point is released.

g) All failures must be reported as a Non-Conformance, rectified and retested in accordance with this section 5.3.2.

### 5.3.3 RF coaxial (antenna) cables

a) Before connecting to equipment, the RF coaxial cables must be tested using a purpose designed RF antenna analyser for:

   i) length;

   ii) Voltage standing wave ratio (VSWR);

iii) return loss; and

iv) “Distance to Fault”.

b) Testing of the RF coaxial cables must be:

i) performed with the cable terminated into a dummy load of the same characteristic impedance (Zo) as the RF coaxial cable, prior to connection of the antenna; and

ii) if an antenna is to be used, after connection of the antenna (this test is not relevant to cables used for connection of a microwave indoor unit (IDU) to an outdoor unit (ODU)).

c) The following information must be recorded for each RF coaxial cable tested (noting that attenuation greater than the levels specified in this section 5.3.3c) constitutes a test fail result, which must be reported as a Non-Conformance), rectified and retested in accordance with section 5.3.3g)):

i) the name and if relevant, Subcontractor details of the person performing the tests;

ii) the time and date of the test;

iii) details of the cable being tested (as shown on the cable label and relevant drawings);

iv) details of the test equipment, including:

A. manufacturer;

B. model;

C. serial number; and

D. calibration date;

v) cable length;

vi) overall insertion loss;

vii) VSWR or return loss when terminated into a dummy load (which must be less than 1.05:1 VSWR, which equates to return loss >32.26 dB);

viii) VSWR or return loss with antenna connected (if applicable) (to be less than 1.5:1 - return loss >14 dB at the operating frequency);

ix) insertion and return loss of all connector interfaces; and

x) screen dump or capture of the test trace if supported by the test equipment (may be printed or in electronic form).

d) If any anomalies are noted along the cable length during testing, the Contractor must ensure that:

i) the reason for the anomaly is investigated;

ii) the anomaly is rectified; and

iii) the cable retested.

e) The Contractor must replace any cable that is damaged, including:

i) crushing;

ii) pinching;

iii) over-bending or kinking; and

iv) jacket damage exposing the shield.

f) For “Leaky Coax” or other distributed antenna installations in Tunnels or building risers:

i) the Contractor must consult with the cable manufacturer regarding appropriate test methodology and accepted pass and fail criteria prior to commencement of installation and testing;

ii) the Contractor must ensure that the test records to be provided to the Principal pursuant to section 5.3.3g) include details of the cable manufacturer's advice regarding test methodology and pass and fail criteria obtained pursuant to section 5.3.3f)i); and

iii) the Contractor must ensure that all relevant tests are undertaken in accordance with the cable manufacturer's advice regarding test methodology and pass and fail criteria obtained pursuant to section 5.3.3f)i).

g) The Contractor must provide a copy of all test records to the Principal within 5 days of completion of testing. Submission of test results constitutes a **Hold Point**. Connection of equipment must not take place until this Hold Point is released.

h) All failures must be reported as a Non-Conformance, rectified and retested in accordance with this section 5.3.3.

### 5.3.4 Electronic recording and submission of test results

The Contractor must ensure that the test records required by this Master Specification Part are generated and submitted in accordance with the following requirements:

a) subject to section 5.3.4c), test records may be submitted to the Principal in electronic format, including from:

i) optical time-domain reflectometers;

ii) local area network cable analysers; and

iii) antenna analysers;

b) for local area network cable tests as required by section 5.3.2f), the Contractor must submit electronic reports and not submit hard-copy reports;

c) complete test reports generated by the test equipment and submitted as PDF files are acceptable in lieu of hard-copy reports provided that all required information (as specified in this Master Specification Part) is included in the report;

d) if the Contractor wishes to submit test results electronically pursuant to section 5.3.4c), the Contractor must provide an example of each report type to the Principal prior to commencement of testing. Submission of the proposed report type constitutes a **Hold Point**. The submission of test results electronically must not occur until this Hold Point is released; and

e) test traces saved by test equipment may be submitted as PDF documents or as images in .jpg, .bmp or .png format as a supplement to hard-copy test records.

# 6 Signal grounding system

## 6.1 General

The Contractor must:

a) provide a signal grounding system to minimise the possibility of earth currents inducing electrical noise into data, video and other sensitive circuits;

b) ensure that DC power supplies within the ITS are electrically isolated from, and not referenced to, the main supply earthing system; and

c) ensure that a 0 V connection or return current is not connected to earth potential.

## 6.2 Compliance

The Contractor must ensure that the signal grounding system provided pursuant to section 6.1 and employed at ITS communications facilities complies with the requirements of AS/CA S009 Installation requirements for customer cabling (Wiring Rules).

## 6.3 Communications earth system

a) The signal grounding system methodology implemented pursuant to section 6.1 and used for ITS telecommunications installations must be referred to as a communications earth system.

b) The Contractor must ensure that:

   i) earth cables used for the communications earth system have green with yellow banded insulation;

   ii) the communications earth system is equipotentially bonded to the protective earth system of the electrical installation; and

   iii) with respect to the communications bonding conductor:

      A. it has a minimum cross-sectional area of 6 $mm^2$;

      B. it has green with yellow banded insulation;

      C. the route is as short and as direct as possible; and

      D. the resistance of the communications bonding conductor does not exceed 0.5 Ohms.

# 7 Cable labelling system

## 7.1 Label types

The Contractor must ensure that all in-ground telecommunications cables are labelled in accordance with the following requirements:

a) the labels must use indelible labels of a type suitable for the installation environment; and

b) the labels must be affixed or secured to the cable in such a manner that they cannot be accidentally removed during normal cable handling, including during:

   i) maintenance;

   ii) termination; or

   iii) re-termination activities.

## 7.2 Label location

The Contractor must ensure that telecommunications cables are labelled at the following locations:

a) in equipment cabinets;

b) in hauling pits;

c) adjacent to joint enclosure entry ports (within 200 mm); and

d) where remake loops are stored in pits, at a point on the remake loop where it can be clearly seen without unrolling the loop.

## 7.3 Label format

The Contractor must ensure that all telecommunications cable labels comply with the following requirements:

a) telecommunications cables forming part of a network backbone must be uniquely identified using the following format:

   i) line 1: service type cable ID segment start - segment end; and

   ii) line 2: core count / cable type;

b) telecommunications cable IDs must:

   i) be the primary site (“site of origin”);

   ii) be followed by a site-unique number (for example, TMC 001); and

   iii) remain the same along the entire length of a cable, regardless of length and the number of segments;

c) spur cables running from a roadside cabinet to a device must be uniquely identified using the following format:

   i) line 1: service type cabinet ID device ID segment start - segment end; and

   ii) line 2: core count / cable type;

d) service types will be as follows:

   i) “F” for optical fibre;

   ii) “S” for serial data;

   iii) “E” for ethernet data;

   iv) “V” for coaxial cable;

   v) “R” for radio or RF; and

   vi) other prefixes or service types must be as specified in the Contract Documents;

e) information may be presented on 3 lines namely:

   i) line 1: service type start point end point;

   ii) line 2: segment start-segment end; and

   iii) line 3: core count / cable type;

f) an example of cable labelling is given in Appendix 1: Cable labelling example; and

g) the same cable designation must be used on the relevant As-Built Records as on the cable labels. Cable and device designations must be as agreed with the Principal prior to installation.

# 8 Cable schedule

a) The Contractor must produce a cable schedule to support its design showing for each telecommunications cable to be installed the following information as a minimum:

   i) cable type;

   ii) length (estimated);

   iii) cable designation (as shown in both schematic drawings and on cable the labels);

   iv) termination schedule (for RS422 or RS485 serial cables) showing pair allocation; and

   v) patch panel port allocations (for local area network cables and optical fibre cables).

b) The Contractor must prepare a splicing schedule for optical fibre cables showing all fibre core allocations (including spare cores).

c) The Contractor must submit the cable and splicing schedules to the Principal 14 Business Days prior to installation commencing which constitutes a **Hold Point**. The installation of telecommunications cable must not occur until this Hold Point is released.

# 9 Hold Points

Table RD-ITS-C3 9-1 details the review period or notification period, and type (documentation or construction quality) for each Hold Point referred to in this Master Specification Part.

**Table RD-ITS-C3 9-1 Hold Points**

| Section reference | Hold Point | Documentation or construction quality | Review period or notification period |
|---|---|---|---|
| 4.1e)ix) | Maximum hauling tension exceeded | Construction quality | 7 days notification |
| 5.2b) | Provision of optical fibre test records | Documentation | 5 Business Days review |
| 5.3.1c) | Provision of general copper communications cable test results | Documentation | 5 Business Days review |
| 5.3.2f) | Provision of local area network cable test results | Documentation | 5 Business Days review |
| 5.3.3g) | Provision of coaxial cable test results | Documentation | 5 Business Days review |
| 5.3.4d) | Provision of example electronic test reports for approval | Documentation | 2 Business Days review |
| 8c) | Provision of cable and splicing schedule | Documentation | 14 Business Days review |

# 10 Appendix 1: Cable labelling example

a) A 96 core SMOF cable running from the Northern Portal Switch Room (Adelaide-Crafers Highway) to OS199, between splice joints SJ111 and SJ222 would be labelled as follows:

   i) F NPSR 001 SJ111-SJ222; and

   ii) 96/SMOF.

b) If that backbone cable is later extended to additional sites, the cable ID of the new extension will be the same as the cable being extended.

c) The next segment between splice joints SJ222 and SJ333 would be labelled:

   i) F NPSR 001 SJ222-SJ333; and

   ii) 96/SMOF.

d) Spur cables between splice joints and devices or field cabinets (with no intervening splice joints) will be labelled similarly:

   i) F OS199 CMS051 SJ111-CMS058; and

   ii) 6/SMOF.

e) This same information may be presented on 3 lines with the start point / end point and segment start / segment end on separate lines (depending on the dimensions of the supplied labels):

   i) F NPSR 001;

   ii) SJ111-SJ222; and

   iii) 96/SMOF.

f) An RG59 type coaxial cable running from OS199 to CAM 051 would be labelled as follows:

   i) V OS199 CAM051; and

   ii) 1/RG59.

g) A Belden 9842 Shielded Twisted Pair RS485 serial cable running to a variable speed limit sign from a field cabinet would be labelled as:

   i) S OS053 VSL079; and

   ii) 4/STP.

h) A Category 6 Unshielded Twisted Pair cable used for Serial or Ethernet respectively:

   i) S OS199 CAM051;

   ii) 8/UTP CAT6;

   iii) E OS199 RAD001; and

   iv) 8/UTP CAT6.

# 11 Appendix 2: Total fibre loss (dB) and slope (dB/km) for fibre spurs 500 m to 5 km

The chart set out in Figure RD-ITS-C3 11-1 assumes the following:

a) 4 connector pairs max 0.5 dB insertion loss per pair (patch leads from FOBOT to equipment at both ends);

b) 4 splices max 0.3 dB bidirectional average loss (2 x pigtail - fibre spurs plus 2x FAP joints); and

c) max fibre loss 0.4 dB/km.

**Figure RD-ITS-C3 11-1 Total loss for fibre runs**