

Roads

Master Specification

RD-ITS-C3 Telecommunications Cabling

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RD-ITS-C3 Telecommunications Cabling

1 General

- 1.1 This Part specifies the requirements for the supply and installation of telecommunications cabling used for Intelligent Transport Systems (ITS). This Part shall be read in conjunction with the following Parts:
- a) RD-EL-C3 Supply and Installation of Conduits and Pits.
 - b) RD-ITS-S1 General Requirements for the Supply of ITS Equipment.
 - c) RD-ITS-C1 Installation and Integration of ITS Equipment.
- 1.2 The following documents are referenced in this Part:
- a) RD-EL-C3 Supply and Installation of Conduits and Pits.
 - b) RD-ITS-C1 Installation and Integration of ITS Equipment.
 - c) AS/CA S008 Requirements for customer cabling products.
 - d) AS/CA S009 Installation requirements for customer cabling (Wiring Rules).
 - e) AS3080 Information technology - Generic cabling for customer premises (ISO/IEC 11801:2011, MOD).
 - f) ITU-T G.650.3 and G.650.3 Amendment 1 (02/2011) Test methods for installed single-mode optical fibre cable links.
 - g) ITU-T G.651.1 Characteristics of a 50/125 µm multimode graded index optical fibre cable for the optical access network.
 - h) ITU-T G.652 Characteristics of a single-mode optical fibre and cable.
 - i) IEC 60793-2-50 Product specifications – Sectional specification for class B single-mode fibres.
 - j) IEC 61300-3-35 Examinations and measurements – Fibre optic cylindrical connector endface visual inspection.
 - k) ISO/IEC 11801 Information technology -- Generic cabling for customer premises.
 - l) ISO/IEC 14763-3 Information technology -- Implementation and operation of customer premises cabling -- Part 3: Testing of optical fibre cabling.

2 Supply of Telecommunications Cabling

General

- 2.1 All cables to be installed in tunnels, or any other situation required by regulations, shall be plenum-type (Low Smoke Zero Halogen (LSZH)) cable.
- 2.2 All cables to be installed where they will be normally exposed to sunlight shall have a UV stable outer jacket.

Twisted - Pair Copper Cables

LAN Cables

- 2.3 Cables intended for Local Area Networks shall:
- a) be of balanced, twisted pair construction (shielded or unshielded);
 - b) be compliant with the relevant requirements of AS/CA S008:2010 and AS/NZS 3080:2013;
 - c) for network connections up to a speed of 1Gbps, be certified to a minimum of Category 6;
 - d) for network connections at speeds greater than 1Gbps, be certified to a minimum of Category 7;

- e) be terminated in purpose-designed break-out enclosures or patch panels using Insulation Displacement Connector terminations rated to the same Category as the cable; and
- f) be terminated at both ends using the 568A standard pin-out.

Patch Panels – LAN Cables

- 2.4 Patch panels used to terminate LAN cables shall comply with the following requirements:
- a) be suitable for the type and number of cables being terminated;
 - b) have a means of positively securing and supporting the cables such that no strain is placed on the terminations either during installation, after installation or during maintenance operations;
 - c) for network connections up to a speed of 1Gbps, connectors shall be certified to a minimum of Category 6;
 - d) for network connections at speeds greater than 1Gbps, connectors shall be certified to a minimum of Category 7; and
 - e) all ports shall be clearly labelled using indelible labels appropriate for the patch panel and the installation environment, such that the purpose for or service connected to each port can be clearly identified. The labelling legends shall be agreed with the Principal and shall be included on the Cable Schedule (see section 7 “Cable Schedule”).

Coaxial Cables - Video

- 2.5 Co-axial cables for video shall comply with the following characteristics:
- a) use a solid or stranded copper centre conductor (MATV cable with a copper-clad steel centre conductor shall not be used);
 - b) for cables to be installed underground or through duct work, use a solid polyethylene dielectric. Foam dielectric cable is acceptable for indoor situations, e.g. in racks in a computer room;
 - c) minimum shield coverage of 95%;
 - d) characteristic impedance (Z_0) of 75 Ω ;
 - e) attenuation ≤ 0.33 dB/m at 1 GHz; and
 - f) environmental operating temperature range of -40°C to 80°C .

Coaxial Cable – RF

- 2.6 Co-axial cables for radio frequency applications shall comply with the following characteristics:
- a) have a characteristic impedance (Z_0) of 50 Ω (or to match the Z_0 of the connected equipment);
 - b) minimum shield coverage of 98%;
 - c) be selected to minimise losses at the operating frequency; and
 - d) environmental operating temperature range of -40°C to 80°C .

Co-axial Cable Connectors

- 2.7 Co-axial cable connectors shall comply with the following specifications:
- a) shall be of a type designed for the cable being terminated;
 - b) have a return loss of greater than 26 dB;
 - c) a characteristic impedance matching the cable;
 - d) shall be installed to the cable in accordance with the manufacturer's instructions, using the manufacturer's recommended tools; and
 - e) where coaxial connectors / cables are placed in environmental service, connections shall be selected and treated in accordance with best industry practice to ensure protection against environmental conditions.

Serial Data Cables

- 2.8 Cables used for RS422 / RS485 serial data connections shall comply with the following specifications:
- a) be of shielded, twisted pair construction;
 - b) minimum shield coverage of 95%;
 - c) characteristic impedance (Z_0) of 120 Ω ; and
 - d) attenuation (dB/30 m) \leq 0.600 dB at 1 MHz.
- 2.9 RS232 serial connections shall only be used if they are for connections between equipment located within the same equipment rack or enclosure. Cables used for RS232 serial data shall comply with the following requirements:
- a) be factory manufactured cables;
 - b) be of shielded construction;
 - c) use moulded connectors and strain relief;
 - d) use connectors of the correct gender and number of pins to match the port they are plugged into. Adaptors (e.g. 9-pin to 25-pin) or "gender changers" will not be accepted;
 - e) have all necessary pins connected through end-to-end; and
 - f) if "Null Modem" cables are required then these shall be clearly labelled as such.

Copper Communications Cable Joints

- 2.10 Copper communications cables shall only be jointed in pits if approved by the Principal. Copper communication cable shall not be joint elsewhere.
- 2.11 Copper Communications cable joints in pits shall comply with the following requirements:
- a) be suitable for underground installation;
 - b) utilise joints or connectors appropriate for the cable type;
 - c) be housed in suitable, re-enterable joint enclosures rated to a minimum of IP67 (or equivalent i.e. no ingress of water in harmful quantities with immersion up to 1 m for 30 minutes);
 - d) be purpose-made and installed in accordance with the manufacturer's instructions; and
 - e) non-corroding fittings and fasteners shall be used on enclosures and approved by the Principal prior to installation.
- 2.12 The Contractor shall be suitably trained in such jointing techniques.

Optical Fibre Cables

General

- 2.13 Single mode optical fibre cable shall be used for all new installations. Departures from this clause will only be granted in extreme cases by the Principal, where a clear benefit has been demonstrated by choosing multi-mode optical fibre and shall be approved in writing.
- 2.14 Multi-mode fibre may be used when extending existing multi-mode installations that are not being replaced.

Single-mode Cable

- 2.15 All single-mode optical fibre cables shall be non-armoured and meet the following requirements:
- a) type OS2 conforming to ITU-T Recommendation G.652.D (IEC 60793-2-50 B1.3);
 - b) core diameter – 9 μm ;
 - c) cladding diameter – 125 μm ;
 - d) coating diameter – 250 μm ;

- e) fibres shall be enclosed by a silicone or other approved composite resin material enclosed within colour coded loose tubes formed around a non-metallic central strength member. Solid polyethylene fillers shall form part of the cable to produce a circular cable and each fibre within a tube shall be individually coloured conforming to AS/CA S008:2010;
- f) maximum attenuation per kilometre at 1 310 nm optical frequency - 0.4 dB/km; and
- g) maximum attenuation per kilometre at 1 550 nm optical frequency - 0.3 dB/km.

Multi-mode Cable

2.16 All multi-mode optical fibre cables shall be non-armoured and meet the following requirements:

- a) type OM3 conforming to ITU-T Recommendation G.651.1;
- b) core diameter - $50 \pm 3 \mu\text{m}$;
- c) cladding diameter – $125 \pm 2 \mu\text{m}$ graded index;
- d) coating diameter – $250 \mu\text{m}$;
- e) fibres shall be enclosed by a silicone or other approved composite resin material enclosed within colour-coded loose tubes formed around a central strength member. Solid polyethylene fillers shall form part of the cable to produce a circular cable and each fibre within a tube shall be individually coloured;
- f) maximum attenuation of 3.5 dB/km @ 850 nm;
- g) maximum attenuation of 1.0 dB/km @ 1 310 nm;
- h) not less than 500 MHz transmission bandwidth @ 850 nm;
- i) not less than 500 MHz transmission bandwidth @ 1 310 nm; and
- j) numerical aperture 0.2 ± 0.015 .

Fibre Optic Break Out Trays (FOBOTs)

2.17 FOBOTs shall meet the following requirements:

- a) 19" Rack Mountable where 19" rack mount facilities are available, otherwise DIN rail mount or surface mount as appropriate for the Enclosure;
- b) use SC/AP connectors. Alternative connectors (e.g. LC) shall not be used unless specifically stated in Contract Documents;
- c) provide for sufficient clearance from connectors to all other surfaces (including cabinet doors) to ensure that patch cables connecting to the FOBOT are not improperly bent, stressed or damaged;
- d) suitable for housing fusion splices;
- e) suitable for loose tube and riser cable installation;
- f) protected against entry of vermin (i.e. "vermin-proof");
- g) be appropriately installed in the Enclosure / cabinet to ensure fibre can be installed in compliance with its minimum bending radius;
- h) provide for rear or side cable entry as appropriate to facilitate vermin-proof requirement (f) above; and
- i) all connectors / ports on the FOBOT shall be clearly labelled using a labelling system appropriate for the FOBOT and the installation environment such that the purpose for, or service connected to, each port is clearly identified. The labelling legends shall be agreed with the Principal prior to installation commencing and shall be included on the Splicing Schedule (refer Clause 7 "Cable Schedule").

Optical Fibre Connectors and Pigtails

2.18 Optical Fibre pigtails terminating optical fibre cables entering equipment Enclosures shall not be directly connected to equipment. The Contractor shall terminate all incoming optical fibres in

- appropriate FOBOT enclosures complying with Clause “Fibre Optic Break Out Trays (FOBOTs)” above.
- 2.19 Optical fibre connectors on patch cables and pigtails inside FOBOTs shall conform to the following specifications:
- a) be guaranteed for a minimum of 500 operations;
 - b) meet or exceed the performance standards specified in ITU-T-Rec L.36. QA documentation from the manufacturer of the patch cord or pigtail shall be accepted as evidence of conformance with this requirement;
 - c) all unused optical connectors shall have dust caps fitted;
 - d) connectors shall be colour coded according to the type of connector end-face finish; Angle Physical Contact (APC) connectors shall have a green body, Physical Contact (PC) connectors shall have a blue body. Additional colour coding (e.g. as per Telcordia GR-326 – see ITU-T Rec L.36 Appendix 1) is optional but should be defined in the As-built documentation;
 - e) insertion loss shall be as specified in Table 9-1, ITU-T-Rec L.36, Grade B or Grade C; and
 - f) return loss shall be as specified in Table 9-2, ITU-T-Rec L.36, Grade 1 (APC connectors) or Grade 2 (PC connectors).

Optical Fibre Patch Leads

- 2.20 Optical fibre patch leads shall be supplied suitable to connect all equipment to the FOBOT. Patch leads shall comply with the following requirements:
- a) be a minimum of 2 metres in length;
 - b) have connectors matching those in the FOBOT and the equipment to be connected. Matching shall include end finish (e.g. APC connectors shall only be mated to APC connectors, PC connectors shall only be mated to PC connectors); and
 - c) connectors shall comply with Clause 2.18-2.19 “Optical Fibre Connectors and Pigtails”.

Cable Management

- 2.21 The Contractor shall provide appropriate methods of cable management for all cables within Enclosures such that they are:
- a) properly secured;
 - b) neatly and properly routed; and
 - c) protected from damage during normal operation and maintenance of the equipment.
- 2.22 The Contractor shall ensure that cable separation / segregation as required under the various applicable standards (e.g. AS/CA S009:2013, AS3000) is maintained at all times during normal operation.

Optical Fibre Cable Joints and Splices

- 2.23 All joints shall use fusion splices, splice protectors and be held in a purpose made splice organiser. Joints shall be made in accordance with the manufacturer's instructions.
- 2.24 Splices shall have an insertion loss of 0.1 dB or less.
- 2.25 All splicing shall be carried out in strict accordance with the cable manufacturer's and splicer manufacturer's instructions. All persons performing optical fibre splicing shall be suitably trained in such jointing techniques.
- 2.26 In pits, optical fibre cable housings shall be suitable for underground installation and have an openable waterproof seal.
- 2.27 Splice Enclosures shall not be left “free floating” in pits and shall be mounted to the long side of the pit using a purpose-made bracket. All fittings and fastenings shall be non-corrosive. Fastener threads shall be treated with a suitable anti-seize compound.

3 Installation of Telecommunications Cables

General

3.1 This Clause provides additional requirements to those of RD-ITS-C1 "Installation and Integration of ITS Equipment" and RD-EL-C3 "Supply and Installation of Conduits and Pits".

- a) Installation of communications cabling shall be undertaken only by, or under the direct supervision of, a person or persons holding an ACMA Open Cabling License, with the appropriate endorsements for the type of cabling being performed. Evidence of cabling registration for installers and / or supervisors is to be submitted to the Principal prior to commencement of installation. This shall constitute a **Hold Point**.
- b) Telecommunications cables shall be installed as a continuous run with no unnecessary joins, and shall be enclosed by conduit throughout. The conduit routes and cable routes to be utilised shall be as shown on the Drawings.
- c) 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 ducts, a tracer wire shall be installed in the conduit along with the non-metallic cable to facilitate future cable location.
- d) The Contractor shall confirm that the conduits are suitable for cable installation prior to hauling the cable. The Contractor shall provide a polypropylene or equivalent rot-proof draw cord of 5 kN breaking load in each conduit on completion of cable installation. Draw cord ends shall be secured within the pits to which the conduit is terminated.
- e) No cables shall be left exposed at the end of any work period.
- f) In the event of any cable damage during installation, the whole of the particular length of cable concerned shall be removed, replaced and re-connected at the Contractor's expense prior to system commissioning.
- g) Where any cable is vandalised or stolen while under the control of the Contractor, the cable shall be replaced with an equal length of unbroken cable at the Contractor's expense.
- h) The Contractor shall identify all cables at all jointing and termination points. Cables shall be labelled as detailed in Clause 6 "Cable Labelling System" immediately following installation.
- i) For copper cables, all unused cores shall be clearly identified (i.e. with cable number) and terminated with each core occupying a separate terminal.
- j) For backbone optical fibre cable, all unused cores shall be spliced through end to end.
- k) For optical fibre spur cables, each unused core shall be coiled within a fibre splice cassette in the joint and the FOBOT.
- l) The draw cord shall not be used for hauling the cable but shall be used to pull through a purpose-made braided cable hauling rope. The cable hauling rope shall be attached to the cable by the method approved by the cable manufacturer. The Contractor shall attach a swivel between the cable hauling rope and the point of attachment to the cable.
- m) Cables shall 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.
- n) The hauling tension shall be continuously monitored by the Contractor during the hauling operation. If the hauling tension is exceeded, hauling shall stop immediately. The cable shall be inspected and tested for damage. The Principal shall be notified immediately 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. This shall constitute a **Hold Point**.
- o) Bell mouths shall be fitted to the entry and exit of every conduit, including intermediate points, prior to the commencement of cable installation, and shall remain in place after installation.
- p) Cable hauling "slippers" shall be used during hauling.

- q) Where intermediate pits exist in the cable route the cable shall be installed through each chamber in one operation. Cable guides shall be used to support the cables in all intermediate pits.
- r) The Contractor shall ensure that all cables are lubricated during installation using an approved water based biodegradable lubricant.
- s) Sufficient length of cable shall be allowed for correct termination.
- t) Cables shall be sealed against the ingress of moisture when termination does not proceed immediately following installation.
- u) The cable-manufacturer-specified minimum bend radius for the cable shall not be exceeded at any time. The Contractor shall be deemed to be fully informed that the minimum bend radius during hauling may be different from the minimum bend radius when installed.
- v) Where optical fibre breakout is required, only the fibre cores to be spurred off shall be jointed. All other cores shall remain intact.

Remake Loops – Copper Cables

- 3.2 For all cables exceeding 50 metres in length, 5 metre remake loops shall be provided at all joint and termination points. Additional 5 metre remake loops shall be provided every 500 metres of cable length. These loops shall be installed in appropriate pits such that sufficient cable is available for re-termination if and when required.
- 3.3 Cables entering a control room or building shall also be provided with 5 metre remake loops as close as practicable to the building entry point. The location of remake loops is to be noted in the As-built documentation (refer Clause 7 “Cable Scheduling”).

Remake Loops – Fibre Optic Cables

- 3.4 Fibre optic cables shall be installed with 30 metre remake loops between each pair of splice joints, between splice joints and equipment enclosures and between splice joints and building entry points. Remake loops are to be coiled in suitable pits of minimum P7 size. Remake loops shall only be stored in pits smaller than P7 with approval of the Principal. Additionally, 15 metres of optical fibre cable shall be left coiled at or near each splice joint. Seeking such approval shall constitute a **Hold Point**.

4 Testing and Commissioning

General

- 4.1 Prior to testing, the Contractor shall demonstrate the correct functioning and current calibration of all test equipment. Copies of current calibration certificates shall be made available to the Principal prior to commencement of testing. Provision of this information shall constitute a **Hold Point**.
- 4.2 Testing shall be carried out by appropriately trained and qualified personnel. Details of the qualifications and experience of the personnel performing the testing shall be provided to the Principal prior to commencement of testing. Provision of this information shall constitute a **Hold Point**.
- 4.3 The Contractor shall provide at least 48 hours’ notice of the time and date that each stage of the testing will be undertaken. Provision of the notification shall constitute a **Hold Point**.
- 4.4 The Principal may choose to witness a representative sample of tests as they are conducted. The Principal will liaise with the Contractor to make mutually suitable arrangements beforehand.
- 4.5 The results shall be submitted within 5 working days of tests being concluded.
- 4.6 Following completion of each package of installation and testing, the installation shall be certified as compliant with all relevant standards using a TCA1 Form (one for each separate package of work). Submission of completed TCA1 forms shall constitute a **Hold Point**.

Optical Fibre Testing

- 4.7 Optical fibre shall be tested in accordance with ITU-T G.650.3 (including subsequent amendment).
- 4.8 Before every mating operation, optical fibre connectors shall be inspected, cleaned and classified according to IEC 61300-3-35.
- 4.9 Any failure or abnormality during cable testing shall be reported and rectified. Following rectification, the failed test shall be repeated along with sufficient testing to verify that no previously passed cabling has been adversely affected during rectification.
- 4.10 The Contractor shall test the completed optical fibre cable system including splices and through connectors in both directions using a bidirectional OTDR test at both 1 310 nm and 1 625 nm optical wavelengths for single mode fibre or 850 nm and 1300 nm wavelengths for multi-mode fibre.
- 4.11 All testing shall be carried out using a launch cable between the OTDR and the fibre under test and a receive cable at the far end. Launch cable and receive cable connectors shall be matched to those on the fibre under test.
- 4.12 Testing of unconnected fibre ports / fibre cores shall be done as Permanent Link tests (i.e. minus the patch cables).
- 4.13 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) must be performed using a calibrated fibre optic power meter set for the tx wavelength of the SFP / fibre port, as follows:
 - a) measure and record the power output from the equipment fibre port or SFP module;
 - b) inspect, clean and connect the patch cable between the equipment just tested and the specified local FOBOT 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 shall be as specified in Clause 4.18 below.
- 4.14 Once successfully tested, the patch cables must remain connected to the patch panel ports on which they have been tested and certified.
- 4.15 All “dark fibre” (unspliced fibre ends) shall also be tested using “bare end” tests. The intent is that the entire length of every fibre core is tested and certified by the Contractor prior to hand-over.
- 4.16 Dust caps shall be refitted to all unmated connectors immediately after a successful test.
- 4.17 The OTDR parameters shall be set such that the residual noise on the trace is less than 0.05 dB.
- 4.18 The Contractor shall record the following:
 - a) the name and employer 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 (metres);
 - h) attenuation of each fibre channel;
 - i) for fibre runs longer than 5 km, must be less than 1.0 dB/km including all splices, connectors, pig tails and patch leads;
 - j) for fibre runs shorter than 500 m, must be less than 3 dB total loss;

- k) for fibre runs between 500 m and 5 km, must be less than the values shown in Figure RD-ITS-C3 12-1 in Appendix 2: Total Fibre Loss (Db) and Slope (Db/Km) For Fibre Spurs 500 m – 5 km;
- l) in any case, the total loss of the fibre channel shall be within the link budget specifications supplied by the system designers;
- m) loss of each splice (dB);
- n) for backbone fibres and spurs longer than 5 km, must be less than 0.1 dB per splice (bidirectional average);
- o) for fibre spurs to devices (shorter than 5 km), must be less than 0.3 db per splice (bidirectional average);
- p) distance to each splice (m);
- q) loss of each mated connector pair – shall be less than 0.5 dB per connector pair; and
- r) return loss of each mated connector pair – shall be ≥ 55 dB for each connector pair.

[Note that ISO/IEC 14763-3 makes mandatory the return loss measurement of all connector interfaces in an OM3 channel to support 1-10Gbps applications, as return loss can have a significant impact on performance at high data rates.]

- 4.19 The cable will not be accepted if the difference between end-to-end attenuation exceeds 0.5 dB/km for any fibre core between the same two locations.
- 4.20 Test results shall be submitted to the Principal within 5 days of completion of testing. All failures will be reported, rectified and retested before connection of equipment. Submission of test results shall constitute a **Hold Point**.

Copper Cable Testing

General

- 4.21 The Contractor shall test the continuity of each core of a copper communications cable immediately following installation.
- 4.22 The Contractor shall carry out the following tests after completion of installation and jointing of copper communications cables:
 - a) Continuity tests on all copper conductors to check there are no "shorts", "opens" or transitions. The Contractor shall rectify any failures prior to commencement of the remaining tests.
 - b) The loop resistance for each pair shall be measured using a "GP", Lines test set (or similar) and appropriately recorded.
 - c) Insulation Resistance (IR) tests shall be carried out using a Megger (or similar) and measurements shall not be less than 10 M Ω (at 20°C) at 250 V DC after one minute. IR tests are applied between "A" and "B" legs and between "A" and "B" and Earth respectively.
- 4.23 All results shall be recorded and forwarded to the Principal within 5 days of completion of testing. All failures will be reported, rectified and retested before connection of equipment. Submission of test results shall constitute a **Hold Point**.

LAN Cables

- 4.24 LAN cables shall be tested using a purpose-designed LAN Cable Analyser in accordance with AS3080:2013.
- 4.25 The following information shall be recorded for each cable tested:
 - a) the name and employer 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) Wire Map test result;

- f) resistance (by pair);
 - g) length (by pair);
 - h) Propagation Delay (by pair);
 - i) Delay Skew (by pair);
 - j) Insertion Loss (by pair);
 - k) Return Loss (by pair);
 - l) NEXT (Near End Cross Talk);
 - m) PS-NEXT (Power Sum Near End Cross Talk);
 - n) ACR-N (Attenuation to Cross-talk Ratio – Near End);
 - o) ACR-F (Attenuation to Cross-talk Ratio – Far End);
 - p) PS-ACR-N;
 - q) PS-ACR-F;
 - r) FEXT (Far End Cross Talk);
 - s) for Category 6 cables, Channel tests to Class EA (minimum) including patch cables; and
 - t) for Category 7 cables, Channel tests to Class F (minimum) including patch cables.
- 4.26 These records may be saved and submitted electronically.
- 4.27 All results shall be recorded and forwarded to the Principal within 5 days of completion of testing. All failures shall be reported, rectified and retested before connection of equipment. Submission of test results shall constitute a **Hold Point**.

RF Coaxial (Antenna) Cables

- 4.28 Before connecting to equipment, RF coaxial cables shall be tested for length, VSWR Return Loss and "Distance to Fault" using a purpose designed RF antenna analyser:
- a) terminated into a dummy load of the same Z_0 as the cable, prior to connection of the antenna; and
 - b) 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)).
- 4.29 The following information shall be recorded for each cable tested:
- a) the name and employer 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) cable length;
 - f) overall insertion loss;
 - g) VSWR (and / or Return Loss) when terminated into a dummy load (to be less than 1.05:1);
 - h) VSWR (and / or Return Loss) with antenna connected (if applicable) (to be less than 1.5:1 at the operating frequency);
 - i) insertion and Return Loss of all connector interfaces; and
 - j) screen dump / capture of the test trace if supported by the test equipment (may be printed or in electronic form).
- 4.30 If any anomalies are noted along the cable length, the reason for the anomaly is to be investigated, rectified and the cable retested. If the cable is damaged (e.g. crushing, pinching, over-bending / kinking, jacket damage exposing the shield) it shall be replaced by the Contractor.

- 4.31 For "Leaky Coax" or other distributed antenna installations in tunnels or building risers, the Principal is to be consulted regarding appropriate test methodology and accepted pass / fail criteria prior to commencement of installation and testing.
- 4.32 All results shall be recorded and forwarded to the Principal within 5 days of completion of testing. All failures will be reported, rectified and retested before connection of equipment. Submission of test results shall constitute a **Hold Point**.

Electronic Recording and Submission of Test Results

- 4.33 Test records may be submitted to the Principal in electronic form if available (e.g. from OTDRs, LAN cable analysers, Antenna Analysers). (For LAN Cable tests, electronic reports are preferred over hard-copy reports.)
- 4.34 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 above) is included in the report. If the Contractor wishes to submit test results electronically, a sample of each report type shall be submitted by the Contractor and approved by the Principal prior to commencement of testing. This shall constitute a **Hold Point**.
- 4.35 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.

5 Signal Grounding System

General

- 5.1 A Signal Grounding System shall be provided so as to minimise the possibility of earth currents inducing electrical noise into data, video and other sensitive circuits.
- 5.2 DC power supplies within the ITS system shall be electrically isolated from, and not referenced to, the main supply earthing system. The 0-Volt connection or return current shall not be connected to earth potential.

Compliance

- 5.3 The Signal Grounding System employed at ITS communications facilities shall comply with objectives of AS/CA S009:2010.

Communications Earth System (CES)

- 5.4 The Signal Grounding System methodology used for ITS telecommunications installations shall be known as a Communications Earth System (CES).
- 5.5 Earth cables used for the CES shall have Green / Yellow banded insulation. The CES shall be equipotentially bonded to the protective earth system of the electrical installation. The communications bonding conductor shall have a minimum cross-sectional area of 6 mm², have Green / Yellow insulation and the route shall be as short and as direct as possible. The resistance of the communications bonding conductor shall not exceed 0.5 Ohms.

6 Cable Labelling System

Label Types

- 6.1 All in-ground cables shall be labelled using indelible labels of a type suitable for the installation environment and affixed or secured to the cable in such a manner that they cannot be accidentally removed during normal cable handling (e.g. during maintenance / termination / re-termination activities).

Label Location

- 6.2 Cables shall be labelled at the following locations:

- a) in equipment cabinets;
- b) in hauling pits;
- c) adjacent 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.

Label Format

- 6.3 Cables forming part of a network backbone shall be uniquely identified using the following format:
 - a) Line 1: Service Type Cable ID Segment Start – Segment End; and
 - b) Line 2: Core Count / Cable Type.
- 6.4 Cable IDs shall be the primary site ("site of origin") followed by a site-unique number (for example, TMC 001) and shall remain the same along the entire length of a cable, regardless of length and the number of segments.
- 6.5 Spur cables running from a roadside cabinet to a device shall be uniquely identified using the following format:
 - a) Line 1: Service Type Cabinet ID Device ID Segment Start – Segment End; and
 - b) Line 2: Core Count / Cable Type.
- 6.6 Service Types will be as follows:
 - a) F – Optical Fibre;
 - b) S – Serial Data;
 - c) E – Ethernet Data;
 - d) V – Coaxial Cable;
 - e) R – Radio/RF; and
 - f) other prefixes / service types as specified by the Principal.
- 6.7 Depending on the dimensions of the supplied labels, information may be presented on 3 lines namely:
 - a) Line 1: Service Type Start Point End Point;
 - b) Line 2: Segment Start-Segment End; and
 - c) Line 3: Core Count / Cable Type.
- 6.8 An example of cable labelling is given in Appendix 1: Cable Labelling Example.
- 6.9 The same cable designation shall be used on the relevant As-built drawings as on the cable labels. Cable and device designations shall be as agreed with the Principal prior to installation. This shall constitute a **Hold Point**.

7 Cable Schedule

- 7.1 The Contractor shall produce a Cable Schedule showing (as a minimum) for each cable to be installed;
 - a) cable type;
 - b) length (estimated);
 - c) cable designation (as it will be shown on the labels);
 - d) termination schedule (for RS422/RS485 serial cables) showing pair allocation; and
 - e) Patch Panel port allocations (for LAN Cables and Optical Fibre cables).

- 7.2 In addition, the Contractor shall prepare a Splicing Schedule for Optical Fibre cables showing all fibre core allocations (including spare cores).
- 7.3 The Cable and Splicing schedules shall be submitted to the Principal 14 business days prior to installation commencing. This shall constitute a **Hold Point**.

8 As-Built Documentation

- 8.1 Further to RD-ITS-S1 “General Requirements for the Supply of ITS Equipment”, Clause 14 “As-Built Documentation”, the drawings, diagrams and circuits of the actual installation shall comply with the Department’s Design Presentation Standards, in particular “DP018 Intelligent Transport System”.

9 Hold Points

- 9.1 The following is a summary of Hold Points referenced in this Part:

Document Ref.	Hold Point	Response Time
3.1	Evidence of Open Cabling Registration for installers / supervisors	2 Working days
3.1	Excess hauling tension – approval to recommence hauling	2 hours
3.4	Approval for remake loops in pits smaller than P7	2 Working days
4.1	Calibration Test Certificates of equipment	2 Working days
4.2	Details of personnel conducting testing	2 Working days
4.3	Notification of testing	48 hours
4.6	Submission of completed TCA1 Forms	5 Working days
4.20	Optical fibre Test records	5 Working days
4.23	General copper communications cable test results	5 Working days
4.27	LAN Cable Test Results	5 Working days
4.32	Coaxial Cable Test Results	5 Working days
4.34	Approval of electronic test reports for submission	2 Working days
6.9	Cable Designators	2 Working days
7.3	Cable Schedule / Splicing Schedule	14 Working days

10 Verification Requirements and Records

- 10.1 The Contractor shall supply the following records:

Table RD-ITS-C3 10-1 Verification Requirements

Document Ref.	Subject	Record to be Provided
4	Testing and commissioning	Test Records Completed TCA1 Forms
7	System documentation	As-Built documentation

11 Appendix 1: Cable Labelling Example

- 11.1 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:
- a) F NPSR 001 SJ111-SJ222
 - b) 96/SMOF
- 11.2 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.
- 11.3 The next segment between splice joints SJ222 and SJ333 would be labelled:
- a) F NPSR 001 SJ222-SJ333
 - b) 96/SMOF
- 11.4 Spur cables between splice joints and devices or field cabinets (with no intervening splice joints) will be labelled similarly:
- a) F OS199 CMS051 SJ111-CMS058
 - b) 6/SMOF
 - c) F NPSR OS199 SJ111-OS199
 - d) 48/SMOF
- 11.5 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):
- a) F NPSR 001
 - b) SJ111-SJ222
 - c) 96/SMOF
- 11.6 An RG59 type coaxial cable running from OS199 to CAM 051 would be labelled as follows:
- a) V OS199 CAM051
 - b) 1/RG59
- 11.7 A Belden 9842 Shielded Twisted Pair RS485 serial cable running to a variable speed limit sign from a field cabinet would be labelled as:
- a) S OS053 VSL079
 - b) 4/STP
- 11.8 A Category 6 Unshielded Twisted Pair cable used for Serial or Ethernet respectively:
- a) S OS199 CAM051
 - b) 8/UTP CAT6
 - c) E OS199 RAD001
 - d) 8/UTP CAT6

12 Appendix 2: Total Fibre Loss (Db) and Slope (Db/Km) For Fibre Spurs 500 m – 5 km

12.1 The chart below 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 (2x pigtail – fibre spurs plus 2x FAP joints).
- c) Max fibre loss 0.4 dB/km

Figure RD-ITS-C3 12-1

