

FIBRE OPTIC COMMUNICATION CABLES, IN DUCTS - Item No.
FIBRE OPTIC COMMUNICATION CABLES, IN DUCTS (TEMPORARY) - Item No.

Special Provision No. 683S01

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1. SCOPE

This Special Provision covers the requirements for the installation, splicing and testing of the fibre optic communication cables to be placed in ducts. The requirements apply to various types of fibre optic cables as defined within this Special Provision.

2. REFERENCES

This Special Provision refers to the following standards, specifications or publications:

Electronic Industries Alliance / Telecommunications Industry Association:

EIA/TIA-455-B Standard Test Procedure for Fibre Optic Fibres, Cables, Transducers, Sensors, Connecting and Terminating Devices, and Other Fibre Optic Components

TIA/EIA-598-B Optical Fibre Cable Color Coding

3. DEFINITIONS

For the purpose of this Special Provision, the following definitions apply:

Branch Cable means fibre optic cable interconnecting the trunk cable with communication equipment adjacent to pedestals through which the trunk cable does not pass.

Drop Cable means fibre optic cable interconnecting the trunk cable or the branch cable with the pre-terminated fibre connection module in cabinets.

Patch Cord Cable means fibre optic cable interconnecting the fibre connection module with the communication equipment in cabinets.

Trunk Cable means fibre optic cable interconnecting the Traffic Operation Centre (TOC) communication equipment with the roadside communication equipment.

The number prior to the designator SM means the number of single mode fibres in the cable.

4. DESIGN AND SUBMISSION REQUIREMENTS

4.1 Submission Requirements

The Contractor shall supply the specification sheets for the fibre optic communication cables including colour coding and position of fibres and buffer tubes within the trunk, branch and drop cables, connectors and terminating blocks to the Contract Administrator for review prior to ordering.

5. MATERIALS

The Contractor shall be allowed to supply different combinations of fibre optic cables to meet the requirements as specified in the Contract Documents; however, the Contractor will not be compensated for any additional lengths of cable or surplus fibres resulting from such substitutions.

5.1 Trunk Cable, Branch Cable

- 5.1.1 The trunk and branch cables shall consist of the required optical SM fibres divided into buffer tubes and housed within a protective armoured jacket suitable for installation in outdoor underground ducts.
- 5.1.2 All fibre optic trunk and branch cable shall include at least one twisted pair within the space allocated for one buffer tube for cable locating purposes. The twisted pair included in the fibre optic cables shall be 22 AWG copper, PVC insulated, twisted and unshielded, with a nominal conductor resistance no more than 57 ohms/km at 20 °C.
- 5.1.3 The cables shall be rated for operation over a temperature range of -30 to +60 °C.
- 5.1.4 The cables shall provide mechanical support and protection for the specified number of fibres.
- 5.1.5 The cables shall be able to withstand a maximum pulling tension of 2500 N during installation without any resulting damage.
- 5.1.6 The minimum static bending radius for the cables under no tension shall be 200 mm. The minimum bending radius during installation and under tension shall be 300 mm.
- 5.1.7 All interstices within the cable's outer jacket shall be filled with a compound to prevent the ingress and migration of water. The compound shall be nontoxic and dermatologically safe. Some leakage of the compound is permitted; however, there shall be no bulk flow of compound out of the cable over the specified operating temperature range which could impact on the waterproofness of the cable.
- 5.1.8 Materials used in the cables shall not produce hydrogen in a concentration large enough to cause any degradation in the transmission performance of the optical fibres.
- 5.1.9 Materials used in the cables shall not support galvanic action.
- 5.1.10 Fibres shall be bundled in buffer tubes. Each buffer tube shall contain 12 fibres.
- 5.1.11 Each individual fibre in the cables shall be identified by means of colour coding or a combination of colour and positional coding as specified in TIA/EIA-598-B.

5.2 Drop Cable

- 5.2.1 The drop cable shall consist of the required optical SM fibres housed in a protective armoured jacket rated for outdoor installation in underground conduits. Each drop cable shall include a pre-terminated fibre connection module complete with integrated connectors and factory terminated onto the armoured drop cable.
- 5.2.2 The attenuation drop cable for SM fibres shall not exceed 0.4 dB/km measured at 1310 nm and 0.3 dB/km measured at 1550 nm.

- 5.2.3 The drop cable shall be suitable for operation over the temperature range of -30 to +60 °C.
- 5.2.4 The exact number of connected drop cables at each pedestal and at the TOC shall be as specified in the Contract Documents. Each drop cable shall contain a minimum of eight (8) fibres or the quantity of fibres equal to the terminations on the pre-terminated connection module.
- 5.2.5 The length of drop cable in the pedestal shall be equal to that of the trunk and branch cable stored in the pedestal. Sufficient slack shall be provided in the cabinet to allow mounting the fibre connection module at the top of the cabinet with at least 1.0 m of spare cable in the cabinet.
- 5.2.6 Each pre-terminated fibre connection module shall have a minimum capacity of eight (8) connectors. The connectors shall be grouped in pairs, and arranged in a step formation and supplied with protective caps or plugs for protection when not in use.
- 5.2.7 Each pre-terminated fibre connection module shall be compatible for connection to the LC style connectors of the fibre optic patch cord cables.
- 5.2.8 The pre-terminated fibre connection module shall be epoxy filled to provide a watertight unit and provide rodent protection.
- 5.2.9 Each fibre connection module shall be equipped with a mounting bracket for installation on EIA rack requiring no special tools. The fibre connection module shall be installed in the cabinet as shown on the Contract Drawings.

5.3 Fibre Optic Patch Cord Cable

- 5.3.1 The fibre optic patch cord cables shall consist of optical SM fibres housed individually in protective armoured jackets. Both ends of the cable shall be connectorized.
- 5.3.2 The attenuation of a fibre optic patch cord cable after installation, not including the connector loss, shall not exceed 0.1 dB measured at 850 nm and 1300 nm.
- 5.3.3 The fibre optic patch cord cable shall be suitable for operation over the temperature range of -30 to +60 °C.
- 5.3.4 Fibre optic patch cord cables in cabinets shall be 2.0 m in length.

5.4 Single Mode (SM) Cabled Fibre

- 5.4.1 The optical attenuation at 1310 nm shall not be greater than 0.4 dB/km for any fibre.
- 5.4.2 The optical attenuation at 1550 nm shall not be greater than 0.3 dB/km for any fibre.
- 5.4.3 The fibre attenuation shall not vary more than 0.2 dB/km over the specified cable operational temperature range.
- 5.4.4 The SM fibre shall be coated with a protective polymer to preserve the strength of the fibre. The coating shall be removable by mechanical or chemical means. The coating shall retain its colour when subject to the manufacturer's recommended fibre cleaning and splicing preparation methods.

- 5.4.5 The SM fibre shall have attenuation and bandwidth specified at two wavelength windows.
- 5.4.6 The first wavelength window shall be at and around 1310 nm.
- 5.4.7 The second wavelength window shall be at and around 1550 nm.
- 5.4.8 The zero dispersion wavelength shall be at a wavelength of 1310 ± 10 nm.

5.5 Twisted Pair Cable

- 5.5.1 A separate twisted pair cable shall be provided for use between the splice enclosure and the terminal block in the pedestal and the pedestal terminal block and the terminal block in the cabinet. For each end of the trunk or branch cable coming into the pedestal, one twisted pair shall be provided. One twisted pair cable shall be provided between the terminal block in the pedestal and the terminal block in the cabinet. The conductors of the cable shall be 22 AWG copper, PVC insulated, twisted and unshielded.
- 5.5.2 The cable shall meet the environmental requirements of the fibre optic cable.
- 5.5.3 Each conductor of the cable shall be identified by means of colour coding.
- 5.5.4 Nominal conductor resistance in any length of completed cable shall not exceed 57 ohms/km at 20 °C.
- 5.5.5 The cable shall be designed for use in underground environments, and shall include outdoor rated cable sheath and filled cores.

5.6 Connectors

- 5.6.1 Connectors shall all be LC style unless otherwise specified in the Contract Documents.
- 5.6.2 The connector mean loss shall not be greater than 0.5 dB with a standard deviation of not greater than 0.2 dB. The connector loss shall not vary more than 0.2 dB over the operating temperature range.
- 5.6.3 Index matching fluids or gels shall not be used.
- 5.6.4 The connector loss shall not vary more than 0.2 dB after 1000 repeated matings.
- 5.6.5 The connector shall withstand an axial load of 135 N.
- 5.6.6 The connectors shall be compatible with the optical fibre surrounding jacket and shall be installed on one end of the optical fibre according to the manufacturer's recommended materials, equipment and practices.
- 5.6.7 The connector shall be suitable for the intended environment and shall meet the following environmental conditions.
- 5.6.8 Operating temperature: -30 to +60 °C.
- 5.6.9 Connectors shall be protected by a suitably installed waterproof protection cap.

5.7 Number of Fibres

The number of SM fibre specified for each cable shall be the guaranteed number of SM fibres, (i.e. SM fibres in the cable shall comply with the specification after installation).

5.8 Fish Line

Fish line shall be nylon or polypropylene material with a minimum test strength of 400 N.

5.9 Packing and Shipment

The cable shall be supplied on reels. Each reel shall have the following information clearly labelled on it in:

- a) Customer
- b) Customer order number
- c) Reel number
- d) Destination
- e) Ship date
- f) Manufactured date
- g) Manufacturer's name
- h) Cable code
- i) Length of cable

6. EQUIPMENT

- 6.1 Where mechanical pulling means is required, a fibre optic cable puller and suitable cable routing accessories shall be used to ensure that the minimum bending radius of the cable is not exceeded.
- 6.2 The connection between the mechanical puller and the fibre optic cable shall be through a break-away link, designed to disconnect the winch cable from the fibre cable when the maximum pulling tension of the cable is exceeded.

7. CONSTRUCTION

7.1 General

- 7.1.1 Care shall be taken at all times to avoid scraping, denting, or otherwise damaging the cable before, during or after installation. Damaged cable shall be replaced by the Contractor at no additional cost to the Owner.
- 7.1.2 The manufacturer's recommended safe pulling tension and minimum bending radius shall not be exceeded at any time.
- 7.1.3 Twisted pairs shall be terminated at the termination block in each pedestal and the cabinet. The termination blocks shall be installed in pedestals external to the splice enclosures as specified in the Contract Drawings and as approved by the Contract Administrator. All connections shall be clearly identified.
- 7.1.4 All cable ends shall be protected from moisture ingress by using properly sealed caps.

7.2 Installation in Ducts

- 7.2.1 Cables shall be installed in duct in the field as specified in the Contract Drawings.
- 7.2.2 All duct ends shall be smoothed prior to installation of the cables to prevent scraping the cable.
- 7.2.3 A stiff bristle brush shall be pulled through each section of duct before pulling cable.
- 7.2.4 A manufacturer recommended lubricant shall be applied to the cable to reduce friction between the cable and the duct.
- 7.2.5 Plastic inner ducts shall be installed inside ducts when specified.
- 7.2.6 Drop cables shall be manually pulled from the cabinet to the pedestal to prevent the connectors from being damaged. Cable ties shall be installed to fasten all drop cables in the cabinet, and to bundle the drop cable with the trunk or branch cables entering a splice enclosure.
- 7.2.7 Where fibre optic cables (trunk, branch or drop) are required to be installed in inner duct, each section of inner duct shall be secured to prevent it from being pulled with the cables.
- 7.2.8 A cable grip (“pulling eye”) shall be attached to the strength members of the cables so that no direct force is applied to the optical fibre. The cable grip shall have a swivel to prevent the cable from twisting during pulling.
- 7.2.9 Cable rollers and feeders and winch cable blocks shall be used to guide the cable freely into the duct and at electrical chamber locations.
- 7.2.10 Mechanical aids and pulling cable or ropes shall be used as required.
- 7.2.11 Personnel equipped with two-way communication equipment shall be stationed at appropriate locations through which the cable is to be pulled to observe and lubricate the cable.
- 7.2.12 Cable pulls shall be continuous and steady between pull points and shall not be interrupted until the entire run of cable has been pulled.
- 7.2.13 At no point shall the pulling tension exceed the maximum pulling tension or minimum bend radius of the cable as specified by the cable manufacturer.
- 7.2.14 During all mechanical pulling operations, a break-away link shall be used to limit pulling tension to the maximum pulling tension of the cable as defined by the cable manufacturer.
- 7.2.15 Cable passing through all electrical chambers and communication chambers shall be marked with a plastic cable tag with permanent printing indicating that this is a fibre optic cable.
- 7.2.16 Cable passing through electrical chambers shall be installed in 90 mm PVC split duct and shall have sufficient slack for expansion and contraction. The split duct shall be installed on the electrical chamber wall opposite the power cables and ladder rungs using galvanized steel conduit straps. The split duct shall clearly identify the contents to be fibre optic cable.
- 7.2.17 The cable shall be securely fastened in place within electrical chambers, pedestals and cabinets. For vertical conduit runs, the cable installation shall include installation of strain relief mechanism.

- 7.2.18 The cable shall be of sufficient length to allow for connection as shown on the Contract Drawings, including provision for slack, vertical runs, cable necessary for splicing, wastage and cable to allow for the removal of the splice enclosure for future splicing.
- 7.2.19 The unconnectorized end of the drop cable shall be spliced to the trunk or branch cable fibres as specified in the Contract Documents.
- 7.2.20 Immediately following installation, each trunk or branch cable entering a pedestal shall be labelled with the cable identification and direction as specified in this Special Provision.
- 7.2.21 Following installation of the cable in the ducts, all duct entrances at pedestals and cabinets shall be sealed with duct plugs to prevent the ingress of moisture, foreign materials, and rodents.
- 7.2.22 Conduit containing cables shall be sealed using a duct plug with an opening approximately the size of the cable. The duct plug may be split in the factory or the field to allow placing around the cable, and the remaining openings in the plug, as well as any spaces between the conduits, cable or plug shall be sealed with duct sealing compound. Expandable foam shall not be used to seal ducts.
- 7.2.23 At least 12 m of trunk cable, 6m on each side of the splice enclosure, and at least 6 m of branch cable shall be coiled at each pedestal.
- 7.2.24 10 m of each cable going to and coming from each pedestal shall be coiled in the first ATMS chamber on either side of the pedestal. In addition, 25 m of cable shall be left coiled in the first ATMS chamber on each side of all surface mounted conduit systems.
- 7.2.25 Where trunk cable terminations are left “dead ended”, 25 m of cable shall be left coiled.
- 7.2.26 All coiled cables shall be securely fastened in place with a minimum of four galvanized steel conduit straps.
- 7.2.27 Fish line shall be installed in all communications ducts or conduits along with fibre optic communication cables. A 2.0 m length of fish line shall be left coiled, tied and accessible in each cabinet, pedestal, electrical chamber and junction box.
- 7.2.28 At intermediate pulling points, to prevent over-tension on the cable, the cable shall be either taken up with an intermediate cable take up device as approved by the Contract Administrator, or all excess cable shall be laid out on the ground in a “figure eight” configuration before subsequent installation.
- 7.2.29 Pedestals may be removed to assist in the installation. If this option is exercised, all removed pedestals shall be reinstalled to their original condition.
- 7.2.30 Unless otherwise specified in the Contract Documents, the temporary fibre cable and associated drop cables shall be removed and delivered to the Owner at the location specified by the Contract Administrator.

7.3 Installation in the Communication Head End

At the communication head end locations, cables shall be installed from the indoor splice enclosures to the communications equipment as specified in the Contract Drawings.

7.4 Splicing

- 7.4.1 Only the splices specified in the Contract Drawings shall be allowed.
- 7.4.2 All pedestal splices shall be housed in a splice enclosure as specified in the Contract Documents. All splices in the head end buildings shall be housed in indoor splice enclosures.
- 7.4.3 The splices shall be performed by high quality fusion type splicing equipment.
- 7.4.4 The maximum loss introduced by any single mode splice shall not exceed 0.25 dB at 1310 nm and 1550 nm.
- 7.4.5 The average single mode splice loss shall not exceed 0.1 dB for any given span, with a standard deviation not greater than 0.07 dB.
- 7.4.6 Only the fibres required to be spliced to drop cables specified in the Contract Documents shall be severed and spliced. Where required, the buffer tube splitting tool recommended by the manufacturer shall be used to open the correct buffer tube. Unsevered fibres in an open buffer tube shall be coiled in the splice tray. When buffer tubes do not need to be opened, at least 3.0 m of unopened buffer tubes shall be coiled at the slack basket in the fibre optic splice enclosure and labeled with the fibre count, highway and direction.
- 7.4.7 The designated fibres of the cable for splicing to the drop cables shall be prepared following manufacturer recommended procedures. All splices shall be arranged neatly in splice trays, supported and protected with a suitable splice protector. At least 1.0 m of each fibre shall be stored in the splice tray.
- 7.4.8 Fibres that do not require splicing shall be contained within buffer tubes and the buffer tubes shall be fastened to the tray.
- 7.4.9 All opened buffer tubes routed to splice trays shall be protected with protective tubing provided with the splice enclosure or spiral wrap to protect the buffer tube.
- 7.4.10 Fibres routing between trays shall be enclosed in tubing designed for this purpose to ensure that the minimum bending radius is not exceeded, both for the completed splice, and during access to any of the splice trays.
- 7.4.11 Splicing shall be completed using a fusion splicer that tests the tensile strength of the completed splice by applying a force of not less than 200 grams.
- 7.4.12 Drop cable entrances to the splice enclosures shall adhere to the outdoor splice enclosure manufacturer's recommendations.
- 7.4.13 To reduce the overall number of splices required, the cable shall be installed in continuous lengths with a minimum average of 2 km. Runs of cable beyond the minimum requirements shall be maximized if possible. Locations for trunk cable splicing shall be approved by the Contract Administrator and documented as part of as-constructed documentation.

7.5 Twisted Pair Cable

- 7.5.1 The twisted pair in the trunk or branch cable shall be spliced to the twisted pair cable leaving the splice enclosure, such that one pair in the twisted pair cable is spliced to the end of each trunk or branch cable. The other end of each twisted pair shall be separately terminated on the pedestal termination block and labelled providing the cable identification as specified in this Special Provision.
- 7.5.2 The ends of the twisted pair cable between the pedestal and the controller cabinet shall be terminated at the termination blocks in the pedestal and in the cabinet and labelled providing cable identification

7.6 Fibre Connection Module

- 7.6.1 The pre-terminated fibre connection module shall be used as a fibre optic 'Patch Panel'.
- 7.6.2 Patch cord cables shall be used between the fibre connection module and communication equipment.
- 7.6.3 The unused ports of the fibre connection module shall be provided with protective caps or plugs to protect dust or unwanted material from degrading the connectors.

7.7 Labeling

- 7.7.1 The trunk, branch and twisted pair cables in the pedestal shall be labelled with permanent indelible ink on a heavy duty marking tape to indicate the following information as specified in the Contract Drawings:
- (a) Cable type, i.e. a Trunk, Branch or a Drop Cable,
 - (b) Direction the cable is coming from or the cabinet number for the Drop Cable
- 7.7.2 Each buffer tube entering the splice tray shall be labeled with vinyl tags directly on the splice tray with the direction of the cable, and with the cable identification (Trunk, Branch or Drop).
- 7.7.3 The interface connector in the pre-terminated fibre connection module shall be labelled. The labelling scheme shall, at a minimum, include the following:
- a) Fibre Type;
 - b) Fibre Number and Direction from the cable it comes from;
 - c) Function (Rx or Tx);
 - d) The adjacent cabinet number from where the cable comes from.

Example:

SMF 34W Tx 401CW0420SWC

- 7.7.4 Both ends of the fibre patch cords from the fibre connection module to the communication equipment, e.g. switch shall be labelled. The labelling scheme shall be as follows:

- a) At the switch end, the label shall indicate to which adjacent cabinet the connection is from;
- b) At the fibre connection module end, the label shall indicate Fibre Type, Fibre Number and Function.

7.8 Grounding

7.8.1 All metallic components in the fibre optic cables shall be bonded together with a connection to the ground lug of the splice enclosures.

7.8.2 If the fibre cable has metallic components, the ground lug of the splice enclosure shall be bonded to the communications pedestal ground.

7.9 Quality Control

The Contractor is responsible for all testing and documentation required to establish approval and acceptance of installation and operation of this equipment. The framework of the approval process shall be as specified elsewhere in the Contract Documents.

The following table details the clauses within this Special Provision, which are to be validated through the PIT, POP, and SIT processes as specified. All measurements shall be performed according to EIA/TIA-455-B.

CLAUSE	PIT	POP	SIT
5.2.2	√	√	
5.3.2	√	√	
5.4.1	√ ¹	√ ²	
5.4.2	√ ¹	√ ²	
5.4.3	√ ¹	√ ²	
5.5.2		√	
7.4.4		√ ³	
7.4.5		√ ³	
7.4.6		√ ³	
7.7.1		√	
7.7.2		√	
7.7.3		√	
7.7.4		√	

Testing Footnotes:

- ¹ Each reel shall be tested prior to installation in ducts. PIT shall include a minimum of 10% of the total fibre optic communication cable. Where 10% equates to more than one fibre, the fibres to be tested shall be located in different buffer tubes.
- ² Each length of fibre cable shall be tested after installation in ducts. POP shall include a minimum of 10% of the single mode fibres to be connected to equipment. The Contractor shall not test the same fibres on consecutive lengths. All spare cables shall be tested. The Contractor shall record the reel number from which the cable came, the identification of the fibres measured and the attenuation in dB/km of the fibres measured.
- ³ Each optical link (fibre link terminated with optical connectors on each end) shall be tested using light source and power meter. Attenuation and continuity shall be demonstrated at 1310 nm and 1550 nm. Calibration between the light source and power meter shall be performed at the beginning of each day of testing and after every 20 optical link measurements.

Each optical fibre with at least one fibre connector shall be tested using an OTDR at 1310 nm and 1550 nm. Test results shall include the following measurements:

- a) Total length of the optical link
- b) Total attenuation of the optical link
- c) Attenuation of each splice in the optical link under test
- d) Attenuation per kilometre of the optical link under test
- e) Wavelength of the measurement
- f) Index of refraction used for the test

Test results shall include electronic copies of the OTDR attenuation profile in searchable PDF format.

When cable installed in this Contract interconnects with existing cable, the Contractor will be provided with test results for existing adjacent communications cable and shall review the results prior to interconnecting to the existing cable.

A certificate confirming the calibration of the OTDR within the past year prior to undertaking any testing shall be submitted to the Contract Administrator.

8. QUALITY ASSURANCE – Not Used

9. MEASUREMENT FOR PAYMENT

9.1 Fibre Optic Communication Cables, In Ducts

Measurement of cables shall be made horizontally in metres along the longitudinal axis of the duct trench from centre to centre of poles, electrical chambers, concrete pads and to the face of bridge structures and retaining walls.

10. BASIS OF PAYMENT

**10.1 Fibre Optic Communication Cables, In Ducts - Item
Fibre Optic Communication Cables, In Ducts (Temporary) - Item**

Payment at the Contract price for the above tender items shall be full compensation for all labour, Equipment and Materials required to do the work regardless of the type or number of fibres in the cable (connecting to both new and existing trunk cable), splices, twisted pair cable, termination blocks, coils of cable, mechanical support, delivery, installation, testing and the production of all drawings, text and test results.

Progress payment for temporary fibre optic cables shall be based on the following percentages of the Contract price:

80% for supply and installation

20% for removal