

SECTION 678 COMMUNICATION SYSTEMS

678.1 Description

- (1) This section describes the furnishing, installing, and testing of communication systems.

678.2 Materials

678.2.1 Department Furnished Materials

- (1) The department will furnish fiber optic cable and termination panels.

678.2.2 Fiber Optic Splices

- (1) Furnish fiber optic splice enclosures to be used in fiber optic splices for both mainline end-to-end splices and drop splices, as the plans show.
- (2) Furnish fiber optic splice enclosures designed for use under the most severe conditions such as moisture, vibration, impact, cable stress and flex temperature extremes as demonstrated by successfully passing the factory test procedures.

678.2.2.1 Physical Requirements

- (1) The enclosure must handle up to 4 cables in a butt configuration. The contractor may use a butt adapter to increase capacity to 6 cables.
- (2) The enclosure must prevent the intrusion of water without the use of encapsulates.
- (3) The enclosure must be capable of accommodating splice organizer trays that accept mechanical, fusion, or multi-fiber array splices. The splice enclosure shall have provisions for storing fiber splices in an orderly manner, mountings for splice organizer assemblies, and space for excess or unspliced fiber. Splice organizers shall be re-enterable. Splice cases shall hold a sufficient number of splice trays to hold up to 144 splices.
- (4) The splice case shall be UL rated.
- (5) Enclosure re-entry and subsequent reassemble shall not require specialized tools or equipment. Further, these operations shall not require the use of additional parts.
- (6) The splice enclosure shall have provisions for controlling the fiber bend radius to a minimum of 1 1/2 inches (38 mm).

678.2.2.2 Factory Testing

678.2.2.2.1 General

- (1) Ensure that the manufacturer or an independent testing laboratory performs the tests listed below in 678.2.2.2.2 through 678.2.2.2.6. Submit certificates of compliance to the department. Manufacturer certification is necessary for the model of enclosure supplied. It is not necessary to test each supplied enclosure.

678.2.2.2.2 Compression Test

- (1) The enclosure shall not deform more than 10 percent in its largest cross-sectional dimension when subjected to a uniformly distributed load of 300 pound-force (1335 N) at a temperature of -1 F (-18 C) and 100 F (38 C). Perform the test after stabilizing at the required temperature for a minimum of 2 hours. It shall consist of placing an assembled enclosure between 2 flat paralleled surfaces, with the longest enclosure dimension parallel to the surfaces. Place the weight on the upper surface for a minimum of 15 minutes. Take the measurement with weight in place.

678.2.2.2.3 Impact Test

- (1) The assembled enclosure shall be capable of withstanding an impact of 20.65 foot-pounds (28 Nm) at temperatures of -1 F (-18) and 100 F (38 C). Perform the test after stabilizing the enclosure at the required temperature for a minimum of 2 hours. The test fixture shall consist of 20-pound (9 kg) cylindrical steel impacting head with a 2-inch (50 mm) spherical radius at the point where it contacts the enclosure. Drop the enclosure from a height of 12 inches (300 mm). The enclosure shall not exhibit any cracks or fractures to the housing that would preclude it from passing the water immersion test. There shall be no permanent deformation to the original diameter or characteristic vertical dimension by more than 5 percent.

678.2.2.2.4 Cable Gripping and Sealing Test

- (1) The cable gripping and sealing hardware shall not cause an increase in fiber attenuation in excess of 0.05 dB/fiber at 1550 nm when attached to the cables and the enclosure assembly. The test shall consist of measurements from 6 fibers, one from each buffer tube or channel, or randomly selected in the case of a single fiber bundle. Take the measurements from the test fibers, before and after assembly to determine the effects of the cable gripping and sealing hardware on the optical transmission of the fibers.

678.2.2.2.5 Vibration Test

- (1) The splice organizers shall securely hold the fiber splices and store the excess fiber. Test the fiber splice organizers and splice-retaining hardware according to EIA standard FOP-II, test condition I. The individual fibers shall not show an increase in attenuation in excess of 0.1 dB/fiber.

678.2.2.2.6 Water Immersion Test

- (1) The enclosure shall be capable of preventing a 10-foot (3 m) water head from intruding into the splice compartment for a period of 7 days. Test splice enclosure by the placing of the enclosure into a pressure vessel and filling the vessel with tap water to cover the enclosure. Apply continuous pressure to the vessel to maintain a hydrostatic head equivalent to 10 feet (3 m) on the enclosure and cable. Continue this process for 30 days. Remove the enclosure and open to check for the presence of water. Any intrusion of water in the compartment containing the splices constitutes a failure.

678.2.3 Fiber Optic Terminations

- (1) Furnish fiber optic connectors from the department's approved products list.
- (2) Connectors shall be type ST.
- (3) Connectors shall utilize epoxy or hot melt adhesive and shall include a ceramic ferrule.

678.2.4 Communication System Testing

- (1) Supply all materials and equipment necessary to perform the tests as described in these specifications. All test equipment will remain property of the contractor. Use equipment consisting of, but not limited to, the following:
 - Optical time domain reflectometer (OTDR).
 - Optical source/power meter.
 - Patch cabling.
 - OTDR software.

678.3 Construction

678.3.1 Fiber Optic Cable

- (1) Install all cables into the conduit using a flat woven pull tape. Optionally, install the cable via forced air and a track pushing mechanism. Do not use a single pull tape for more than a single cable pull. Install the pull tape and fiber optic cables according to the testing procedures completed for this project and the pull tape and cable manufacturer's recommendations.
- (2) Install all cable according to Siecor recommended procedure SRP 005-011 for fiber optic cable placing - duct. Follow these procedures regardless of the manufacturer of the cable. If the cable manufacturer recommends an operation in conflict with these procedures, submit a request for installation procedure change to the department for approval. Do not exceed a maximum pulling tension of 608 pounds-force (2700 N) during installation and 200 pounds-force (890 N) after installation.
- (3) If the total loss exceeds the allowable loss specified under 678.3.4, replace or repair that cable run. If elevated attenuation due to exceeding the pulling tension during installation is determined, replace that cable run.

678.3.2 Fiber Optic Splices

- (1) Use only fusion splicing for all splices. Ensure that each splice does not exceed the attenuation limits set forth in 678.3.4.
- (2) Do not make mechanical splices.

- (3) Protect each splice in a protective sleeve and secure in the splice tray. Protect bare fibers with a heat-shrink coating before placement in a sleeve or housing. Install the heat-shrink coating in to protect the fiber from scoring, dirt, accumulation, moisture intrusion, and micro bending.
- (4) Install the fiber optic splice enclosure according to the manufacturer's recommended guidelines.
- (5) Perform end-to-end splicing according to the manufacturer's instructions for the supplied splice enclosure units.
- (6) Perform mid-span splicing, drop splicing, for each device location at locations the plans show. Splice according to Siecor recommended procedure SRP-004-013 for mid-span access of fiber optic cable with cable slack present, or appropriate manufacturer instructions. Contain all mid-span splices within enclosures.
- (7) Do not deviate from the splice details as the plans show without the engineer's approval.

678.3.3 Fiber Optic Terminations

- (1) Install type ST connectors to the fiber optic cable.
- (2) Terminate all fibers on the rear of the termination panel with type ST connectors.
- (3) Install fiber optic jumpers of sufficient length to connect the front side of the termination panel to the fiber equipment contained within the cabinet.
- (4) Ensure that each termination does not exceed the attenuation limits specified in 678.3.4.

678.3.4 Communication System Testing

- (1) Perform all communication system testing using certified fiber optic technicians approved under 670.3.2.2.
- (2) Provide the date, time, and location of required tests to the engineer at least 24 hours before performing the test.
- (3) After completing cable installation, splicing, and termination, test all fibers for continuity, events losses, and total attenuation of the cable as follows:
 1. Test each individual fiber for event losses using an OTDR. Conduct the test using the standard operating procedure as defined by the manufacturer of the test equipment.
 2. Connect the OTDR and the cable with a factory patch cord of a length equal to the dead zone of the OTDR. Optionally, the technician can use a factory fiber box of 325 feet (100 m) minimum with no splices within the box.
 3. Test each individual fiber for total segment attenuation loss using an optical source/power meter. Conduct the test using the standard operating procedure as defined by the manufacturer of the test equipment.
 4. Conduct both tests, OTDR and optical source/power meter, at 1310 nm and 1550 nm for each fiber in the cable.
 5. Conduct both tests bi-directionally for each fiber in the cable.
- (4) After completing the tests, submit 5 hard copies of the test results to the engineer documenting the following test parameters:

Operator name	Setup parameters	Pulse width OTDR	Range OTDR
Date and time	Wavelength	Refractory index OTDR	Scale OTDR
- (5) Summarize the results of both the OTDR and optical source/power meter tests in spreadsheet/tabular format adhering to the following requirements:
 - List fiber optic segment name including route, start point, and end point.
 - List all fibers by number.
 - List direction of test as NB, SB, EB, or WB.
 - List total fiber optic cable length for each fiber as documented in the OTDR test.
 - List attenuation in dB of gain or loss for each fiber optic event in the OTDR test.
 - List fiber optic loss event descriptions and locations including splices, miscellaneous events, and terminations.
 - List the attenuation across the cable in dB/mile for each fiber tested.

- List the total segment loss for each fiber as determined by the optical source/power meter test.
 - Provide bi-directional data including event distances, event descriptions, and attenuation losses for each fiber corresponding to a common start point
 - Provide bi-directional data on separate lines, side-by-side within the same sheet.
 - Provide 1310 nm and 1550 nm test results on separate sheets in identical formats.
- (6) Provide copies of the fiber cable traces taken during the OTDR test to the department on diskette for review. Provide electronic files in a universal file format, or with software to view the files.
- (7) Ensure that test results demonstrate that the dB/mile loss does not exceed plus 3 percent of the factory test or plus one percent of the cable's published production loss. The department will consider the error rate for the test equipment in evaluating results.
- (8) Event losses are an average for each direction tested, and are limited to the following:

EVENT TYPE	ALLOWABLE LOSS
Fusion Splicing	0.10 dB
ST Connector	0.50 dB
Other miscellaneous events	0.10 dB
Total loss across the cable ^[1]	1 dB/mile (0.62 dB/km)

^[1] Including events and cable attenuation.

678.4 Measurement

- (1) The department will measure the Install Fiber Optic Cable Outdoor Plant bid items by the linear foot acceptably completed.
- (2) The department will measure Fiber Optic Splice Enclosure and Fiber Optic Splice as each fiber strand acceptably spliced and completed.
- (3) The department will measure Fiber Optic Termination as each fiber termination acceptably completed.
- (4) The department will measure Communication System Testing as a single lump sum unit for each service acceptably completed.

678.5 Payment

- (1) The department will pay for measured quantities at the contract unit price under the following bid items:

<u>ITEM NUMBER</u>	<u>DESCRIPTION</u>	<u>UNIT</u>
678.0000 - 0199	Install Fiber Optic Cable Outdoor Plant (count)	LF
678.0200	Fiber Optic Splice Enclosure	EACH
678.0300	Fiber Optic Splice	EACH
678.0400	Fiber Optic Termination	EACH
678.0500	Communication System Testing	LS

- (2) Payment for the Install Fiber Optic Cable Outdoor Plant bid items is full compensation for installing and testing department-furnished cabling.
- (3) Payment for Fiber Optic Splice Enclosure and Fiber Optic Splice is full compensation for all work required under the individual bid items.
- (4) Payment for Fiber Optic Termination is full compensation for providing connectors and jumper cables; and for completing the installation using department-furnished termination panels.
- (5) Payment for Communication System Testing is full compensation for furnishing testing and all documentation and certifications of testing necessary.
- (6) The department will not pay for replacements or repairs required under 678.3.1.