MICHIGAN
DEPARTMENT OF TRANSPORTATION

SPECIAL PROVISION
FOR
FIBER OPTICS

a. Description. This work consists of furnishing, installing, splicing, and testing single mode fiber optic cable and fiber optic communications hardware.

b. Materials.

1. Fiber Optic Cable - Outside Plant (OSP).

A. Provide single mode, loose tube, gel free, non-armored fiber optic cable.

B. Provide cable constructed with 12 fibers per buffer tube.

C. Provide cable meeting the following environmental conditions:

(1) Storage. -40 degrees Fahrenheit (F) to +158 degrees F;

(2) Installation. -20 degrees F to +140 degrees F; and

(3) Operation. -40 degrees F to +158 degrees F.

D. Provide cable with maximum attenuation of 0.35 decibels per kilometer (dB/km) maximum at a wavelength of 1310 nanometers (nm) and attenuation of 0.25 dB/km maximum at a wavelength of 1550 nm.

E. Show the date of manufacturer and the manufacturer's name as a permanent marking on the outer jacket. Mark a numerical sequence on the jacket at intervals no greater than 3 feet to facilitate determination of length of cable and amount of cable remaining on the reel. Ensure the height of the marking is a minimum of 0.08 inch nominal. In addition, the cable must have permanent markings as indicated in the contract.

F. Ensure the cable designated for "Partner Agency Cable," if required, is color coded as shown on the plans. Deliver the cable on reels without splices. Ensure both ends of the cable are sealed to prevent moisture ingress.

2. Above Ground Fiber Optic Marker. Ensure the above-ground portion of the marker is made entirely of Polypropylene or high-density polyethylene (HDPE) and is protected against damage from ultraviolet (UV) light. Ensure the marker can withstand extreme temperatures. Ensure the marker is hollow, white, and a minimum 6 feet long. Its outer diameter must be at least 3.5 inches and its wall thickness must be at least 0.100 to 0.125 thousandths of an inch on the base and 0.085 to 0.110 thousandths of an inch on the topper. Ensure the top of the marker is covered with an orange outer tube that has a domed top, nominally 16 inches in

height. The domed top must have an inside diameter of 3.5 inches. The marker must have a physical mechanism made of HDPE or galvanized steel to anchor the marker to the ground and prevent uplift.

Ensure that black lettering is printed on, or molded into, both sides of the top of the marker saying “MDOT FIBER OPTIC CABLE ROUTE”; decals are permitted where approved by MDOT. Guarantee this lettering to remain visible for at least 10 years. Ensure the lettering is approximately 1 inch high, with a 0.2 inch stroke width. In smaller letters, the printing must say “BEFORE DIGGING, CALL MDOT.” Submit the proposed size and layout of all text to the Engineer for approval as part of the catalog cut sheet for this item.

3. Fiber Optic Cable - Indoor. Provide indoor-rated fiber optic cable and all hardware required for splicing indoor/outdoor cables and to facilitate cable installation. Ensure fiber capacity is as indicated on the plans.

A. Provide Plenum-rated, flame resistant single mode fiber optic cable.

B. Ensure the cable has 12 fibers per buffer tube.

C. Provide non-armored cable.

D. Ensure the indoor single mode cable has a maximum attenuation of 0.35 dB/km at 1310 nm wavelength and 0.25 dB/km at 1550 nm wavelength.

E Provide cable that meets the following environmental conditions:

(1) Storage. -40 degrees F to +158 degrees F;

(2) Installation. +32 degrees F to +140 degrees F;

(3) Operation. +32 degrees F to +158 degrees F.

4. Fiber Optic Connectors. Provide type LC fiber optic connectors for pigtails and type LC-to-LC connectors for jumper cables. Ensure connectors are comprised of a ceramic ferrule with a nickel plated zinc or composite connector body. Ensure the average loss is 0.3 dB or less.

5. Fiber Optic Pigtail.

A. Ensure pigtails are factory-made, buffered, and strengthened with aramid yarn to reduce the possibility that accidental mishandling will damage the fiber or connection.

B. Ensure pigtails are yellow.

C. Ensure they use the type of connector specified in subsection b.4 of this special provision and are factory terminated.

D. Ensure each pigtail contains one or two fibers (simplex or duplex). Provide lengths sufficient to provide 2 feet of slack after installation.

6. Fiber Optic Jumper.

A. Ensure jumpers meet the requirements for pigtails and have a connector on each end of the appropriate type.

B. Provide lengths that ensure sufficient slack after installation to avoid undue force on connectors and to facilitate the ease of maintenance work.

7. Wall-Mounted Splice Enclosure, Small.

A. Provide a small splice enclosure made for wall or Deutsches Institut für Normung (DIN)-rail mounting that meets the following requirements:

(1) Approximately 9 inches wide by 9 inches high by 4 inches deep;

(2) Made of powder-coated aluminum or 16-guage steel;

(3) Has hinged front door;

(4) Designed to be hung from two hooks on a panel or wall;

(5) Designed to hold two splice trays or single-slot modules (cassette), with 24 fusion splices per tray.

B. Provide two 24-splice trays or two 24-single-slot modules with each enclosure.

C. Provide means for anchoring two incoming cables and the outgoing pigtails. The pigtails may be anchored to the splice trays or single-slot modules.

8. Fiber Optic Hardware Assembly.

A. Designate one hardware assembly per terminated fiber cable.

B. Ensure the hardware assembly is labeled based on the terminated fiber designation.

9. Fiber Optic Hardware Assembly, Small. Provide a small (minimum of 24 fibers up to 48 fibers) rack-mounted interconnect center with built-in patch panel, splice enclosure, splice trays or single-slot modules, and all splicing hardware.

A. An interconnect center is defined herein as a splice and termination enclosure, that houses the internal patch panel for fiber termination via fiber optic pigtail. Ensure the interconnect center is capable of housing the splice trays or single-slot modules for fiber optic splicing.

B. Ensure the interconnect center enclosure has brackets and all other hardware required for rack mounting in an Electronic Industries Alliance (EIA) standard 19-inch equipment rack. Ensure it takes up no more than one rack unit (RU) (1¾ inch) in the cabinet. Ensure it has front and rear doors. Ensure it is made of powder-coated aluminum or 16-guage steel.

C. Provide enough trays or single-slot modules for all splices made in the interconnect

center. Ensure the interconnect center enclosure's patch panel has at least 24 positions, compatible with the connectors specified in subsection b.4 of this special provision. Ensure it has provisions for cable strain relief and for connector labeling.

D. Hold the spliced fibers in splice trays or single-slot modules, with each fiber neatly secured to the tray or module. Ensure the splice trays or single-slot modules are compatible with the fiber optic splices specified herein and meets the following minimum requirements:

(1) Ensure the tray or module can accommodate loose tube buffers;

(2) Ensure slack fiber within the tray or module is placed neatly in an oval shape along an inside wall;

(3) Provide splice trays or single-slot modules designed for an outdoor enclosure; and

(4) Ensure the single-slot module is a fixed solution with no moving parts.

10. Fiber Optic Hardware Assembly, Medium. Provide a medium (minimum of 48 fibers up to 96 fibers) rack-mounted interconnect center per requirements in section b.8 of this special provision. Ensure it takes up no more than two RU in the cabinet.

11. Fiber Optic Hardware Assembly, Large. Provide a large (minimum of 144 fibers up to 288 fibers) rack-mounted interconnect center per requirements in section b.8 of this special provision. Ensure it takes up no more than four RU in the cabinet.

12. Wall-Mounted Fiber Optic Storage Cabinet.

A. Provide a wall-mounted fiber optic storage cabinet for storage of fiber optic slack cable during initial installation and future cable management.

B. Ensure the storage cabinet has at least four cable entry holes.

C. Size the storage cabinet to accommodate at minimum 500 feet of fiber optic cable slack.

D. Design the storage cabinet for indoor use. Ensure the cabinet has a powder-coat finish and is made of aluminum.

13. Fiber Optic Splice Cabinet. Provide splice cabinets at locations shown on the plans.

A. Provide a fiber optic splice cabinet that meets *NEMA 250 Enclosure Type 3R* requirements with minimum dimensions of 46 inches high by 24 inches wide by 20 inches deep. Ensure the cabinet is furnished with an *EIA* standard 19-inch equipment rack and is fully compatible with the rack-mounted interconnect centers.

B. Design the fiber optic splice cabinet to be mounted on a pedestal as shown on the plans.

C. Ensure the foundation and pedestal for the splice cabinet conforms to the

requirements for traffic signal pedestals in sections 820 and 921 of the Standard Specifications for Construction.

D. Construct all cabinets from 1/8 inch 5052 aluminum. Provide a cabinet with a white polyester powder coat finish on both the interior and exterior

E. Provide an engraved plaque on the front door, displaying the cabinet ID indicated on the plans. Ensure characters are at least 4 inches high with a minimum stroke width of 0.4 inches unless smaller characters are required to fit the ID on one line. Provide a plaque made of multilayered plastic with a black surface over a white interior; the engraving will reveal the white interior.

F. Provide continuous gas tungsten arc (TIG) welding for all external welds. Use the gas metal arc (MIG) or TIG welding method for all internal welds.

G. Provide two removable lifting eyes, each rated to 1,000 pounds, on either side of the top of the cabinet. Each eye must have a minimum internal diameter of 3/4 inch.

H. Doors.

(1) Ensure front and rear access doors are of same metal grade and finish as the cabinet body.

(2) Hinges are to be approximately 1/8 inch stainless steel piano hinge or continuous door length stainless steel hinges to provide a rigid and strong door construction.

(3) Ensure hinge pin stops are welded on top and bottom to prevent tampering.

(4) Mount hinges on internal side of door, so that hinges cannot be removed without first opening the door.

(5) Ensure the two-position door stop allows the door to remain open at the 90 degree position and at the 120 or 180 degree positions.

(6) Mount the door stop to the top or bottom of the door.

(7) Ensure each door has a 3-point locking/latching mechanism.

(a) Provide three latch points - center, top, and bottom of each door.

(b) Ensure that the latch points do not move until the cabinet door is unlocked.

(c) Use stainless steel locking bars for the top and bottom latch points capable of resisting manual prying.

(d) Provide nylon rollers on the top and bottom locking bar ends.

(e) Provide an industrial standard pin tumbler lock (Corbin lock), keyed #2, with two keys per locking mechanism.

(f) Door handle and locking mechanism may be separate.

(g) Provide locking eyes on handle and door, for each door such that a padlock may be installed.

I. Provide a louvered vent near the bottom of each door capable of deflecting water and directing incoming air downward towards the bottom of the cabinet. Provide a reusable-washable filter that will be placed inside the door vents.

J. Provide R-4 insulation on interior sides, top, and both doors.

14. Fiber Optic Tracer Wire.

A. Provide fiber optic tracer wire at locations as indicated on the plans and as directed by the Engineer.

B. Ensure the tracer wire is a single conductor solid copper, American Wire Gauge (AWG) 14/1, gauge size 14, underground, UL Rated.

C. Insulate the tracer wire using High Molecular Weight Polyethylene (HMWPE) meeting *ASTM D1248* or High-Density Polyethylene (HDPE) as approved by the Engineer and be an orange jacket color.

D. Ensure wire connectors are 3M DBR, IDEAL UnderGround, or approved equal, and are watertight to provide electrical continuity.

E. Ensure the tracer wire is accessed/connectorized from each handhole.

F. Install minimum 6 feet tracer wire slack at each head end of tracer wire.

c. Construction.

1. Cable Pulling.

A. Install the cable such that the optical and mechanical characteristics of the fiber are not degraded.

B. Do not violate the minimum bend radius or the maximum tension, both during and after installation. Corner rollers (wheels), if used, must not have radii less than the minimum installation bending radius of the cable. A series array of smaller wheels can be used for accomplishing the bend if the cable manufacturer specifically approves the array.

C. Use a clutch device to ensure the allowable pulling tension is not exceeded, if the cable is pulled by mechanical means. Also, attach a strain gauge to the pulling line at the cable exit location, and at a sufficient distance from the take-up device such that the strain gauge can be read throughout the entire cable pulling operation.

D. Do not leave the let-off reel unattended during a pull to minimize the chance of applying excess force, center pull, or back feeding.

E. Use entry guide chutes to guide the cable into the pull-box conduit ports.

F. Only lubricants approved by the cable manufacturer are permitted. Wipe the exposed cable in a pull box, junction box, or cabinet clean of cable lubricant with a cloth, after the cable has been installed.

G. Use separate grooved rollers for each cable, when simultaneously pulling fiber optic cable with other cables.

H. Seal the fiber optic cable ends to prevent the entry of water.

I. Install above ground fiber optic markers every 500 feet and also where the cable changes direction.

J. Install fiber optic tracer wire at locations as indicated on the plans.

2. Cable Slack Requirements. Throughout the cable plant, pull and store excess cable slack at designated intervals. These intervals must occur at each handhole. Table 1 identifies the minimum cable slack requirements.

Table 1. Cable Slack Requirements by Handhole Type

Handhole Type	Minimum Slack Length, Feet
HH, Round, 3 foot diameter (36 inches)	50
HH, Type D	100

3. Optical Splicing Requirements.

A. Use a fusion splicer that automatically positions the fibers using the Light Injection and Detection (LID) system when making splices.

B. Package each spliced fiber in a heat-shrinkable splice protection sleeve with strength member. Cover the splice and any bare fiber stripped of its coating with the protective sleeve. Completely re-coat bare fibers with a protective gel or similar substance, prior to application of the sleeve or housing to protect the fiber from scoring, dirt, or microbending. The use of Room Temperature Vulcanizing (RTV) or silicone sealants is strictly prohibited.

C. Do not splice fibers from a given buffer tube in multiple splice trays or single-slot modules.

D. Furnish and install a fiber optic splice cabinet for end-to-end fusion splicing and at other locations shown on the plans. End-to-end splicing at locations not shown on the plans is permitted only when cable distance exceeds maximum reel length and must be approved by the Engineer. Pull cables into splice cabinet such that the bending radius of the fiber is not compromised.

E. No splice is acceptable with an attenuation of greater than 0.06 dB. Test all fibers spliced, end-to-end once all fibers have been terminated, unless otherwise indicated on the plans. If a splice is measured to exceed 0.06 dB during the splicing process, it must be remade until its loss falls below 0.06 dB, unless otherwise approved by the Engineer. Record each attempt for purposes of acceptance.

F. Terminate fibers by splicing them to factory-made pigtails or matching fibers as shown on the plans. Cap all connectors that are not connected to a mating connector.

4. Fiber Acceptance Testing.

A. The basis of fiber acceptance is testing using an optical loss test set (OLTS).

B. Test the fiber after installation, including all splicing and termination, is complete. Note, however, that this test procedure involves measuring the optical loss of any fiber installed by others, prior to splicing to it.

C. For each fiber optic link, including spare fibers, determine whether the optical loss is within the limits permitted by this special provision. A link is defined as a continuous segment of fiber between one connector and another connector.

D. When testing links that do not have connectors on both ends, use a mechanical splice to attach a pigtail to the unterminated fiber for the duration of the test. Mechanical splices will not be measured for separate payment.

E. For each fiber link, follow this procedure:

(1) If the link includes fiber installed by others, measure and record the optical loss over that portion of the link before it is spliced to new fiber.

(2) Calculate the maximum allowable loss for the completed link, both at 1310 nm and 1550 nm. Use the following formula:

MAL = MLL + OFL + FSL + MSL + CL

Where:

MAL = Maximum Allowable Loss (calculate at both 1310 nm and 1550 nm)

MLL = Maximum Link Loss for cable portions installed by others

OFL = Outdoor Fiber Length in km multiplied by (0.35 dB for 1310 nm and 0.25 dB for 1550 nm)

FSL = Number of fusion splices multiplied by 0.06 dB

MSL = Number of mechanical splices multiplied by 0.3 dB

CL = Number of Connections multiplied by 0.3 dB

Provide this calculation to the Engineer along with the test results.

(3) Calibrate an OLTS and provide evidence satisfactory to the Engineer that the set produces accurate results at both wavelengths. This can be a demonstration that the set correctly measures the loss of a test fiber whose loss is known.

(4) Use the OLTS to measure the loss of the link under test. Record the results at both 1310 nm and 1550 nm, and submit a summary to the Engineer in a tabulated format.

(5) If the measured loss exceeds the calculated maximum, use an Optical Time Domain Reflectometer (OTDR) and other test equipment to troubleshoot the link. Take whatever corrective action is required, including cable replacement, to achieve a loss less than the calculated maximum.

F. Fiber Optic Tracer Wire Testing.

(1) Perform a continuity test on all tracer wire. If the tracer wire is found to be not continuous after testing, repair or replace the failed segment of the wire.

(2) Perform the test using a transmitter and tracer provided by MDOT or approved equal. Arrange for the test to be witnessed by the Engineer.

5. Documentation. Provide a spreadsheet showing the maximum allowable loss and the actual loss calculations per link. The actual loss must be the one measured after all corrective actions have been taken. If required by the plans, provide an OTDR trace for all fibers to document the location of the sources of optical loss in the cable. In the same spreadsheet provide the test results for the fiber optic links as described in subsection c.4.E of this special provision.

6. Warranties. Furnish warranty and other applicable documents from the manufacturer, and a copy of the invoice showing the date of shipment, to the Engineer prior to final written acceptance.

A. Provide fiber optic cable (inside and outside plant) with a standard manufacturer's warranty, transferable to MDOT. The fiber optic cable must carry a warranty (parts and labor) of 1 year from the date of shipment with at least 6 months of warranty remaining at the start of burn-in.

B. Provide above ground fiber optic marker with a standard manufacturer's warranty, transferable to MDOT. The fiber optic marker must carry a warranty (parts and labor) of 1 year from the date of shipment with at least 6 months of warranty remaining at the start of burn-in.

C. Provide fiber optic connectors, pigtails, and jumpers with a standard manufacturer's warranty, transferable to MDOT. The fiber optic connectors, pigtails, jumpers must carry a warranty (parts and labor) of 2 years from the date of shipment with at least 1 years of warranty remaining at the start of burn-in. The fiber optic connectors, pigtails, and jumpers must carry an additional parts-only (no labor) warranty of 5 years from the date of shipment with a least 4 years remaining at the start of burn-in.

D. Provide wall-mounted splice enclosure with a standard manufacturer's warranty, transferable to MDOT. The splice enclosure must carry a warranty (parts and labor) of 2 years from the date of shipment with at least 1 year of warranty remaining at the start of burn-in.

E. Provide fiber optic hardware assembly with a standard manufacturer's warranty,

transferable to MDOT. The hardware assembly must carry a warranty (parts and labor) of 2 years from the date of shipment with at least 1 year of warranty remaining at the start of burn-in.

F. Provide wall-mounted fiber optic storage cabinet with a standard manufacturer's warranty, transferable to MDOT. The storage cabinet must carry a warranty (parts and labor) of 1 years from the date of shipment with at least 6 months of warranty remaining at the start of burn-in.

G. Provide fiber optic splice cabinet with a standard manufacturer's warranty, transferable to MDOT. The splice cabinet must carry a warranty (parts and labor) of 1 years from the date of shipment with at least 6 months of warranty remaining at the start of burn-in.

H. Provide fiber optic tracer wire with a standard manufacturer's warranty, transferable to MDOT. The splice cabinet must carry a warranty (parts and labor) of 1 years from the date of shipment with at least 6 months of warranty remaining at the start of burn-in.

d. Measurement and Payment. The completed work, as described, will be measured and paid for at the contract unit price using the following pay items:

Pay Item	**Pay Unit**
Fiber Optic, Cable, Single Mode Fiber, __Strand	Foot
Fiber Optic, Cable, Indoor, Single Mode Fiber, __Strand	Foot
Fiber Optic, Splice Enclosure, Wall-Mtd, Small	Each
Fiber Optic, Splice Cabinet	Each
Fiber Optic, Pigtail	Each
Fiber Optic, Jumper	Each
Fiber Optic, Hardware Assembly, (size)	Each
Fiber Optic, Storage Cabinet, Wall-Mtd	Each
Fiber Optic, Marker, Above Ground	Each
Tracer Wire	Foot

1. **Fiber Optic, Cable, Single Mode Fiber, __Strand** includes furnishing and installing outdoor-rated fiber optic cable and all fusion splicing as shown on the plans. Number of fibers will be as indicated on the plans.

2. **Fiber Optic, Cable, Indoor, Single Mode Fiber, __Strand** includes furnishing and installing plenum-rated indoor fiber optic cable, fusion splicing, and all hardware required for splicing indoor/outdoor cables and to facilitate cable installation. Number of fibers will be as indicated on the plans.

3. **Fiber Optic, Splice Enclosure, Wall-Mtd, Small** includes furnishing and installing a small (up to 48 fibers) wall-mounted or din-rail mounted interconnect center (splice enclosure, and splice trays or single-slot modules).

4. **Fiber Optic, Splice Cabinet** includes furnishing and installing a pedestal mounted cabinet, pedestal, and pedestal foundation at locations as indicated on the plans.

5. **Fiber Optic, Pigtail** includes furnishing and installing a single mode fiber pigtail and includes the associated fusion splicing.

6. **Fiber Optic, Jumper** includes furnishing and installing a single mode fiber optic jumper.

7. **Fiber Optic, Hardware Assembly, Small** includes furnishing and installing a small (up to 48 fibers) rack-mounted interconnect center (includes built in patch panel, splice enclosure, and splice trays or single-slot modules).

8. **Fiber Optic, Hardware Assembly, Medium** includes furnishing and installing a medium (up to 96 fibers) rack-mounted interconnect center (includes built in patch panel, splice enclosure, and splice trays or single-slot modules).

9. **Fiber Optic, Hardware Assembly, Large** includes furnishing and installing a large (up to 288 fibers) rack-mounted interconnect center (includes built in patch panel, splice enclosure, and splice trays or single-slot modules).

10. **Fiber Optic, Storage Cabinet, Wall-Mtd** includes furnishing and installing a plain storage cabinet for the fiber optic cable slack.

11. **Fiber Optic, Marker, Above Ground** includes furnishing and installing markers at intervals and locations as described in this special provision and on the plans.

12. **Tracer Wire** includes furnishing, installing, and testing tracer wire at locations as described and/or shown on the plans.