STATE OF OHIO
DEPARTMENT OF TRANSPORTATION

SUPPLEMENTAL SPECIFICATION 904
FIBER OPTIC CABLE AND COMPONENTS

October 19, 2018

904.01 Fiber Optic Cable. Furnish loose-tube, single-mode, step-index dielectric cable, manufactured in the United States.

Cable shall be 8.1-8.3/125 um loose buffer, single-mode, step index optical fiber cable containing glass of type, Corning SMF-28e, AFL SR-15e, or approved equal, and that meets the following specifications:

1. ITU-T G.652 (Categories A, B, C and D)
2. IEC Specification 60793-2-50 Type B1.3
3. TIA/EIA 492-CAAB
4. Telecordia GR-20

All cables shall be free of material or manufacturing defects and dimensional non-uniformity that would:

Interfere with the cable installation using accepted cable installation practices.
Degrade the transmission performance and environmental resistance after installation.
Inhibit proper connection to interfacing elements.
Otherwise yield an inferior product.

A. Mechanical and Performance Requirements. The cable shall be a rugged <u>all dielectric</u> outdoor cable containing color coded buffer tubes with 12 single mode color-coded fibers per-buffer tube, dual window (1310 nm and 1550 nm) fibers with UV acrylate coating in color coded,

gel-free, loose buffer tubes with the maximum outer diameter as shown in the chart below based on cable strand count.

Fiber Count	Maximum Outside Diameter (Inches)
6	0.45
12	0.45
24	0.45
48	0.45
72	0.45
144	0.65
288	0.75

Strand the loose buffer tubes around an all-dielectric center strength element using a reverse oscillation lay, wrapped by water blocking core separator or functional equivalent.

The maximum allowable attenuation of the fiber is .35 dB/km for 1310 nm and .25 dB/km for 1550 nm.

Each buffer tube shall contain a water blocking element for water-blocking protection.

No water blocking yarns are permitted to avoid accidentally cutting fibers.

The water blocking elements shall be non-nutritive to fungus, electrically non-conductive, and homogeneous; it shall also be free from dirt or foreign matter.

This water blocking element will preclude the need for other water-blocking material; the buffer-tube shall be gel-free.

Apply water swellable tape longitudinally around the outside of the stranded tubes/fillers.

The water swellable tape shall be non-nutritive to fungus, electrically non-conductive, and homogenous.

It shall also be free from dirt and foreign matter.

The cable manufacturer shall be TL 9000 registered.

The optical fiber cable shall withstand water penetration when tested with a one-meter static head or equivalent continuous pressure applied at one end of a one-meter length of filled cable for one hour.

No water shall leak through the open cable end.

Perform testing in accordance with EIA-455-82B.

B. Outer Jacket. Cables shall be all dielectric cable (with no armoring) and shall be jacketed (sheathed) with medium density polyethylene as defined by ASTM D1248, Type II, Class C, Category 4 and Grades J4, E7 and E8.

If the project plans require armored cable, the cable shall have two jackets, one molded to the outside of the armor and one that floats freely within the armor and contains the buffer tubes and other fiber optic cable construction components as required.

Apply jacketing material directly over the tensile strength members to provide mechanical protection, and to serve as the primary moisture barrier.

Design cable sheath to meet or exceed the tensile criteria defined in EIA-455-89a.

Each jacketed fiber shall have a tensile strength in excess of 50 lbs.

The polyethylene shall contain carbon black to provide ultra-violet light protection, and it shall not promote the growth of fungus.

Ensure the jacket or sheath is free of any holes, splits, or blisters.

The cable jacket shall contain no metal elements and shall be of a consistent thickness.

The cable shall contain at least one ripcord under the sheath for easy sheath removal.

C. Crush Resistance. The non-armored optical fiber cables shall withstand a compressive load of 220 N/cm applied uniformly over the length of the cable.

The average increase in attenuation for the fibers shall be ≤ 0.10 dB at 1550 nm for a cable subjected to this load.

The cable shall not exhibit any measurable increase in attenuation after load removal.

Testing shall be in accordance with EIA-455-41, "compressive loading resistance of fiber optic cable," except that the load shall be applied at the rate of 3 mm to 20 mm per minute and maintained for 10 minutes.

Submit the manufacturer's certification for approval.

D. Cyclic Flexing. The cable shall be capable of withstanding 25 cycles of mechanical flexing at a rate of 30 ± 1 cycles/minute.

The average increase in attenuation for the fibers shall be ≤ 0.10dB at 1550 nm at the completion of the test.

Outer cable jacket cracking or splitting observed under 10x magnification shall constitute failure.

Conduct the test in accordance with EIA-455-104, except that the sheave diameter shall be a maximum diameter of 20 times the cable outer diameter (O.D.).

Test the cable in accordance with test conditions I and III of EIA-455-104.

The cable shall withstand 25 impact cycles.

The average increase in attenuation for the fibers shall be ≤ 0.20dB at 1550 nm (single-mode).

The cable jacket shall not exhibit evidence of cracking or splitting. The test shall be conducted in accordance with EIA/TIA-455-25A.

Submit the manufacturer's certification for approval.

E. Tensile Strength. Provide tensile strength by high tensile strength aramid yarns and fiberglass, which shall be helically stranded evenly around the cable core.

The cable shall withstand a tensile load of 2700 Newtons (N) [600 lbs.] without exhibiting an average increase in attenuation of greater than 0.10dB.

Conduct test in accordance with EIA-455-33A, using a maximum mandrel and sheave diameter of 560 mm.

Apply load for one hour in test condition II of EIA-455-33A.

The optical fiber cable shall withstand a maximum pulling tension of 2700N (600 lbs.) during installation (short term) with no damage and 845N (190 lbs.) installed (long term).

Submit the manufacturer's certification for approval.

F. Temperature. The shipping, storage, installation, and operating temperature range of the cable shall meet or exceed -20 °F to +155 °F (-29 °C to +60°C).

G. Loose Buffer. Contain single-mode fibers in a loose buffer tube.

The configuration shall be dimensionally sized to minimize local stresses and microbend losses.

Buffer tubes shall be 2.5mm in outer diameter.

The optical fiber cable shall be an approved product of the U.S. Department of Agriculture, Rural Electrification Administration in accordance with the requirements of REA-PE-90, or as otherwise indicated, and shall conform to EIA/TIA-598.

Each optical fiber shall consist of a doped silica core surrounded by a concentric silica cladding.

Buffer tubes shall be polypropylene.

Include fillers in the cable core to lend symmetry to the cable cross section where needed.

The central anti-buckling member shall consist of a glass reinforced plastic rod; the purpose of the central member is to prevent buckling of the cable.

H. Colors. All optical fibers shall be identifiable by standard color codes as defined in EIA/TIA-598. Each fiber shall be distinguishable, as determined by the maintaining agency, from others by means of color coding and shall conform to the following EIA/TIA sequence of colors:

1. Blue	7. Red
2. Orange	8. Black
3. Green	9. Yellow
4. Brown	10. Violet
5. Slate	11. Rose
6. White	12. Aqua

The colors shall be in accordance with the Munsell color shades.

The fiber coloring shall be an ultraviolet (UV) curable ink which is applied to the outside of the optical fiber protective coating layer and shall not be an integral component of the coating layer itself in order to produce more distinguishable colored fiber.

Buffer tubes containing fibers shall also be color-coded with distinct and recognizable colors according to the following sequence of colors:

1. Blue	13. Blue with black tracer
2. Orange	14. Orange with black tracer
3. Green	15. Green with black tracer
4. Brown	16. Brown with black tracer
5. Slate	17. Slate with black tracer
6. White	18. White with black tracer
7. Red	19. Red with black tracer
8. Black	20. Black with white tracer or black with yellow tracer
9. Yellow	21. Yellow with black tracer
10. Violet	22. Violet with black tracer
11. Rose	23. Rose with black tracer
12. Aqua	24. Aqua with black tracer

The color formulation shall be compatible with the fiber coating and be heat stable.

Color formulation shall not fade or smear or be susceptible to migration and it shall not affect the transmission characteristics of the optical fibers and shall not cause fibers to stick together.

I. Cable Marking. The fiber optic cable outer jacket shall be capable of being marked by the vendor, on a project-by-project basis, with manufacturer's name, the year of manufacture, the words "optical fiber cable", fiber count, type of fiber, the name of the cable owner (e.g., "ODOT I.T.S."), Project ID number ("PID # xxxxx") and sequential linear foot markings.

Repeat the markings every 3 feet.

The actual length of the cable shall be within -0/+1% of the length marking.

The marking shall be in a contrasting color to the cable jacket.

The marking shall be 2.5 mm in height and must be permanent weatherproof and shall not wear off during the installation in the underground conduit system.

J. Quality Assurance Provision. The fiber optic cable shall meet or exceed the requirements of this specification when measured in accordance with the methods of the individual requirements or the following methods as defined in EIA-455-A:

1. Fiber dimensions
2. Attenuation
3. Numerical aperture
4. Fiber proof test
5. Crush resistance
6. Cable bending
7. Tensile load
8. Impact resistance
9. Attenuation vs. Temperature

904.02 Air-Blown/Pushable Fiber Optic Cable. Furnish bend-insensitive G.657.A1 or G.657.A2, single-mode, step-index dielectric cable, manufactured in the United States.

Cable shall be 8.1-8.3/125 um single-mode, bend-insensitive optical fiber cable containing glass of type, Corning SMF-28e, AFL SR-15e, or approved equal, and that meets the following specifications:

ITU-T G.652 (Categories A, B, C and D)
IEC Specification 60793-2-50 Type B1.3
TIA/EIA 492-CAAB
Telecordia GR-20

All cables shall be free of material or manufacturing defects and dimensional non-uniformity that would:

Interfere with the cable installation using manufacturer recommended cable installation methods.
Degrade the transmission performance and environmental resistance after installation.
Inhibit proper connection to interfacing elements.
Otherwise yield an inferior product.

A. Mechanical and Performance Requirements. The cable shall be a rugged all dielectric outdoor cable containing color coded buffer tubes / binders with 12 single mode color-coded fibers per binder, dual window (1310 nm and 1550 nm) fibers with UV acrylate coating in color coded, buffer tubes or binders with the maximum outer diameter as shown in the chart below based on cable strand count.

Fiber Count	Maximum Outside Diameter (Inches)
6	0.125
12	0.3
24	0.3
48	0.3
72	0.3
144	0.33
288	0..41
432	0.5

The buffer tubes / binders shall be stranded around an all-dielectric center strength element using a reverse oscillation lay, wrapped by water blocking core separator or functional equivalent.

The maximum allowable attenuation of the fiber is .35 dB/km for 1310 nm and .25 dB/km for 1550 nm.

No water blocking yarns are permitted to avoid accidentally cutting fibers.

The water blocking elements shall be non-nutritive to fungus, electrically non-conductive, and homogeneous; it shall also be free from dirt or foreign matter.

This water blocking element will preclude the need for other water-blocking material.

The cables shall include GR-20 compliant water-blocked cable core and buffer tubes / binders.

The cable components shall be non-nutritive to fungus, electrically non-conductive, and homogenous.

It shall also be free from dirt and foreign matter.

The cable manufacturer shall be TL 9000 registered.

The optical fiber cable shall withstand water penetration when tested with a one-meter static head or equivalent continuous pressure applied at one end of a one-meter length of filled cable for one hour.

No water shall leak through the open cable end.

Perform testing in accordance with EIA-455-82B.

B. Outer Jacket. Cables shall be all dielectric cable (with no armoring) and shall be jacketed (sheathed) with Polybutylene Terephthalate or High-Density PolyEthylene.

Jacketing material shall be applied directly over the tensile strength members to provide mechanical protection, and to serve as the primary moisture barrier.

This cable sheath shall be designed to meet or exceed the tensile criteria defined in EIA-455-89a.

Each jacketed fiber shall have a tensile strength in excess of 50 lbs.

The jacketing shall contain carbon black to provide ultra-violet light protection, and it shall not promote the growth of fungus.

The jacket or sheath shall be free of any holes, splits, or blisters.

The cable jacket shall contain no metal elements and shall be of a consistent thickness.

The cable shall contain at least one ripcord under the sheath for easy sheath removal.

C. Crush Resistance. The non-armored optical fiber cables shall withstand a compressive load of 220 N/cm applied uniformly over the length of the cable.

The average increase in attenuation for the fibers shall be ≤ 0.10 dB at 1550 nm for a cable subjected to this load.

The cable shall not exhibit any measurable increase in attenuation after load removal.

Perform testing in accordance with EIA-455-41, "compressive loading resistance of fiber optic cable," except that the load shall be applied at the rate of 3 mm to 20 mm per minute and maintained for 10 minutes.

Submit the manufacturer's certification for approval.

D. Cyclic Flexing. The cable shall be capable of withstanding 25 cycles of mechanical flexing at a rate of 30 ± 1 cycles/minute.

The average increase in attenuation for the fibers shall be ≤ 0.10dB at 1550 nm at the completion of the test.

Outer cable jacket cracking or splitting observed under 10x magnification shall constitute failure.

Conduct the test in accordance with EIA-455-104, except that the sheave diameter shall be a maximum diameter of 20 times the cable outer diameter (O.D.).

Test the cable in accordance with test conditions I and III of EIA-455-104.

The cable shall withstand 25 impact cycles.

The average increase in attenuation for the fibers shall be ≤ 0.20dB at 1550 nm (single-mode).

The cable jacket shall not exhibit evidence of cracking or splitting. The test shall be conducted in accordance with EIA/TIA-455-25A.

Submit the manufacturer's certification for approval.

E. Tensile Strength. Tensile strength shall be provided by high tensile strength aramid yarns and fiberglass, which shall be helically stranded evenly around the cable core.

The cable shall withstand a tensile load of 1334 Newtons (N) [300 lbs.] without exhibiting an average increase in attenuation of greater than 0.10dB.

Apply the load for one hour in test condition II of EIA-455-33A.

The optical fiber cable shall withstand a maximum pulling tension of 1334N (300 lbs.) during installation (short term) with no damage and 400N (90 lbs.) installed (long term).

Submit the manufacturer's certification for approval.

F. Temperature. The shipping, storage, installation, and operating temperature range of the cable shall meet or exceed 14 °F to +158 °F (-10°C to +70°C).

G. Bend-Insensitive. Single-mode fibers shall be contained in color-coded binders.

The configuration shall be dimensionally sized to minimize local stresses and microbend losses.

The optical fiber cable shall be an approved product of the U.S. Department of Agriculture, Rural Electrification Administration in accordance with the requirements of REA-PE-90, or as otherwise indicated, and shall conform to EIA/TIA-598.

Each optical fiber shall consist of a doped silica core surrounded by a concentric silica cladding.

The central anti-buckling member shall consist of a glass reinforced plastic rod; the purpose of the central member is to prevent buckling of the cable.

H. Colors. All optical fibers shall be identifiable by standard color codes as defined in EIA/TIA-598. Each fiber shall be distinguishable, as determined by the maintaining agency, from others by means of color coding and shall conform to the following EIA/TIA sequence of colors:

1. Blue	7. Red
2. Orange	8. Black
3. Green	9. Yellow
4. Brown	10. Violet
5. Slate	11. Rose
6. White	12. Aqua

The colors shall be in accordance with the Munsell color shades.

The fiber coloring shall be an ultraviolet (UV) curable ink which is applied to the outside of the optical fiber protective coating layer and shall not be an integral component of the coating layer itself in order to produce more distinguishable colored fiber.

Buffer tubes containing fibers shall also be color-coded with distinct and recognizable colors according to the following sequence of colors:

1. Blue	13. Blue with black tracer
2. Orange	14. Orange with black tracer
3. Green	15. Green with black tracer
4. Brown	16. Brown with black tracer
5. Slate	17. Slate with black tracer
6. White	18. White with black tracer
7. Red	19. Red with black tracer
8. Black	20. Black with white tracer or black with yellow tracer
9. Yellow	21. Yellow with black tracer
10. Violet	22. Violet with black tracer
11. Rose	23. Rose with black tracer
12. Aqua	24. Aqua with black tracer

The color formulation shall be compatible with the fiber coating and be heat stable.

Color formulation shall not fade or smear or be susceptible to migration and it shall not affect the transmission characteristics of the optical fibers and shall not cause fibers to stick together.

I. Cable Marking. The fiber optic cable outer jacket shall be capable of being marked by the vendor, on a project-by-project basis, with manufacturer's name, the year of manufacture, the words "optical fiber cable", fiber count, type of fiber, the name of the cable owner (e.g., "ODOT I.T.S."), Project ID number ("PID # xxxxx") and sequential linear foot markings.

The markings shall be repeated every 3 feet.

The actual length of the cable shall be within -0/+1% of the length marking.

The marking shall be in a contrasting color to the cable jacket.

The marking shall be 2.5 mm in height and must be permanent weatherproof and shall not wear off during the installation in the underground conduit system.

J. Quality Assurance Provision. Fiber optic cable shall meet or exceed the requirements of this specification when measured in accordance with the methods of the individual requirements or the following methods as defined in EIA-455-A:

1. Fiber dimensions
2. Attenuation
3. Numerical aperture
4. Fiber proof test
5. Crush resistance
6. Cable bending
7. Tensile load
8. Impact resistance
9. Attenuation vs. Temperature

904.03 Micro-Duct Pathway. Furnish and install a micro-duct pathway for the purpose of installing air-blown / pushable fiber optic cable.

All components of the pathway shall be constructed of clean virgin high density polyethylene (HDPE) conforming to ASTM D3350-98a, Type III, Category 5, Class B or C and Grade P-34 per ASTM D1248-84 or equivalent.

The pathways may consist of multiple micro-ducts within a single jacketed duct.

All micro-duct oversheathing shall be orange in color and shall include a locate wire.

The locate wire shall be installed in the pathway and shall not be permitted to be located within a micro-duct.

All micro-ducts and oversheathing are to be flexible, lightweight, durable, corrosion resistant, non-conductive and easy to install. Micro-ducts and oversheath shall be constructed of polymeric materials. All micro-ducts are to be smooth on the outside, micro-ribbed on the inside, and have a co-extruded permanent lubrication layer. All oversheathing shall be smooth.

Provide a silicone lubricated co-extruded permanent layer of uniform thickness, containing active or polymeric materials which provide a permanent low friction boundary layer between the micro-duct and cable for a minimum service life of 15 years for the micro-duct. All micro-duct included in the pathway shall be equipped with silicone super slick permanent liner.

All micro-duct and oversheath shall be free from holes, blisters, inclusions, cracks, or other imperfections, which would affect the performance or serviceability

The micro-duct and oversheath shall be homogenous throughout and free from dimensional non-conformities as much as possible within the manufacturing process.

Micro-Duct Specifications:

Micro-Duct Size	12.7/10	22/16
Outside Diameter	12.7mm	21.3mm
Wall thickness	1.05-1.4mm	1.3-1.4mm
Inside Diameter	10mm ± 0.3	15.5 mm

The micro-duct pathway shall contain micro-ducts dissimilar in color and be provided in the following configurations:

A. 7-Cell Pathway
This pathway shall consist of 7 micro-ducts in a single oversheathed pathway and shall be sized as follows:
7 micro-ducts sized at 22 mm OD and 16 mm ID

B. 4-Cell Pathway
This pathway shall consist of 4 micro-ducts in a single oversheathed pathway and shall be sized as follows:
4 micro-ducts sized at 22 mm OD and 16 mm ID

C. 2-Cell Pathway
This pathway shall consist of 2 micro-ducts in a single oversheathed pathway and shall be sized as follows:
2 micro-ducts sized at 12.7 mm OD and 10 mm ID

D. 1-Cell Pathway
This pathway shall consist of 1 micro-duct in a single oversheathed pathway and shall be sized as follows:
1 micro-ducts sized at 22 mm OD and 16 mm ID

904.04 Reserved for Future Use

904.05 Fan-Out Kit. Furnish a 900um fan-out kit assembly of size twelve fiber capacity.
Minimum length shall be 24 inches. It shall be outdoor-rated for operation with a minimum operating temperature range of -40 °F to +149 °F (-30 °C to +65°C).
Each assembly shall contain a Fan-Out Top, Fan-Out Bottom, Fan-Out Tubing, epoxy, syringe, and insert.

904.06 Drop Cable. All drop cable shall meet the requirements of 904.01, except for 904.01.I, Cable Marking.

All Drop Cable shall be marked by the vendor with the manufacturer's name, year of manufacture, the words "Optical Fiber Cable" or similar, fiber count, type of fiber, and sequential linear foot marking.

Repeat markings every 3 feet.

The actual length of the cable shall be within +/-1% of the length marking.

The marking shall be in contrasting color to the cable jacket, minimum 2.5mm in height, permanent and weatherproof, and shall not wear off during installation in the underground conduit system.

904.07 Fiber Optic Patch Cord. The optical patch cords furnished shall consist of a single fiber jacketed cable equipped with optical connectors at each end.

Each patch cable shall have a unique identification label on each end.

Mark labels in indelible ink and do not crimp, kink or otherwise harm the patch cable.

Equip patch cords for connection between two Fiber Distribution Panels (FDPs) with approved connectors on each end.

The sheath shall be flame retardant and coded NFR in accordance with the national electric code.

The patch cord jacket shall be resistant to ultraviolet radiation.

Optical fiber connectors shall satisfy the interface parameters of the equipment components as defined by the transceiver equipment specifications.

All connectors shall be of Type UPC or APC.

SPC-type connectors are not permitted.

904.08 Fiber Termination Panel. Fiber Termination Panels shall include all materials as described in the respective specifications for NEMA Cabinet types and Caltrans (332,334,336) Cabinet or AASHTO/ITE/NEMA ITS Cabinet types.

A. NEMA Cabinet Type. Fiber termination panels shall house and protect the connectors on each pigtail.

Securely insert the optical connectors on each pigtail in a connector panel that is manufactured to be mated with the LC (UPC) connector type.

The connector panel shall be made by the housing manufacturer and be designed for the specified housing.

Maximum optical loss across the connection shall be 0.25dB.

The fiber optic cable shall be of a sufficient length that will allow the cable to be pulled from the cabinet through conduit to adjacent overhead or underground splice enclosures and fusion spliced to the trunk fiber optic cables as depicted in the communications splicing diagrams, leaving 75 feet of slack at the splice enclosure and 15 feet of slack in the cabinet.

The termination panel shall use LC connectors for the equipment side and specified connectors shall be core-aligned fusion spliced or factory pre-connectorized to the fiber optic drop cable that leads to the splice enclosure.

The fiber termination panel shall be compact, rugged and shelf mountable to ensure secure mounting within existing NEMA controller cabinets and shall be IP-65 rated.

24-fiber termination panels shall mount neatly in the cabinet space as defined by the Traffic Engineer.

48-fiber termination panels may consist of two side-by-side 24-fiber termination panels.

Panel shall be manufactured by Corning, Gatorpatch, AFL, or approved equal.

B. Caltrans (332,334,336) Cabinet or AASHTO/ITE/NEMA ITS Cabinet Type. The fiber termination panel enclosure shall consist of a self-contained metal enclosure including LC style fiber optic connectors and MTP modules (as specified below).

Pre-terminate outdoor rated fiber optic cable to the proper MTP connector (pinned or non-pinned).

In cases where the fiber optic cable has more than 48 strands of fiber the MTP pre-terminated cable shall be of a sufficient length as shown on the plans that will allow the cable to be pulled from the cabinet through conduit to adjacent overhead or underground splice enclosures and fusion spliced to the trunk fiber optic cables as depicted in the communications splicing diagrams, leaving 75 feet of slack at the splice enclosure and 15 feet of slack in the cabinet.

In cases where the fiber optic cable has 48 strands or less the MTP pre-terminated cable shall be 12 feet in length and shall splice into the trunk cable utilizing splice trays in the cabinet. Store splice trays neatly in the termination panel, while allowing easy removal for troubleshooting purposes.

All connector terminations shall be ceramic UPC connectors.

Dimensions of patch panels shall mount inside a standard EIA 19-inch rack.

Patch Panel Enclosures shall be equipped with a locking mechanism for front and back of patch panel assembly to prevent unauthorized access.

Patch Panels shall include MTP modules capable of housing 12-24 fiber optic LC-type connectors. The modules shall interface with the cabinet equipment via LC connectors and the fiber optic trunk cable via MTP connectors. The fiber optic cable shall be secured in a manner that no strain is presented to the MTP connector.

MTP Modules, connectors, patch cables, pre-terminated fiber cables and fusion splices shall be incidental to the fiber termination panel.

904.09 Fiber Optic Connectors. All optical fiber termination components shall meet or exceed the applicable provisions of EIA/TIA-455-A.

All optical fiber connectors shall be of industry standard and of type for single-mode optical fiber and shall meet or exceed the applicable provisions of EIA/TIA-455-2b, EIA/TIA-455-5a, and EIA-455-34. All connectors shall be compliant with industry standard ANSI/TIA/EIA-568B.3. The connector shall comply with TIA/EIA fiber optic connector intermateability standard (FOCIS) document, TIA/EIA-604-3.

Single-mode pigtails shall be provided with factory pre-connectorized single-mode connectors. Connectors shall have a maximum loss of 0.5 dB through each mated pair of single-mode fibers. Each connector shall be capable of 100 repeated matings with maximum increase in splice loss limited to 0.2 dB per connector.

Single mode fiber optic pigtails shall be provided.

Optical fiber cable used for pigtails shall be of the tight buffered type protected by aramid fibers.

The pigtail jacket shall be resistant to ultraviolet radiation.

Connector reflectance shall be measured at the factory to be = -40 dB for super physical contact (SPC), -55 dB for ultra physical contact (UPC), and -60 dB for angle polished contact (APC).

Strain-relief boot color shall be white for SPC, blue for UPC, and green for APC.

Manufacturer shall be ISO 9001 and TL 9000 registered.

All connectors shall be LC-type UPC.
SPC-type connectors are not permitted.

904.10 Splice Enclosure. The splice enclosure shall be weatherproof, corrosion resistant, rodent proof, re-enterable, and crush resistant.

A. Butt Style

The splice enclosure shall easily fit into a 32 inch pull box along with loops of slack cable in box (approximately 150 ft.). The splice enclosure shall be a complete kit including all components and hardware for installation.

The splice enclosure shall be suitable for application in the temperature range of -40 °C to +70 °C.

The splice enclosure shall provide space, allowing entry of fiber optic cable without exceeding the minimum bend radius of the cable.

The enclosure shall have provisions for cable and pigtail strain-relief, and shall be equipped with strain-relief hardware.

The splice enclosure shall be designed to permit selective fiber splicing (looping a backbone cable in and out while only cutting into the desired fibers).

The size of the enclosure shall allow all the fibers of the largest optical fiber trunk cable to be fusion spliced to a second cable of the same size, plus additional pigtails.

The splice enclosure shall allow splicing of all fibers up to the maximum number.

B. In-Line

The splice enclosure shall be of In-Line design so it can be installed aerially between poles.

The splice enclosure shall be a complete kit including all components and hardware for installation.

The splice enclosure shall be suitable for application in the temperature range of -40 °C to +70 °C.

The splice enclosure shall provide space, allowing entry of fiber optic cable without exceeding the minimum bend radius of the cable.

The enclosure shall have provisions for cable and pigtail strain-relief, and shall be equipped with strain-relief hardware.

The splice enclosure shall be designed to permit selective fiber splicing (looping a backbone cable in and out while only cutting into the desired fibers).

The size of the enclosure shall allow all the fibers of the largest optical fiber trunk cable to be fusion spliced to a second cable of the same size, plus additional pigtails.

The splice enclosure shall allow splicing of all fibers up to the maximum number.

904.11 Fiber Optic Media Converter. Operating temperature range shall be -20 °F to +155 °F (-29 °C to +68 °C).

Electrical power for freestanding units shall be provided by NEMA 5-15 compatible plug and/or Class 2 switching power supply with a minimum cord length of 6 feet.

Established and documented MTBF shall be 100,000 hours, minimum.

A. Fiber Optic to Ethernet Media Converter. Converter shall provide RJ-45 interface compatible with 100BaseT-TX: Cat. 5, EIA/TIA-568 100-Ohm UTP cable.

B. Fiber Optic to RS-232 Media Converter. Converter shall provide a RS232 Asynchronous communications channel using a 9-pin D-sub or RJ-45 connector using industry-standard pin configuration or a plug-in module connection to a controller unit.
The FO Module shall be one of the following, per project operational requirements:

1. A free-standing, shelf-mounted enclosed unit.
2. A plug-in module compatible with an ODOT-approved Caltrans or NEMA controller unit, and approved in writing by the manufacturer of the controller.

904.12 Fiber Optic Fusion Splicer. The Fiber Optic Fusion Splicer shall be one of the following types:

1. AFL FSM-70S
2. FITEL S178A version 2
3. SUMITOMO T-55
4. SUMITOMO TYPE-71C+
5. Or Approved Equal, that meets the following minimum specifications as determined by the ODOT Department of Traffic Operations:
   Splicing Method – Core Alignment
   Applicable Fibers – SM, MM, DS, NZ-DS
   Cladding Diameter – 80-125 um
   Splice loss estimation using Core Alignment
   Camera Axis – X and Y
   Typical Splicing time of Single-Mode Fiber less than or equal to 13 seconds
   Operating Temperature – (-10 to +50 C)
   Color LCD Monitor
   High wind velocity protection
   Average Splice Loss (dB) – 0.02 SM, 0.01 MM, 0.04 DS
   Internal Battery w/ AC adapter– capable of performing minimum of 100 splices on full charge
   Ability to download splice data to PC via USB
   Internal Splice Data Storage = 2,000 splice results
   Maximum Dimension (inches) – 8 x 9.5 x 6
   If available, hard carrying case

904.13 Fiber Optic Optical Time Domain Reflectometer (OTDR). The Fiber Optic OTDR shall be one of the following types and shall include adapters for FC, ST, SC, and LC type connectors:

1. AFL M310-25K-01-HC2
2. FLUKE OFP-100-QI
3. Or Approved Equal, that meets the following minimum specifications as determined by the ODOT Department of Traffic Operations:
   Shall have a Built-in Optical Power Meter
   Shall have a Built-in Visual Fault Locator
   Internal Memory storage – 500 traces
   Color Display
   Multi-mode and Single-mode fiber testing capability
   Ability to download splice data to PC via USB

Rugged Construction
If available, hard carrying case
Operating Temperature – (-10 to +45 C)
Li-Ion Battery w/ AC adapter
Digital Fiber Scope for video inspection that is compatible with the UPC and APC types of connectors.
Maximum Dimension (inches) – 11 x 5.5 x 3

904.14 Fiber Optic Cleaver. The Fiber Optic Cleaver shall be one of the following types:

1. AFL CT-30A
2. CORNING FBC-012
3. SUMITOMO FC-7
4. Or Approved Equal, that meets the following minimum specifications as determined by the ODOT Department of Traffic Operations:

    Fiber Blade Life – 24,000
    Fiber scrap collection-free with use of integrated scrap container
    If available, hard carrying case

904.15 Fiber Optic Power Meter. The Fiber Optic Power Meter shall include dual optical light sources (LED / LASER) and shall be one of the following types:

1. AFL OPM4
2. EXFO ELS-50 (235BL & 12C) and EPM-53
3. FLUKE FTK1450
5. Or Approved Equal, that meets the following minimum specifications as determined by the ODOT Department of Traffic Operations:

    Calibration Wavelengths (nm) – 850, 1300, 1310, and 1550
    Include SC, ST, and LC adapters
    Measurement range – (+6 TO -50 dBm)
    Accuracy – ±0.25 dB
    Resolution – 0.01 dB
    Measurement Units –dBm, W
    Power – AA Batteries
    Operating Temperature – (-10 to +50 C)
    Maximum Dimensions (inches) – 7.5 x 4 x 2.5
    If available, hard carrying case

904.16 Fiber Optic Visual Fault Locator. The Fiber Optic Visual Fault Locator shall be one of the following types:

1. AFL VF12-01-0900PR
2. CORNING VFL350
3. FLUKE VisiFault with NF380 adapter
4. Or Approved Equal, that meets the following minimum specifications as determined by the ODOT Department of Traffic Operations:

    Emitter Type – Laser Class II
    Wavelength – 650 nm ± 20 nm
    Maximum Output Power – 1.3 mW (into single-mode fiber)

Modulation – 2-3 Hz or CW selectable
Operating Temperature – (-10 to 40 C)
Maximum Dimensions (inches) – 7 x 2.5 x 1.5
Power – AA or AAA Batteries
Connection Ferrule Diameter – 2.5 mm and 1.25 mm
Compatible Fiber Optic Connectors – SC, LC, and ST
If available, hard carrying case