

2015

City of PSL

PSL USD,PW,MIS



"A City for All Ages"

CITY OF PORT ST LUCIE

FIBER OPTIC NETWORK

Minimum Design Standards and Details

***Appendix H –City of Port St Lucie Utility Systems Department
Minimum Standards Manual***

V1.2 4-2015

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DESIGN

The Engineer of Record shall submit, through the City's Project Manager, the design plans for review to the City at the 60% and 90% plan review.

The plans should include the fiber optic conduit, pull box, and splice box location. The size of the conduit, fiber size and type and the type of splice/pull box shall also be included on the drawing. The location of the trunk line splice shall be shown for review and approval. A proposed splice diagram shall be included.

Midspan splices should be avoided to the trunk line and will need to be approved by the City.

CONSTRUCTION

The contractor shall provide complete installation of conduits and pull boxes including materials, equipment, labor and documentation, in accordance with these specifications and recognized industry standards and the system must be fully operational.

SHOP DRAWINGS

Shop drawings shall be submitted of all equipment and appurtenances required for a complete fiber optic infrastructure, which includes but is not limited to, the following:

- Conduit
- Pull Boxes, Splices Boxes, Splice Vaults, Splice Enclosures, Splice Cabinets
- Fiber Optic Cable
- Network Devices
- Digital Video Encoder
- Locate Tracer Wire
- Marking Tape
- Pull Tape
- Cable Route Markers
- Splice trays
- Fiber Optic Test Procedures

Shop drawings must be approved prior to construction. Any work conducted prior to approved shop drawings will be at the Contractors expense and may be required to be removed based on shop drawing approval.

PULL BOX, SPLICE BOX AND SWEEPS

Conduit plans need to be approved prior to construction. All items identified in the design section shall be shown on the construction plans.

Upon request, a schematic including proposed location of pull boxes at locations shown on the approved plans with provisions for maximum pull box spacing.

Pull Box spacing will be a maximum of 1000 feet. Splice box spacing intervals shall be a maximum of every 3000 feet. This establishes a pattern of one splice box after every two pull boxes (i.e. pull box, pull box, splice box, pull box, pull box, splice box, etc). Inside each pull and splice boxes the contractor shall provide 90 degree conduit sweeps as shown in Appendix A. In the conduit run, 45 degree conduit sweeps may be permitted, no more than 2, prior to a pull or splice box. These 45 degree conduit sweeps should be referenced on the construction plans and must be approved prior to construction.

SPLICING REQUIREMENTS

No splicing of the fiber optic cable system will be permitted without appropriate qualified City Public Works Traffic Operations Division staff present during splicing activity. Staff member will be determined

at the pre-construction meeting. The Staff Member may elect to not be present and still authorize splicing of the fiber optic cable system to be performed, if this is not reasonable or in emergency situations.

The contractor shall submit final splice diagrams for review and approval prior to splicing. Once the splice diagram is approved the contractor shall give a minimum of 3 business day notice to the City prior to construction.

AS-BUILT DRAWINGS

As-built drawings shall be provided by means of a secure method, ie, CD or thumb drive and shall not be transmitted via internet.

APPROVED PRODUCT LIST (QPL)

All material used shall be per the Approved products noted at the end of each appropriate section and shall be new, unused and of current design and manufacturer.

Any materials not found in the Approved products section shall not be used without the City’s approval.

Materials not found in the Approved product section may be submitted for approval to the City. Documentation of the material’s specifications shall be submitted to the City for approval. Any materials/products submitted for approval must meet the minimum specifications explicitly stated in this document.

All material will be inspected and verified prior to installation.

All other applicable specifications will be adhered to as directed by the City.

DEFINITION of TERMS:

CITY: The terms “City” and “the City” shall refer to the City of PSL personnel, or their representatives.

CONTRACTOR: “Contractor” shall mean an individual, firm, partnership, or corporation, and his, their or its heirs, executors, administrators, successors and assigns or the lawful agent of any such individual, firm, partnership, covenanter or corporation, or his, their or its surety under any contract bond, constituting one of the principals to the Contract and undertaking to perform the work specified in the design plans and specifications. Where any pronoun is used as referring to the word “Contractor”, it shall mean the Contractor as defined herein.

ENGINEER OF RECORD: The terms “Engineer” and “Engineer of Record” shall be a duly licensed and registered engineer in the State of Florida.

1.0 FIBER OPTIC CABLE SYSTEM

1.1 FIBER OPTIC CABLE

Furnish fiber optic cable that shall be 100% compatible with the existing fiber optic cable plant.

1.1.1 MANUFACTURER:

The cable manufacturer shall be ISO9001 certified and shall be TL9000 registered.

1.1.2 CABLE CONSTRUCTION:

The cable shall be free of hazardous materials in compliance with RoHS 2002/95/EC. The cable shall be of all-dielectric (non-shielded, non-metal) construction. The cable shall be of loose-tube construction. The cable shall be of entirely gel-free construction.

1.1.3 OUTER JACKET:

- Carbon Black Medium Density Polyethylene (MDPE)
- 1.3mm Thickness
- UV Resistant
- Fungus Resistant
- 2.5mm White Length Markings in Feet (US)
- Labeled "City of PSL Fiber Optic Cable" after every length marking

1.1.4 RIPCORDER: The cable shall contain at least one ripcord under the sheath (outer jacket).

1.1.5 WATER BLOCKING COMPOUND:

The cable shall contain a dry water blocking material under the outer jacket.

1.1.6 STRANDING/STRUCTURE:

The cable shall contain up to 12 buffer tubes wrapped around a central strength member in a reverse oscillation stranding structure.

1.1.7 STRENGTH MEMBER:

The central strength member shall consist of a dielectric, glass reinforced plastic (GRP) rod.

1.1.8 FILLER: Filler(s) may be used in the cable core. Fillers shall be 2.5mm in diameter.

1.1.9 BUFFER TUBES:

- Polypropylene
- Dry Water-Blocking Material inside (Gel-Free, Foam-Free)
- 2.5mm Outer Diameter
- EIA/TIA-598-B Color Code Compliant
- Exactly 12 fibers per Buffer Tube

1.1.10 OTHER:

Fibers shall not adhere to the inside of the buffer tube. Fibers shall not stick together. The optical fibers shall not require cleaning before placement into a splice tray.

1.1.11 OPTICAL FIBER CONSTRUCTION:

Optical fibers shall be dispersion-unshifted, step-index, single-mode fibers. Each fiber shall consist of a Germania-doped silica core surrounded by a concentric glass cladding. Fibers shall be a matched clad design. All fiber optic glass shall be from the same manufacturer. Fibers shall be coated with a dual layer acrylate protective coating. Fiber coatings shall be colored with ultraviolet (UV) curable inks. Fibers shall be colored in compliance with EIA/TIA-598-B.

1.1.12 OPTICAL FIBER GEOMETRY & OPTIC SPECIFICATIONS:

- Core Diameter: 8.2 μm
- Cladding Diameter: 125 μm +/- 0.7 μm
- Core-to-Cladding Concentricity: $\leq 0.5 \mu\text{m}$
- Cladding Non-Circularity: $\leq 0.7\%$
- Coating Diameter: 245 μm +/- 5 μm
- Attenuation @ 1310 nm: $\leq 0.4 \text{ dB/km}$
- Attenuation @ 1550 nm: $\leq 0.3 \text{ dB/km}$
- Cutoff Wavelength: $\leq 1260 \text{ nm}$

1.1.13 CABLE OPERATING REQUIREMENTS:

- OPERATING TEMPERATURE RANGE: -40°F to 158°F.
- MINIMUM BEND RADIUS: 10 X cable outer diameter (installed), 15 X under tension
- CABLE STRENGTH/MAX PULLING TENSION: 600 lbf during installation, 200 lbf installed.
- CRUSHING RESISTANCE: Withstands a minimum compressive load of 125 lbf/in.

1.1.14 MANUFACTURER TESTING:

All optical fibers shall be 100% attenuation tested at the factory for compliance with performance specifications described herein. The attenuation data for each fiber shall be provided with each cable reel.

The cable shall be subjected to testing by the cable manufacturer in accordance with the following ANSI/EIA/TIA-455-xx testing procedures (FOTP's):

- FOTP-3, FOTP-41, FOTP-104, FOTP-25, FOTP-33 and FOTP-8
(Result = Δ Attenuation $\leq 0.15 \text{ dB @ } 1550 \text{ nm}$)
- FOTP-37 (Result = Δ Attenuation $\leq 0.3 \text{ dB @ } 1550 \text{ nm}$)
- FOTP-82 without leakage through the open cable end.
(1 meter of cable shall withstand 1 meter static head water pressure for 1 hour)
- FOTP-81 exhibiting no flow (drip or leak) of filling or flooding material @ 70° C.
- FOTP-181 without loss of fiber continuity.
(Cable shall withstand a simulated lightning strike w/ 55kA peak current pulse)

1.1.15 MISCELLANEOUS:

The top and bottom ends of the cable shall be accessible for testing. Both ends of the cable shall be sealed.

APPROVED FIBER OPTIC CABLES: Corning ALTOS Loose Tube, Gel-Free Cable Single-Mode (OS2)

GENERAL PROPERTIES

ISO 9001 Compliant Manufacturer
 TL 9000 Registered Manufacturer
 RoHS 2002/95/EG Compliant Materials
 All-Dielectric (Non-Shielded, Non-Metal)
 Gel-Free, Foam-Free Construction
 Loose-Tube Cable
 600 lbf Max Tensile Strength (Installation)
 200 lbf Max Tensile Strength (Static)
 125 lbf/in Crush Resistance
 Operating Temperature Range of -40°F to 158°F
 Minimum Bend Radius = 10 x Cable Diameter (Static)
 Min. Bend Radius = 15 x Cable Diameter (Tension)

EXTERNAL PROPERTIES

1.3mm Medium Density Polyethylene (MDPE)
 UV Resistant
 Fungus Resistant
 Black Color
 2.5mm Length Markings in Feet (US)
 Labeled "City of PSL Fiber Optic Cable" every X Feet

INTERNAL PROPERTIES

Easy Access Jacket Ripcord

Dielectric (GRP) Central Strength Member

Water-Blocking Tape (Outside of Buffer Tubes)

Up to 12 Buffer Tubes
 Reverse Oscillation Stranding Structure
 2.5m Polypropylene Buffer Tubes
 EIA/TIA-598 Color Code Compliant Buffer Tubes
 Dry Water-Blocking Material Inside Buffer Tubes
 12 Fibers per Buffer Tube
 All Fibers contained in Buffer Tubes

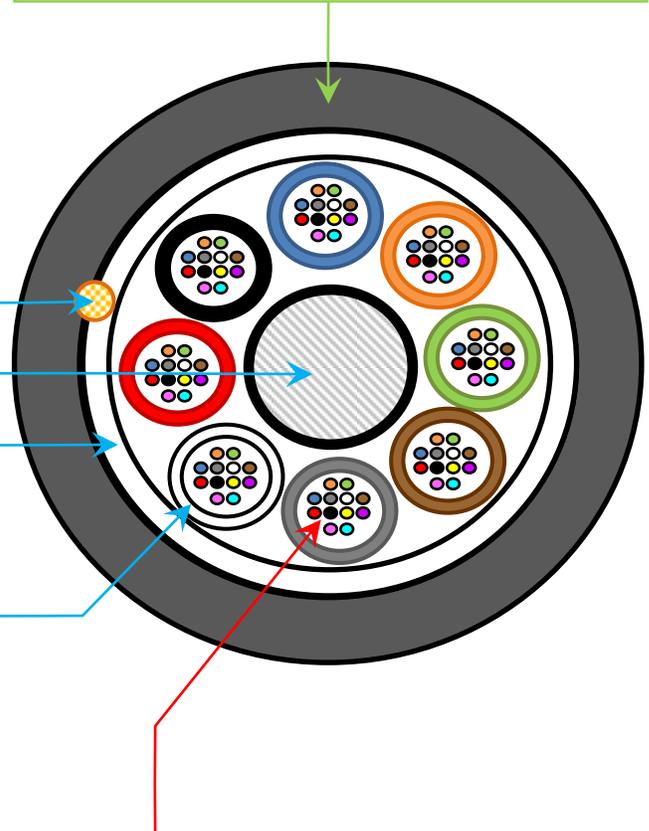
FIBER PROPERTIES

CONSTRUCTION:

Dispersion-Unshifted Step-Index Single-Mode Fibers
 Germania-Doped Silica Core surrounded by a Concentric Glass Cladding
 Matched Clad Design
 Dual Layer Acrylate Coatings
 Ultraviolet (UV) Curable Inks
 EIA/TIA -598-B Color Code Compliant

GEOMETRY & OPTICS:

Core Diameter: 8.3µm
Cladding Diameter: 125µm +/-0.7µm
Core-to-Cladding Concentricity: ≤ 0.5µm
Cladding Non-Circularity: ≤ 0.7%
Coating Diameter: 245µm +/-5µm
Attenuation @1310nm: ≤ 0.4 dB/km
Attenuation @1550nm: ≤ 0.3 dB/km
Cut-Off Wavelength: 1260nm



1.2 FIBER OPTIC SPLICE CLOSURES

1.2.1 MANUFACTURER:

The splice closure manufacturer shall be ISO9001 certified and shall be TL9000 registered.

1.2.2 GENERAL:

Splice closures shall be “dome type” splice closures. Splice closures shall be designed for all outdoor applications (aerial, duct, buried, etc.). Splice closures shall be free of hazardous substances according to RoHS 2002/95/EC. Splice closures shall be constructed of a black thermoplastic material. Splice closures shall be capable of through, branch and mid-span type splice applications. Splice closures shall be airtight and prevent water intrusion. Splice closures shall permit pressurization. Splice closures shall not contain gel, or any substance which requires cleaning or removal before splicing.

1.2.3 ENTRY MECHANISM:

Splice closures shall allow tool-less re-entry via an exterior mechanical base-to-dome seal. The interior shall permit access to splice trays without kinking buffer tubes or macro-bending.

1.2.4 CABLE ENTRY PORTS:

Splice closures shall have a total of 6 cable entry ports: 5 round ports for cables up to 1.25” and 1 oval port supporting up to two 1” cables (feeder on mid-span splices). Splice closures shall permit the use of all ports without the use of expansion kits. Cable entry ports shall be sealed with heat shrinkable materials.

1.2.5 DIMENSIONS:

Splice closures shall have enough interior space to accommodate 10 feet of slack from each cable that enters the splice without exceeding the minimum bend radius of the cable.

Only 2 sizes of splice closure shall be used as directed by the City:

SMALL CLOSURES: ≤ 19”L x 10.5”W x 10.5”D (Accommodates 8 trays/192 splices)

- Through splices of 2 x ≤96 fiber trunk cables
- Drop splices of 2 x ≤96 fiber trunks and 1 x 12 fiber drop cable

LARGE CLOSURES: ≤ 28”L x 10.5”W x 10.5”D (Accommodates 8 trays/576 splices)

- Splices of 2 or more 144 fiber cables
- Complex splices of 3 or more trunk cables
- Upsizing may be required at locations depending on the City’s future plans

1.2.6 SLACK BASKET: Splice closures shall include a slack basket for managing loose buffer tubes.

1.2.7 SPLICE TRAYS:

Splice trays shall be specifically designed for use with the selected splice closure and shall fit accordingly into the splice closure. Splice closures shall use hinged splice trays. Splice trays shall be re-enterable. Splice trays shall provide storage and protection for 24 splices for small closures and 72 splices for large closures. Splice trays shall hold (splice sleeves) rigidly in place. Splice trays shall provide sufficient space to prevent macro-bending of the optical fibers.

APPROVED SPLICE CLOSURE: TYCO/RAYCHEM FOSC 400

1.3 PATCH PANELS

Furnish modular interconnect centers (Patch Panels) for installation inside the equipment cabinets.

1.3.1 MANUFACTURER:

The manufacturer shall be ISO 9001 certified and TL9000 registered.

1.3.2 PATCH PANEL CONSTRUCTION:

Patch panel housings shall be constructed of powder-painted baked-epoxy galvanized steel. Patch panels shall be designed for cable entry parallel to the rear of the panel. Cable openings shall be protected by grommets. The front of the panel shall form a shelf providing physical protection of connectors and routing options for the patch cords. The housing shall include strain relief, bend radius protection, and short-term cable retention clamps.

1.3.3 PORTS:

Patch panels shall provide 12 ST SM coupler ports with ceramic inserts on its front-facing panel.

- Compatible with pre-assembled coupling plates (6 or 8 ports per plate, 3 plates per row).
- Designed to contain 24 ports per unit of rack space (1U=1.75"H).
- Expandable up to 144 ports (24 ports per unit of rack space, 6U total).
- Dust caps included with all coupler ports.

Couplers shall be configured in an arrangement to facilitate easy access to each coupler pair.

APPROVED PATCH PANELS: 3M 8423 Rack Mount Patch Panel

1.4 PIGTAILS

1.4.1 MANUFACTURER:

The manufacturer shall be ISO 9001 certified compliant.

1.4.2 PIGTAIL CONSTRUCTION:

Pigtails shall consist of a standard 250µm fiber single-mode fiber enveloped with a 900µm tight buffer inside a 3mm jacket. The fiber shall be constructed with a Dual-Acrylate Slip Layer between the 250µm fiber and the 900µm tight buffer. Stripping the 900µm tight buffer off of the 250µm fiber shall only require the use of standard mechanical strippers and shall not require the use of thermal strippers.

The fiber type shall be single mode and the core characteristics shall be splice compatible with existing fiber, matching the specifications stated in Section 1.1.12.

Pigtails shall be individually labeled on the strain relief boot to indicate the fiber # (position) or which color fiber they are splice onto.

Pigtails shall be protected with dust caps on the connector ferrules until connected to a port.

1.4.3 SPECIFICATIONS:

Pigtails and their pre-assembled connectors shall also meet or exceed all of the following specifications:

CONNECTOR:

- Connector Type: ST (Non-Keyed/No Security)
- Polish/Contact Type: UPC (Ultra Polish/Physical Contact)
- Boot: Blue, Fungus Resistant material
- Body: Metal (Stainless-Steel, Nickel-Plated Zinc, etc.)
- Ferrule: 2.5mm Zirconia Ceramic
- Max. Typical Loss: 0.15dB
- Reflectance/Back Reflection: ≤ -59dB
- Operating Temperature: -40°F to 185°F
- Intermateability Standard: TIA/EIA-604-2
- Durability Testing: ≤ 0.2 dB loss per 1000 rematings, FOTP-21

CABLE:

- Type: Simplex, Single-Mode
- Jacket: 3mm, Yellow, OFNR rated
- Length: 2 meters
- Minimum Bend Radius: 30mm
- Crush Resistance: 1000 N/10cm
- Tensile Strength: 200 N

GENERAL:

- Materials/Construction: LSZH, FRNC
- Substance Restrictions: RoHS Compliant construction

APPROVED PIGTAILS: L-com Item # FPT3SNG-ST-YLW-1 9/125 Fiber Pigtail ST, Yellow 1.0m

1.5 PATCH CORDS/CABLES

1.5.1 MANUFACTURER:

The manufacturer shall be ISO 9001 certified.

1.5.2 PATCH CORD CONSTRUCTION:

Patch cordage shall be factory pre-assembled, pre-terminated patch cords that are compatible with the existing fiber system, adhering to the fiber specifications found in Section 1.1.12.

All inside plant (IP) assemblies shall meet NEC jacketing requirements for the application.

Jumpers shall be of the same fiber core size, performance and connector type as the existing cable system (see Section 1.1 “Fiber Optic Cable”).

Patch cords shall be protected with dust caps on the connector ferrules.

1.5.3 SPECIFICATIONS:

Patch cords and their connectors shall also meet or exceed all of the following specifications:

CONNECTOR:

- Connector Type: ST, SC, or LC (as specified by the City)
- Polish/Contact Type: UPC (Ultra Polish / Physical Contact)
- Connector Body: Metal (Stainless-Steel, Nickel-Plated Zinc, etc.)
- Connector Boot: 1 x Blue, 1 x White (for Tx/Rx Identification)
- Connector Ferrule: 2.5mm Zirconia Ceramic
- Max. Typical Loss: $\leq 0.15\text{dB}$ (UPC)
- Reflectance/Back Reflection: $\leq -59\text{dB}$ (UPC)
- Operating Temperature: -40°F to 185°F
- Intermateability Standard: TIA/EIA-604-2
- Durability Testing: ≤ 0.2 dB loss per 1000 rematings, FOTP-21

CABLE:

- Type: Duplex, Single-Mode
- Jacket: 3mm, Yellow, OFNR rated
- Length: 2 meters
- Minimum Bend Radius: 30mm
- Crush Resistance: 1000 N/10cm
- Tensile Strength: 200 N

GENERAL:

- Materials/Construction: LSZH, FRNC
- Substance Restrictions: RoHS Compliant construction

APPROVED PATCH CORDS:

ST to ST: L-com Item # SFODPST-02 9/125, Single mode Plenum Fiber Cable ST / Dual ST, 2.0m

ST to SC: L-com Item # SFODST-SC-02 9/125, Single mode Fiber Cable, Dual ST /Dual SC, 2.0m

1.6 SPLICING EQUIPMENT

1.6.1 MANUFACTURER:

The fusion splicer manufacturer shall be ISO9001 certified and TL9000 registered.

1.6.2 FUSION SPLICER FEATURES:

The fusion splicer shall be designed to splice standard single-mode fibers with a cladding diameter of 125µm and coating diameters from 250 µm to 900 µm.

The fusion splicer shall be equipped with a heat shrink oven compatible with 60mm splice sleeves.

The fusion splicer shall be equipped with a true splice loss measurement system (not only a splice loss *estimation* system).

The fusion splicer shall be equipped with a monitor display that allows inspection of the fiber ends with 120 X magnification.

1.6.3 SPECIFICATIONS:

The fusion splice shall also meet or exceed all of the following specifications:

- Typical Splice Loss (Standard Single-Mode): < 0.02 dB (similar fibers)
- Splice loss measurement accuracy: +/- 0.02 dB
- Operating Temperature Range: -15° to +50°C
- Relative Humidity: <95%, non-condensing
- Built-in GPS System
- Splice Data storage capability (including GPS location data)

The fusion splicer shall be new from the factory or serviced and certified by the manufacturer or its authorized representative within 6 months prior to its use for splicing. The Engineer shall be provided with a letter from the manufacturer or its authorized representative certifying compliance. The fusion splicer used shall have yearly calibration and provide the yearly certification certificate prior to splicing procedure.

APPROVED FUSION SPLICER: Corning M90e Fusion Splicer

1.7 OTDR TEST EQUIPMENT

The OTDR shall to be used for testing purposes shall be compatible with the installed fiber optic cable (single-mode 8/125 fiber) to be tested.

1.7.1 MANUFACTURER:

The manufacturer shall be ISO9001 certified and TL9000 registered.

1.7.2 SPECIFICATIONS:

- Test Wavelengths: 1310nm / 1550nm
- Event Dead Zone: 1m / 1m
- Attenuation Dead Zone: 5m / 6m
- Dynamic Range: 39dB / 38dB

- Distance Ranges (km): 5/10/30/100/275/1,000/10,000/20,000
- Loss Resolution: 0.001dB
- Sampling Resolution: 0.004m to 5m
- Sampling Points: Up to 128,000

1.7.3 FILE FORMAT:

The OTDR save all traces and data in the “.SOR” file format.

1.7.4 CALIBRATION:

The OTDR shall be new from the factory or serviced and certified by the manufacturer or its authorized representative within 1 year prior to its use for splicing. The Engineer shall be provided with a letter from the manufacturer or its authorized representative certifying compliance. The OTDR Test Equipment used shall have yearly calibration and provide the yearly certification certificate prior to testing procedure.

APPROVED OTDR: CORNING OV-1000 OTDR

1.8 INSTALLATION

1.8.1 PRECONSTRUCTION:

Before starting any installation, the City shall be notified 3 business days in advance. Failure to notify the City may result in rejection of the installation and may subject the contractor to be responsible for removal of the installation at no cost to City of PSL. Before installation, the cable to be installed shall be reel tested (Section 1.11.12).

1.8.2 PERSONNEL:

Personnel performing the cable installation shall be adequately trained, and shall be IMSA MOT Level 1 certified. All Contractor personnel (including subcontractors) shall be thoroughly familiar with and shall comply with all Occupational Safety and Hazard Act (OSHA) regulations.

1.8.3 MAINTENANCE of TRAFFIC (MOT) PLAN:

An approved MOT Plan shall be required any time work is being performed within the City of PSL Right of Way, regardless of permit requirements. MOT Plans shall conform to the latest FDOT Design Standards 600 Series and the latest Manual on Uniform Traffic Control Devices (MUTCD). The Contractor shall be responsible for setup and removal of all MOT devices.

1.8.4 COMPLIANCE:

The Contractor shall obtain a Road Closure Permit from the City of PSL or FDOT, where necessary. Cable shall be installed in compliance with NEC requirements where applicable. The Contractor shall receive an Excavation Permit from the City of PSL, where necessary.

1.8.5 INSTALLATION:

Conventional fiber optic cable installation techniques shall be used within the conduit in such a manner that the optical and mechanical characteristics of the cables are not degraded in any manner at the time of installation. Use of Air Blown Fiber System cable and/or Air Blown Fiber System installation techniques (such as HASB and the piston method) shall not be permitted. Cables shall not be pushed into conduits. (Pushing can violate the bend radius)

1.8.6 UNREELING:

Cable shall be rolled off of the spool. Spinning off the side of the spool end shall not be permitted. (It will put a twist in the cable for every turn on the spool.) The figure-eight configuration shall be used for storing cable at intermediate locations to prevent kinking or twisting when the cable must be unreeled and backfed. Pulling and reel locations should be set near the sharpest conduit bend locations (i.e. corner vaults, etc.) where possible.

1.8.7 PULLING:

Fiber optic cable shall be installed by hand or by using a mechanical pulling machine. When a mechanical/automated pulling machine is used it shall be equipped with a monitored tension meter/tension control. Cable pulling tension shall be continuously monitored; the pulling process shall not be allowed to exceed the maximum tension specified by the manufacturer of the cable. A proper wire mesh pulling grip and swivel shall be used in the cable pulling process.

1.8.7 PULLING continued...

Fuse links and breaks shall be used to insure that the cable will not be subjected to stresses exceeding 600 lbf.

The minimum-bending radius of the cable shall not be exceeded. Corner rollers (wheels), if used, shall not have radii less than the minimum installation bend radius of the cable. A series array of smaller wheels may be used for accomplishing the bend if the cable manufacturer specifically approves the array. Entry guide chutes shall be used to guide the cable into the pull-box conduit ports. When simultaneously pulling fiber optic cable with other cables, separate grooved rollers shall be used for each cable.

On runs over 100 feet, lubricating compound shall be used to minimize cable-to-conduit friction. Lubricating compound shall be a water-based compound specifically produced for fiber optic cable lubrication. Lubricants such as dish soap and other substitutes shall not be permitted.

Every effort shall be made to pull cables from a conduit in as straight an angle as possible. "Offset" pulling shall be avoided whenever possible. (Pulling on an angle can cause damage to the cable.) The number of 90° turns on a pull shall not exceed 4.

The cable shall be installed in continuous lengths from splice point to splice point, as indicated in the plans.

1.8.8 CABLE SLACK REQUIREMENTS:

Throughout the cable plant, pull and store excess cable slack at each pull box, splice box, hub, and each TMC or TOC. The following lengths of slack cable are minimums:

Fiber Pull Box:	50 ft.
Fiber Splice Box:	100 ft.
Bridge Barrier Wall:	20 ft.
Device Cabinet:	20 ft.
Hub Building (Inside):	100 ft.

Cable slack shall be neatly arranged and looped horizontally on the floor of each pull box. Coils of slack from separate cables shall be grouped together and taped individually.

Do not leave slack cable lying free (uncoiled) on the ground, bottom of a pull box, or floor of a Device Cabinet, Hub Building, etc., except during the installation/pulling process.

When coiling and storing cable slack the cable minimum bend radius shall not be exceeded. The cable slack/coils shall not protrude above the pull box/splice vault cover or in any way interfere with the placing or replacing the splice box cover.

1.8.9 LABELING & DOCUMENTATION:

Document the sequential cable length markings at each pull box and splice vault wall that the cable passes through and include this information with the as-built documentation.

Each cable that enters/exits a conduit inside a pull box shall be clearly labeled with a weatherproof tape/tag within 3 foot of the conduit. The tag/label shall indicate: the cable type, fiber count, length marking, "from" direction, and the cable's origination and termination points. The tag shall provide enough space for all info to be written clearly and legibly on its front.

1.8.10 INSPECTION:

Prior to splicing and/or termination, the City shall be notified immediately when cable installation (pulling) is complete so that they may be present during inspection of the cable installation. The cable shall be inspected at all accessible locations (pull boxes, splice vaults, traffic cabinets, etc.) for correctness and for damage to the cable that may have occurred or may have been preexisting.

Once the cable installation has been inspected and met by approval from the City, then the contractor may proceed with completion of the installation (splicing, termination, testing, etc.).

1.8.11 DAMAGE:

The City shall be notified immediately of any damage to the cable, including, but not limited to: any nick that penetrates the outer jacket of the cable (even if buffer tubes, gel, fibers, etc., are not exposed); any kinks, twists, warps, bends, or crushing of the cable that result in a deformation that does not restore to normal on its own, even if the damage appears to be only superficial.

If any damage to the fiber optic cable occurs before, during or after installation, the contractor shall not attempt to repair the damage before the City has been notified and exercised its option to inspect the damage. Once inspected, the City will choose the repair method and direct all repair operations, including but not limited to: placing fiber splints, sealing, splicing and re-splicing cable, etc. The City reserves the right to perform any repairs itself wherever it deems necessary.

1.9 FIBER OPTIC SPLICING REQUIREMENTS

All fibers in the fiber optic cable shall be spliced and/or terminated.

1.9.1 SPLICE PLAN:

Provide a splice plan showing the location and configuration of the splices in the system for approval by the City. All splicing shall be performed according to the plan. Document each splice location and identify the source and destination of each fiber in each splice tray. Document all fiber colors and buffer jacket colors used during installation. Develop and document a sequential fiber numbering plan as required in the TIA/EIA-598-A standard.

1.9.2 FUSION SPLICING:

The fusion technique shall be used for all splices and terminations. A fusion splicing machine (Fusion Splicer) shall be used to splice all optical fiber as specified in Section 1.6.

1.9.3 PERSONELL:

All splicing personnel shall be adequately trained for the fusion splicing, and shall possess a fiber optic splicing certification from an industry recognized authority such as IMSA or ETA.

1.9.4 SPLICING EQUIPMENT PREPARATION:

Provide splice closures, organizers and incidentals, and cable end preparation tools and procedures, compatible with the cable type being delivered. Fusion splicing equipment shall be cleaned and calibrated per the manufacturer's specifications, and specifically adjusted to the fiber and environmental conditions at the start of each splicing shift.

1.9.5 SPLICE CLOSURE PREPARATION:

Select a splice closure appropriate for the application that complies with section (1.2 Splice Enclosures) and shall allow all of the fibers in each cable to be spliced and stored. All cables shall enter into the splice closure on only one side ("butt" configuration). Only one cable per entry port shall be allowed (except for mid-span "oval" ports). A minimum of 10 feet of cable from each cable entering the closure (i.e. 20 feet of trunk cable in mid-span splicing) shall be prepared and installed within the enclosure.

1.9.6 SPLICE TRAY PREPARATION:

Splice trays shall be selected that will accommodate the required number of splices and provide sufficient storage space and protection to prevent micro-bending of slack fiber. Accomplish loose tube entry using a mid-access tool or split-entry tool. Only open the buffer(s) that contain(s) the fibers to be spliced, and only cut the fibers that must be spliced. Buffer tubes shall be secured onto the splice tray and held rigidly in place. At least 36" of loose fiber shall be exposed for splicing and the remainder shall be stored as slack, along with any exposed fibers that will not be spliced.

1.9.7 SPLICING:

Perform fusion splicing according to latest version of the cable manufacturer's and fusion splicer's procedures, accepted standards, codes, and practices; or as directed by the City. Fibers shall not be fused or re-fused more than a total of 3 times.

1.9.8 SPLICE LOSS:

Individual splice loss shall not exceed 0 .05 dB loss.

1.9.9 SPLICE PROTECTION:

Each spliced fiber shall be packaged in a 60mm heat shrinkable splice protection sleeve with strength member. The protection sleeve shall cover the splice and any bare fiber stripped of its coating.

1.9.10 STORAGE:

A maintenance loop at each Pull Box or Fiber Splice Box shall be per Section 1.8.8.

1.9.11 LABELING:

Each cable entering a splice closure shall be clearly labeled with a weatherproof tape/tag within 1 foot of the splice closure, which shall indicate: the cable type, fiber count, length marking, "from" direction, and the cable's origination and termination points. Splice closures shall be tagged with a weatherproof tag/label. The tag shall provide enough space for all info to be written clearly and legibly on its front. Labeling shall include: date of installation, splicing technician name, splice diagram/chart reference #, etc. A splice diagram/chart shall be included inside the splice. The diagram will define each fiber from every cable that enters the enclosure.

1.10 FIBER OPTIC TERMINATION REQUIREMENTS

All fiber optic cables shall be terminated by means of fusion splicing onto factory pre-terminated assemblies (pigtailed) with ST connectors. Patch Panels, Pigtailed and Splice Trays shall be provided as specified earlier in this document. Patch panels shall accommodate all fibers entering equipment cabinets. Splice Trays shall be selected that fit accordingly into the patch panel.

1.10.1 PATCH PANEL PREPARATION:

The cable shall be clamped to the patch panel by means of a “hose clamp”. The cable central strength member shall be secured (clamped) to the patch panel. Protective spiral wrap shall be placed and secured (taped) over the cable and buffer tubes where the cable enters the panel and passes through the grommet. 10 feet of cable entering the panel shall be prepared and installed within the enclosure.

Pigtailed shall be spliced onto the bare fibers as detailed in section 1.9. The splicing sequence shall follow the order of the fiber # position within the buffer and cable.

Once all bare fibers have been terminated onto pigtailed, the pigtailed shall be connected to the ST coupler ports according to their position within the fiber or cable. Pigtailed shall be arranged and secured neatly within the panel without crushing, exceeding the minimum bend radius, or introducing losses. Dust caps shall be placed on all unused coupler ports.

All fiber terminations shall be visually inspected, and optically tested for attenuation and reflectance, and shall exhibit an optical performance with a maximum insertion loss and a minimum return loss as stated in Section 1.4.

1.10.2 LABELING:

PATCH PANELS:

Patch panels shall be labeled to indicate which cable and direction they provide access to. Port plates shall be labeled to indicate which buffer within the cable they provide access to. Coupler ports shall be labeled to identify which fiber # or color that the port provides access to.

EQUIPMENT PATCH CORDS:

Patch cords that provide connections to network switches shall be labeled at each end to indicate the source cable & fiber #/color it connects to for transmit and receive, and which port on the switch it connects to.

JUMPER PATCH CORDS:

Jumper patch cords, if any, shall be labeled at each end to indicate which cable & fiber #/colors that they are connected to for transmit and receive, as well as a simple description of the link they are associated with (i.e. “backup link to router 9”, etc.), and shall include labeling which indicates the “To” and “From” connection end points.

1.11 ACCEPTANCE TESTING

The Fiber Optic Cable Network shall be tested as follows:

1.11.1 MANUFACTURER’S TEST AND CERTIFICATION:

Each reel of fiber optic cable shall be accompanied by the manufacturer's test data (Section 1.1.14). The manufacturer’s test data shall identify each fiber in each cable and list its factory-tested attenuation in dB/km. Attenuation shall meet attenuation requirements Section 1.1.12.

1.11.2 PRE-INSTALLATION TESTS (REEL TEST):

Notify the City 3 business days in advance of the cable installation date, so that the City may be present at the tests. At the direction of PSL, test the fiber optic cable at the site storage area prior to installation. Each optical fiber in the cable shall be tested from one end at one wavelength with a compatible OTDR. Test for continuity, length, anomalies, and approximate attenuation. Record each measurement with color, location and fiber type measured, and submit the documentation to the City in “.SOR” file electronic format. If the tested loss per Km exceeds the loss from the manufacturer's test data the City will reject the cable.

1.11.3 SPLICE TEST RESULTS:

Splice loss measurement test results from the fusion splicer shall be recorded and submitted to the City in an electronic format for evaluation. Test results shall include: Date and Time, Splicing Technician Name/ID, splice loss, and GPS location data for each fiber optic splice.

1.11.4 POST INSTALLATION TESTS (FINAL TEST):

1. Notify the City 3 business days in advance of the Final Testing so that the City may be present for the tests.
2. After installation (splicing and termination) is complete, the optical fibers shall be tested for loss characteristics. A full bi-directional test (using bi-directional averaging) shall be performed on all terminated fibers in each cable (including those extra fibers which the Contractor elects to include above those invoiced) using an Optical Time Domain Reflectometer (OTDR) (See Section 1.7). Fibers shall be tested at 1310nm and 1550nm.
3. The connection between the OTDR and each tested fiber shall be factory assembled patch cords, or launch cables equal to a length of 150% of the Dead Zone as published by the OTDR Manufacturer. The launch cable shall have the appropriate connectors to allow for connection to the terminated fiber port without the use of additional couplers.
4. Test result printouts shall include, but not be limited to, the following:
 - a. Cable ID and Fiber ID;
 - b. Distance of trace;
 - c. Total Loss;
 - d. Splice Loss;
 - f. Beginning Testing Location;
 - g. End of Fiber Testing Location;
 - h. Operator/Technician Name or Initials;
 - i. Date and Time test was performed;
 - j. Test Wavelength;
 - k. Test Pulse Width;
 - l. Refractory Index

5. All installation test data shall be submitted in electronic format (.SOR file format) to the City as basis for acceptance.

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1.12 MULTI-PAIR CABLES (COPPER DATA CABLES):

Furnish and install multi-pair data cable (CAT5e) that will support full-duplex Fast Ethernet operations. Furnish all tools, materials, connectors, and required consumables, and perform all installation operations necessary to provide a complete, fully operational multi-pair data cable (CAT5e).

1.12.1 MANUFACTURER:

The manufacturer shall be ISO9001 certified and TL9000 registered.

1.12.2 SPECIFICATIONS:

Multi-pair data cable, CAT5e shall meet the following minimum specifications:

Frequency	100 MHz
Attenuation (min. at 100 MHz)	22 dB
Characteristic Impedance	100 ohms \pm 15%
NEXT (min. at 100 MHz)	35.3 dB
PS-NEXT (min. at 100 MHz)	32.3 dB
ELFEXT (min. at 100 MHz)	23.8 dB
PS-ELFEXT (min. at 100 MHz)	20.8 dB
Return Loss (min. at 100 MHz)	20.1 dB
Delay Skew (min. at 100 MHz)	45 ns

NEXT = Near-End Crosstalk

PS-NEXT = Power Sum Near-End Crosstalk

ELFEXT = Equal-Level Far-End Crosstalk

PS-ELFEXT = Power Sum Equal-Level Far-End Crosstalk

1.12.3 CONNECTORS:

CAT5e cabling shall be terminated with Connectors shall be RJ-45 (8P8C) type connectors.

1.12.4 COMPLIANCE:

All Category 5E unshielded twisted pair/shielded twisted pair network cables and connectors shall be compliant with the EIA/TIA-568-A standard.

2 NETWORK DEVICES

Provide hardened, Managed Field Ethernet Switches (MFES) for drop termination connections in Traffic Cabinets. The MFES shall be 100% compatible and interoperable with the existing ITS trunk Ethernet network interface.

2.1 MANUFACTURER:

The manufacturer shall be ISO9001 compliant.

2.2 CONSTRUCTION:

All parts shall be made of corrosion resistant materials such as plastic, stainless steel, anodized aluminum, brass, or gold-plated metals. Every conductive contact surface shall be gold-plated or made of a noncorrosive, non-rusting, conductive metal. The MFESs shall be constructed with no moving parts (Fan-Less Design).

2.3 PHYSICAL/MECHANICAL:

Height: $\leq 8''H \times \leq 3''W \times \leq 5''D$
 Mounting: DIN rail mounted

2.4 ELECTRICAL:

All wiring shall meet NEC requirements and standards.

- Power Consumption: $\leq 10W$
- Input Voltage: 85-264 VAC

2.5 ENVIRONMENTAL:

- Operating Temperature Range: $-40^{\circ}C$ to $+85^{\circ}C$
- Humidity: $\leq 95\%$ non-condensing
- Ingress protection: IP40 rated (1mm objects)
- Compliance: NEMA TS 2 Standard (Traffic Control Equipment)

2.6 ETHERNET PORTS:

8 "Fast Ethernet" (10/100BaseTX) Copper Ports.

- Copper ports shall be RJ-45 Type.
- Auto-negotiate speed (10/100/1000) and duplex (half/full).
- IEEE 802.3 standard compliant pinouts.

2 Fiber Optic single-mode "Gigabit Ethernet" (1000BaseX) ports

- Each optical port shall consist of a pair of SC or LC Type connectors only
- Optical power budget ≥ 15 dB

2.7 WARRANTY: 5 years manufacturer warranty from the date of purchase.

2.8 PERFORMANCE:

- Switching Latency: $\leq 7\mu s$
- Switching Bandwidth: ≥ 5.6 Gbps

- VLANs: 255
- IGMP Groups: 255
- Minimum 32KB MAC address table (8192 MAC addresses)
- Minimum 4Kb VLAN address table
- Forwarding/Filtering rate: 14,888pps@10Mbps; 148,880pps@100Mbps; 1,488,800pps@1Gbps
- Minimum Mean Time Before Failures (MTBF) of 10 years (87,600 hours)

2.9 OTHER:

Diagnostic Light Emitting Diodes (LEDs) indicating Link, TX, RX and speed for each port, as well as Alarms and Power on unit. LED indicators shall be on the front panel of the unit.

2.10 MANAGEMENT CAPABILITIES:

The City shall be able to manage each MFES individually or as a group/cluster for switch configuration, performance monitoring, and troubleshooting. The MFES shall support setup/configuration and management and/or monitoring of all user programmable features and functions via the following:

- Local access to a Command Line Interface (CLI) via built-in serial (RS-232) port and/or USB port
- Remote access to the CLI via Telnet and SSH connections
- Remote access to a web server Graphical User Interface (GUI) via HTTP/SSL (128-bit encryption)
- Remote setup via Simple Network Management Protocol (SNMP) v1/v2/v3 (56-bit encryption)
- Remote setup via Trivial File Transfer Protocol (TFTP)
- Remote Monitoring (RMON)

2.11 CYBER SECURITY FEATURES:

The MFES shall support the following standard and advanced cyber security features:

- Multi-Level User Passwords
- SSH/SSL (128-bit encryption)
- Enable/Disable Ports
- MAC based port security
- Port based network access control
- Port-based VLANs and VLAN Tagging with GVRP
- Ability to generate an alarm and shut down ports if an unauthorized user accesses the network.

2.12 NETWORKING FEATURES:

Standard and advanced (layer 2+) networking features shall include, but are not limited to:

- Port Rate Limiting
- Port Mirroring
- Internet Group Messaging Protocol (IGMP) v1/v2 (Supporting “router-less” operation)
- Quality of Service (QoS) priority classify by port, tags, MAC address and IP type of service (ToS)

2.13 NETWORKING STANDARDS / IEEE COMPLIANCE:

The MFES shall comply with all applicable IEEE networking standards for Ethernet communications, including but not limited to:

- 802.3-10BaseT

- 802.3u-100BaseTX, 100BaseFX
- 802.3x-Flow Control
- 802.3z-1000BaseLX
- 802.3ab-1000BaseTX
- 802.3ad-Link Aggregation
- 802.1d-MAC Bridges
- 802.1d-Spanning Tree Protocol
- 802.1p-Class of Service (Quality of Service QoS)
- 802.1Q-VLAN Tagging
- 802.1w-Rapid Spanning Tree Protocol
- 802.1x-Port Based Network Access Control
- 802.1Q-2005 (formerly 802.1s) Multiple Spanning Tree Protocol (MSTP)

2.14 IETF RFC COMPLIANCE:

- | | |
|---------------------------|-----------------------------------|
| ▪ RFC768-UDP | ▪ RFC1541-DHCP (Client) |
| ▪ RFC783-TFTP | ▪ RFC2030-SNTP |
| ▪ RFC791-IP | ▪ RFC2068-HTTP |
| ▪ RFC792-ICMP | ▪ RFC2236-IGMP v2 |
| ▪ RFC793-TCP | ▪ RFC2284-EAP |
| ▪ RFC826-ARP | ▪ RFC2475-Differentiated Services |
| ▪ RFC854-Telnet | ▪ RFC2865-RADIUS |
| ▪ RFC894-IP over Ethernet | ▪ RFC3414-SNMP v3-VSM |
| ▪ RFC112-IGMP v1 | ▪ RFC3415 v3-VACM |
| ▪ RFC1519-CIDR | |

2.15 INSTALLATION REQUIREMENTS:

Furnish and identify all equipment and appurtenances by name, model number, serial number, technical support and warranty telephone numbers, and any other pertinent information required to facilitate equipment maintenance.

The MFES shall be mounted securely in a DIN rail mounting bracket, inside a field site cabinet, and shall be fully accessible by field technicians. Do not use self-tapping screws. Ensure that the MFES is protected from rain, dust, corrosive elements, and typical conditions found in a roadside environment. All wiring shall comply with NEC requirements and standards.

Connect devices to the power sources. Connect all remote ITS field devices to the appropriate MFES copper ports as specified in the plans. Connect the MFES to the fiber network trunk/drop cable termination panel as specified in the plans. Fiber optic patch cables shall be arranged and secured neatly in the patch panel and the minimum bend radius shall not be exceeded.

Use MFES units that can be serviced or replaced immediately when defective or damaged units must be removed and replaced. The Department shall return damaged units to the manufacturer for warranty repair or replacement.

All front panel status indicators (LEDs) shall remain unobstructed and visible.

2.16 FIELD TEST / VERIFICATION REQUIREMENTS:

The Contractor shall arrange for and conduct the tests and is responsible for satisfying all inspection requirements prior to submission for the City's inspection and acceptance. The City reserves the right to witness all FATs. Complete the tests within five business days.

Once the MFES has been installed, conduct local Field Acceptance Tests (FATs) at the MFES field site according to the test procedures stated herein.

1. Verify that physical construction has been completed as detailed in the plans.
2. Inspect the quality and tightness of ground and surge protector connections.
3. Verify proper voltages for all power supplies and related power circuits.
4. Verify all connections, including correct installation of communication and power cables.
5. Verify connectivity by means of link LEDs.
6. Verify configuration of the MFES Internet Protocol (IP) addresses and subnet mask.
7. Verify the network connection to the MFES through ping and telnet sessions from a remote personal computer (PC).
8. Perform testing on multicast routing functionality.
9. Call the City to verify that all field devices are reachable over the network.

3 DIGITAL VIDEO ENCODER

Hardware-based network device able to accept a minimum of one analog National Television System Committee (NTSC) video input and digitize it for transport across IP networks, as well as command and control signals for PTZ cameras.

3.1 INTEROPERABILITY:

Encoders, decoders and any related software applications shall be 100% compatible with the City’s existing Video/CCTV hardware devices from other manufacturers and developers that are currently in use by, or planned for purchase and use by the City of PSL, such as encoders, decoders, and its current Video Management Software (VMS) platform (Bosch “VIDOS”). Video and data packets produced by the encoder and placed onto the network shall allow reconstruction of digital video signals by hardware-based and software-based decoders that are also attached to the network.

3.2 PHYSICAL:

All exposed parts shall be constructed of corrosion resistant materials such as plastic, stainless steel, anodized or painted aluminum, brass or gold-plated metal.

- DIMENSIONS: >2” x >6” x >8”
- MOUNTING: DIN rail, or some other means that holds the device rigidly in place.

3.3 ELECTRICAL:

All wiring shall meet NEC requirements and standards.

- Input voltage: 89Vac to 135Vac @ 60Hz (may use power supply/converter)
- Power Consumption: ≤ 10W

3.4 ENVIRONMENTAL:

- Operating Temperature Range: +32°F to +122°F
- Max. Relative Humidity: 90% (Non-Condensing)

3.5 WARRANTY: 3 years

3.6 VIDEO SPECIFICATIONS:

Encoders shall operate with color and monochrome video. Encoders shall allow the user to select and adjust video resolution. Devices shall stream color and monochrome video at 30 frames per second (30fps) regardless of resolution.

3.7 H.264 FORMAT:

Encoder components shall employ video compression technology in accordance with the International Organization for Standardization (ISO) and International Electrotechnical Commission (IEC) requirements detailed in the ISO/IEC 14496-10:2009 standard. The encoder shall allow selection of various programmable fixed and variable H.264 bit rates.

3.8 INPUT/OUTPUT (I/O):

3.8.1 VIDEO:

- Inputs: 1 for PTZ Cameras / 4 for Video Detection Cameras

- Connector: BNC
- Impedance (Z): 75Ω, switchable
- Signal: Composite (analog), 1Vp-p, NTSC

3.8.2 COM PORT:

To transmit/receive command & control data from other devices (camera PTZ commands, etc).

- Inputs: 1
- Connector: Clamp (screw terminal)
- Signal: RS-232/422/485
- Data Rate: Up to 115Kbps
- Parity Bits: None, Odd, Even
- Stop Bits: 1 or 2

3.8.3 ALARM:

- Inputs: 1 for PTZ Cameras / 4 for Video Detection Cameras
- Connector: Clamp (non-isolated closing-contact)
- Activation Resistance: 10Ω max

3.8.4 RELAY:

- Output: 1
- Connector: Clamp
- Signal: 30Vp-p(SELV), 200 mA

3.9 NETWORK INTERFACE:

The encoder shall provide one 10/100BaseT “Fast Ethernet” port.

- Connector: RJ-45
- Auto-sensing
- Half/Full Duplex

3.9.1 PROTOCOLS:

RTP, Telnet, UDP, TCP, IP, HTTP, HTTPS, FTP, DHCP, IGMP v2/v3, ICMP, ARP, SMTP, SNMP, 802.1x

3.9.2 ENCRYPTION:

TLS 1.0, SSL, AES

3.10 SERIAL INTERFACE:

Encoders shall provide/support a TCP/IP interface (Virtual COM port) to their serial port using a network socket connection with configurable IP address and port number.

3.11 FRONT PANEL STATUS INDICATORS:

Devices shall provide light-emitting diode (LED) displays, liquid crystal displays (LCD), or similar illuminated displays to indicate status for power, data activity, link status, and video transmission.

3.12 SOFTWARE:

Provide compatible decoder software with the encoder device at no additional cost.

Decoding and control software packages shall allow viewing of any video source connected to the network through an encoder, including pan-tilt-zoom (PTZ) control of any PTZ camera on the

network, the discovery of encoder and decoder devices on the network, and the control and management of the programmable parameters of these devices, at no additional cost. All equipment licenses, where required for any software or hardware in the system shall be provided.

Any software-based video decoder application shall provide PC desktop/laptop display of IP network video streams.

3.13 ONVIF CONFORMANCE:

To ensure future compatibility with encoder and decoder devices and software applications or Video Management Systems (VMSs) from other manufacturers and developers, encoder devices shall be fully compliant with the latest version of the Open Network Video Interface Forum (ONVIF) core specification. Encoder and decoder devices and related software applications shall support stream selection and switching as well as full control and configuration using ONVIF commands.

3.14 CONFIGURATION and MANAGEMENT:

Devices shall support local and remote configuration and management. Configuration and management function shall include access to all user programmable features, including but not limited to: addressing serial port configuration, video settings, device monitoring, and security functions. Devices shall support configuration and management via local serial login and remote telnet login, web browser and Simple network Management Protocol (SNMP).

The encoder and decoder devices shall be capable of unicast and multicast operation. Encoders shall support Session Announcement Protocol (SAP) and Real Time Streaming Protocol (RTSP).

3.15 INSTALLATION:

The encoder shall be housed in a field cabinet with protection from moisture and airborne contaminants, blowing rain, wind, sand, dust, humidity, roadside pollutants, vandalism and theft.

The encoder shall be mounted on a DIN rail, or secured in place by a similar mounting method that will hold the device rigidly in place.

The device shall be mounted so that the front panel and status indicators remain unobstructed and visible, and in such a way that technicians have easy access to the input/output connections for power, video, serial/control, Ethernet, etc.

4 GUARANTY PROVISIONS:

The manufacturers' warranties for the MFES, encoders, decoders, and software applications shall be fully transferrable from the Contractor to the Department. These warranties shall require the manufacturer to furnish replacements for any part or equipment found to be defective during the warranty period at no cost to the Department within 10 calendar days.

REFERENCES:

Corning Cable Systems - Generic Specification "Single-Mode Optical Fiber in Loose Tube ... Cables"
Corning Cable Systems - Generic Specification "Gel-Free Loose Tube... Cables for Outdoor Applications..."
Corning Cable Systems – SRP-005-011 "Duct Installation of Fiber Optic Cable"
Corning Cable Systems - SRP-005-044 "Installing a Wire Mesh Pulling Grip On ... ALTOS Cables"
Corning Cable Systems - Whitepaper "Air Blown Fiber Systems – A Technical Discussion"

5 CONDUIT

5.1 MATERIAL SPECIFICATIONS FOR UNDERGROUND INSTALLATION

5.1.1 HDPE

HDPE conduit shall be used for directional bores.

5.1.1.1 OUTER DUCT

Conduit shall be manufactured from virgin high-density polyethylene with PE 3408 resin. Conduit shall be extruded with uniform full-thickness orange only coloring. Printed or embossed striping is not permitted.

Conduit shall be labeled with durable identification giving the name of the manufacturer, conduit size (inner diameter trade size and wall thickness/rating), manufacture/date codes, and sequential foot marking.

Conduits shall be 2" in diameter (IPS) and shall conform to ASTM D-3305 meeting the following minimum requirements:

- Smoothwall DR 11
- Nominal outer diameter - 2.375"
- Average inner diameter - 1.926"
- Minimum Wall thickness - 0.216"
- Tensile Strength – 3,000 psi min (ASTM-D638).
- Elongation – 400% min.
- Melt Index – 0.4max (ASTM-D1238).
- Condition B – 20% failure max (ASTM-D1693).
- Cell classification -3340 or 34420 (ASTM-D3350).
- Impact – NEMA Standards Publication TC7 (ASTM-D2444).

Conduits shall be factory treated with an atomized silicone or manufactured in a manner to reduce friction during pulling fiber optic cable. The coefficient of friction shall be 0.09 or less.

Conduit shall be resistant to calcium chloride, potassium chloride, sodium chloride, sodium nitrate, benzene, ethyl alcohol, fuel oil gasoline, lubricating oil, and transformer oil and is protected against degradation due to oxidation and general corrosion.

Conduit shall be suitable for underground use in an ambient temperature range of -30 to 130 degrees F without degradation of material properties.

All underground conduit installations shall be 2" Schedule 80 PVC or HDPE conduit with a minimum of 30" of cover as shown on the approved plans and standard detail. The

contractor shall use the following methods for placement of the buried fiber optic cable conduit:

- Trenching
- Plowing
- Joint Trench Installation
- Directional Drilling where necessary, or
- Other methods approved by PSL and EOR

The top of the conduit shall be not less than 30" below grade, and shall have a minimum slope of 3" in each 100' away from buildings and toward pull boxes and other necessary drainage points.

If the required depth cannot be accomplished due to soil conditions or obstructions, additional mechanical protection shall be provided as indicated by the EOR and PSL. For underground conduit requiring additional mechanical protection, i.e. boring under railroads, shall boring depth, proximity to other utilities, a black steel pipe shall be installed as an outer sleeve/casing or other material specified by the EOR and approved by the PSL.

The conduit shall be run in straight lines except where a change of direction is necessary. Should unsuitable soils be found, the contractor shall contact the EOR and PSL for final determination. Where installation is conduit only (i.e., not a joint trench installation), unsuitable soils shall be removed up an additional 3" of depth and will be replaced with clean fine sands, tamped level and meet density requirements.

For all new duct runs a continuous marking tape shall be direct buried at 12"-18" below grade.

Every effort shall be made to minimize HDPE couplings. Couplings shall be airtight and watertight. All couplings shall be installed in accordance with the conduit and the coupling manufacturer's recommendations. Only couplings of the type specified below and approved by the conduit manufacturer are permitted. Couplings shall be accomplished only by hydraulic press-on or electro-fusion coupling methods. Hydraulic press-on couplings of seamless tool-grade tubular aluminum with sealing barbs and center stop shall be used. Hydraulic compression duct coupling tools and manufacturer's installation procedures shall be utilized to fully insert both conduit sections to the coupling center stop. Pre-fabricated electro-fusion couplings shall be used in accordance with the manufacturer's recommended automatic self-monitoring fusing machine and installation procedures.

5.1.1.2 INNER-DUCT

Provide factory lubricated, industry sized 1.25-inch inside diameter, low friction, coilable, conduit constructed of virgin high-density polyethylene outer duct. Said inner duct shall conform to ASTM D-2239 and meet the following minimum

requirements: Smooth wall SDR-11, nominal outer diameter of 1.592 inches, minimum inner diameter 1.360 inches and a minimum wall thickness of 0.106 inches.

Provide conduit with a smooth outer wall and ribbed inner wall and ensure the conduit is capable of being coiled on reels in continuous lengths, transported, stored outdoors and subsequently uncoiled for installation without affecting its properties or performance. Inner duct shall be furnished in the following factory extruded colors: orange, red, and yellow.

Furnish and install inner duct with an uninterrupted detectable Kevlar pull (mule) tape, with a minimum of 3-feet of excess tape extending out of each end of the outer duct; these pull tapes shall be utilized in future phases for the installation and detection of fiber optic cable.

Provide mechanical duct plugs that provide a watertight barrier when installed in an unused inner duct conduit. Provide duct plugs sized in accordance with the conduit furnished. Provide duct lugs that are removable. All conduits shall come with factory installed duct plugs to keep out dust, dirt, and water.

Provide mechanical sealing devices that provide a watertight barrier between the conduit and communications cable. Provide mechanical sealing devices sized in accordance with the conduit furnished and with appropriately sized holes for the communications cable. Provide mechanical sealing devices that are removable.

5.1.2 PVC CONDUIT

Use of PVC conduit materials is specifically required in joint trench applications and in other instances, if approved by PSL.

Conduit shall be 2" schedule 80 PVC manufactured to NEMA TC-2, Federal Specifications WC1094A and VC651.

All bends shall consist of a minimum 48" radius sweep. Sweeps shall be fabricated by the manufacturer and shall have no indications of deformations of the pipe circumference or scorching of the conduit, otherwise the material will be rejected.

No more than an equivalent 180° bend radius shall be allowed in any conduit run in-between hand-holes/pull-boxes. PVC conduit shall be manufactured and installed in 20' lengths with bell and spigot design and all joints solvent welded and fully seated.

5.2 MATERIAL SPECIFICATIONS FOR ABOVE GROUND INSTALLATION

Conduit shall be 2" galvanized rigid steel (GRS), aluminum, or Schedule 80 PVC in accordance with ASTM D 1785. Rigid steel conduit material utilized shall be compliant with UL-6, ANSI C-80.1 and to Article 346 of the NEC. Aluminum conduits shall be of aluminum 6063 aluminum alloy, T-1 Temper, ANCI C80.5, and NEC 250.118(2). No reducing couplings or reduction in the inside diameter of conduit shall be permitted.

All required connectors, adapters, fittings, conduit straps or "U" guard clamps and incidentals required and necessary for above ground installations shall be galvanized and provided to construct a complete conduit/duct system.

The conduit for above ground use (a riser assembly on a utility service pole for the purpose of bringing power from above ground to underground conduit/duct, or bridge mounted or other above ground structure) consisting of galvanized rigid steel (GRS), aluminum, or Schedule 80 PVC conduit in accordance with ASTM D 1785 and as approved by the City.

Schedule 80 PVC conduit, aluminum or Rigid Metal Conduit (RMC) for bridge applicable. All rigid steel conduit material utilized shall be compliant with UL-6, ANSI C-80.1 and to Article 346 of the NEC. All aluminum conduits shall be of aluminum 6063 aluminum alloy, T-1 Temper, ANCI C80.5, and NEC 250.118(2). All required connectors, adapters, fittings, conduit straps or "U" guard clamps and incidentals required and necessary for above ground installations shall be galvanized and provided to construct a complete conduit/duct system.

No reducing couplings or reduction in the inside diameter of conduit shall be permitted. No intermediate metallic conduit (IMC) or thin-wall type electrical conduit shall be permitted on this project for outdoor use.

A galvanized metal conduit grounding bushing, or aluminum metal conduit grounding bushing on the terminating ends of all GRS/aluminum conduit runs. The bushings shall have an insert made of plastic or other suitable material to protect wiring installed in the conduit. The bushing shall have a compression-type grounding lug for bonding the conduit to the ground rod in the pull box. Do not field drill sealing bushings.

5.3 INSTALLATION REQUIREMENTS

5.3.1 SPLICING OF THE CONDUIT

Splice or join sections of conduit(s) using manufacturer's recommended splice kits. Upon approval, a junction box or pull box may be installed at locations where splicing or coupling of the conduit is necessary due to problems encountered with the installation.

5.3.2 DUCT PLUGS AND MECHANICAL SEALING DEVICES

Following the installation of conduit where the communications cable is not immediately installed use a duct plug to seal the ends of the conduit. Secure the pull line to the duct plug in such a manner that it will not interfere with the installation of the duct plug and provide a watertight seal.

In conduits containing communications cable, seal the conduit with an approved mechanical sealing device. Ensure the installation provides a watertight seal.

5.3.3 CONDUIT SEALS AND COUPLINGS

Conduit in which cable is placed shall be sealed with urethane foam duct seal; this material shall be inserted between the cable and the conduit.

5.4 TESTING OF CONDUIT

After installation of the conduit and completion of tamping/backfill process, a mandrel test shall be performed to ensure the conduit has not been damaged. A non-metallic mandrel with an outer diameter of at least 95% of the internal diameter of the conduit shall be passed through the conduit. If the mandrel fails to pass through the conduit, the defect shall be exposed and corrected. The test shall be repeated to assure that the defect has been satisfactorily corrected.

The PSL may accept alternative testing to demonstrate that the conductor can be pulled through the conduit if a written justification is submitted by the contractor.

6 LOCATE TRACER WIRE

Tracer wire shall be placed inside all conduits, terminating at the nearest pull box. The wire shall not be run into the cabinet.

The tracer wire shall be continuous and un-spliced between pull boxes, except in places where a directional drill occurs. The tracer wire shall be inside the conduit with fiber.

A continuity test shall be performed after installation to confirm that a continuous run of tracer wire was installed between pull boxes or directional drill. The tracer wire shall be tested before and after backfilling. The purpose of this test is to document that no damage or separation of the tracer wire has occurred during the installation of wire, backfilling of the trench, or box installation

7 MARKING TAPE

Marking tape shall be bright orange color, minimum 6" wide.

Marking tape shall be per the QPL, as specified, with " CAUTION PSL FIBER OPTIC CABLE CALL BEFORE DIGGING (800) 638-4097 " printed every 3' in black letters.

The tape shall be a dielectric, polyolefin film tape that is tear resistant, and corrosion resistant. The tape shall be constructed using material and ink colors, which will not change when exposed to acids and other destructive substances commonly found in the soil.

A marking tape shall be placed in the trench during cable installation, directly above the cable, 18" below grade. All conduit installed by use of directional boring shall not include the marking tape.

Marking tape shall be installed for the full length of the cable or conduit run.

8 PULL TAPE – MULE TAPE

Mule tape shall only be utilized if fiber optic cable is to be installed by the pull method. Pull tape shall be per the QPL. Mule tape shall be pulled in unison with the cable and left in all duct/s. In the case of conduit without fiber being pulled, a pull tape shall be pulled and left in the duct/s.

The tape shall have the following properties:

- Tensile strength of 1800 lbs
- Flat, not round, construction
- Printed foot markings
- Pre-lubricated for reduced pulling tension at start of cable pull, low susceptibility to absorption of moisture: moisture resistant
- Wire continuity testing shall be done.

9 CABLE ROUTE MARKERS

Markers shall be tubular in design and constructed of Type III high-density polyethylene material ultraviolet stabilized to help prevent their components from color fading, warping, absorbing water and deteriorating with prolonged exposure to the elements. Marker posts shall be orange in color.

The marker assemblies shall include the descriptive information " CITY OF PSL FIBER OPTIC CABLE – CALL BEFORE DIGGING (800) 638-4097" printed in black on an orange reflective background material that will not fade or deteriorate over time. The printed message shall be visible from all directions approaching the assembly.

As field conditions dictate, fiber markers shall be placed at approximately 500 foot intervals or as approved by the City on the rights-of-way line, but should be placed to avoid visual clutter in urban areas. Markers shall be placed at every pull box and midpoint. In unique situations, they could be shortened up to 250 feet or lengthened out to 750 feet, as approved by the City.

As field conditions dictate, fiber markers shall be placed at approximately 500 foot intervals or as approved by the City on the rights-of-way line, but should be placed to avoid visual clutter in urban areas. Markers should be as close to the property lines as possible. In unique situations, they could be shortened up to 250 feet or lengthened out to 750 feet, as approved by the City.

10 HUB SITES

Hub sites shall be installed at predetermined locations. The hub sites will provide full access and interconnections to ALL fibers in each cable that appear at these locations. The purpose of these locations is to provide an adaptable level of re-routing capabilities, which will be especially advantageous during emergency repair situations as well as routine and planned fiber network modifications. The re-routing capabilities gained from the locations will allow for network connectivity to be restored within minutes to hours, instead of hours to days, and will allow for fiber cable repairs and modifications to take place during normal working hours instead of overtime. The advantages gained in re-routing capabilities far outweigh any perceived disadvantages of increased exposure above ground.

Hub sites shall consist of a hub cabinet secured to a concrete pad. The Hub Cabinet specifications and construction shall be in accordance with the following:

- Enclosure shall be made from .125 thick aluminum type 5052-H32 and have the dimensions of 52.5 inches wide, 67.5 inches tall and 41.75 inches deep.
- The enclosure shall be weather tight, have provision for a screened air exhaust opening at the top of enclosure, all external hardware to be stainless steel.
- The enclosure should be equipped with 2 equal sized doors with three point latching system with nylon rollers at the top and bottom. Door handle is 3/4" diameter stainless steel and can be padlocked. The doors must be tamper resistant.

The hub cabinet shall also include:

- 12 Volt 103 AH power supply rechargeable sealed lead battery
- Air-cooled Panel mounted Air conditioner with BTU/H Capacity 4000, 95/95 Rating BTU/H 3340, Ambient Temp, F, Max/Min, 125/0, Volts 115/100 or 230/200, Hz 60/50, Running Amps 13.6/13.3 or 5.8

The Contractor is to provide shop drawings for review prior to construction.

Within each hub cabinet, each fiber optic cable existing at the location shall be pulled into the cabinet and be terminated separately. Each cable shall be terminated into its own individual 3M 8423 patch panel found in section 1.3 of this document. More than one fiber cable shall *not* be terminated into one patch panel.

Each fiber in the fiber optic cable shall be terminated by fusion splicing it into a pigtail with an ST connector found in section 1.4 of this document. Each pigtail shall be terminated into an 8-port ST adapter plate (part # 8408-TS). Three individual 8-port adapter plates shall be used per each row of the 8423 patch panel for a total of 24 accessible ST connector ports per row of the patch panel. A total of three 8423 expansion kits shall be used to increase the storage capacity of the patch panel to provide accessible ST connector ports for 96 fibers per cable, even if the number of fibers in the cable is less than 96. Fiber optic pigtails shall be placed into the adapter plate ports starting with the lowest number fiber (#1 or Blue fiber or the blue buffer) in the upper left-most port and increasing from left to right and with the last fiber (#96 or Aqua fiber of the Black buffer) in the lower right-most port.

The following equipment shall be required to terminate all fibers at each hub location:

4 x	3M 8423 Fiber Distribution Unit (Patch Panel)	3M part # 8423
12 x	3M Fiber Distribution Unit Expansion Ring	3M product # 8423-EXP
48 x	3M Adapter Plates	3M Product # 8408-TS
16 x	3M Small Fiber Splice Tray	3M Product # 2522-24-SF
384 x	Fiber Optic Pigtails w/ ST Connector	L-com Item # FPT3SNG-ST-YLW-1

11 MDF(main distribution frame)-Indoor Facilities/Lift Station Panels-MIS

The following items are to be used in indoor facilities such as server rooms and at Lift Station Panels as described.

11. 1 Panels & Modules

There are 2 different modular couplers that would be required for Lift Station panel work dependent on required number of connections.

Simplex, UPC, 12F, Single-mode (OS2) panel shall be used when interconnect or cross-connect capability is required to securely mate 12 fiber strands connectors in a panel configuration. The design adapter shall have blue housing and the housing material shall be of metal. The adapter style shall be standard, ST Compatible, and ceramic.

Simplex, UPC, 6F, Single-mode (OS2) panel shall be used when interconnect or cross-connect capability is required to securely mate 6 fiber strands connectors in a panel configuration. The design adapter shall have blue housing and the housing material shall be of metal. The adapter style shall be standard, ST Compatible, and ceramic.

11. 2 Module Coupler-Rack Mountable Hardware

This module unit shall be used inside a building when fusion splicing a 96 fiber is needed.

The Splice Module (6.4 in x 1.4 in x 7.9 in) with Pigtails shall be preloaded and pre-routed for quick fusion splicing of either individual or ribbon fiber pigtails. The fiber cable type shall be single fiber (250 mm), single mode (OS2). The design hardware shall include the connector configuration ST, fiber count 6, module type CCH, with 6 splice protector single fiber heat-shrink. The number of splice protectors is 6. The connector type is ST, with 12-port with 3 meter length. The optical specification of the hardware is a typical module insertion loss, typical 0.15 dB and maximum of 0.4 dB. The design adapter shall be SC.

11. 3 Enclosures

There are three types of enclosures that would be required for various applications.

- (1) For inside a building, Closet Connector Housing (CCH) provide interconnect and cross-connect capabilities between the outside plant, riser or distribution cables and opto-electronics. The housing must accept CCH connector panels CCH cassettes and CCH modules. The unit must be able to mount a rack 19-in, 23-in or cabinet mount. The dimension of the unit shall be (7 in x 19 in x 17 in) for proper rack placement. The design hardware consists of locking availability of front or rear, number of panels per housing of 12, panel or module type CCH and splice tray options of CCH Splice Cassette (CCH-CS).
- (2) For connection of an exterior fiber cable to the inside fiber splice, the Closet Splice Housing (CSH) must provide storage and protection of fiber splices in individually accessible trays. The housing must

be able to accommodate a rack 19-in, 23-in or cabinet mount. The dimension of the unit shall be (5.25 in x 17 in x 12 in). The design hardware consists of locking availability of front or rear, and the splice tray options are up to (12) category 2R, 2S or 2 M.

- (3) For Lift Station panels, the Single Panel Housing (SPH) shall provide storage, protection and termination of optical fiber cables. This unit shall include 1 panel per housing for a CCH module and include a 6- slot, 0.4-in splice holder which will accommodate up to 12 heat shrink single splices (double-staked) and/or six heat-shrink ribbon splices. The dimension of the unit shall be (6.3 in x 5.5 in x 2.0 in).

11. 4 Fan Out Kits

There are two types of fan out kits, indoor and outdoor.

- (1) Indoor Fan Out Kits: The buffer tube fan out kits shall be specifically designed for the termination of 6- and 12- fiber buffer types. The fiber cable to be connected shall be 250 mm coated fibers. The indoor kit should provide a 900 mm fan-out assembly that is color coded to match the fiber color scheme. The fan-out assembly must be in lengths of 25 in or 47 in. The temperature operation range shall be 0 C to 70 C.
- (2) Outdoor Fan Out Kits: The buffer tube fan out kits shall be specifically designed for the termination of 6- and 12- fiber buffer types. The outdoor kit should provide a 900 mm fan-out assembly that is color coded to match the fiber color scheme. The fan-out assembly must be in lengths of 25 in or 47 in. The temperature operation range shall be -40 C to 70 C.

11. 5 Connectors

There are three different type of ST compatible connector based on intended use.

- (1) For outdoor camera use: The connectors must be high precision zirconia ceramic ferrule connectors. The connector must be 62.5 mm multimode (OM1). The temperature range shall be 0 C to 60 C, meets TIA/EIA 568-B.3

The mechanical specifications shall be:

- durability \leq 0.2 dB change by 500 remating, FOTP-21,
- nominal fiber outer diameter of 125 mm,
- tensile strength jacketed cable of 50 N, change \leq 0.2 dB, FOTP-6 (11 lb, change \leq 0.2 dB FOTP-6)
- Tensile strength 900 mm cable of 4.9 N, change \leq 0.2 dB, FOTP-6 (1.1 lb, change \leq 0.2 dB, FOTP-6)

The optical specifications shall be:

- Insertion loss, typical 0.3 dB
- Insertion loss, max 0.75 dB
- Reflectance: \leq -26 dB

- (2) For Lift Station control panel: The connectors must be high precision zirconia ceramic ferrule connectors. The connector must be for single mode (OS2). The temperature range shall be 0 C to 60 C, meets TIA/EIA 568-B.3.

The mechanical specifications shall be:

- durability \leq 0.2 dB change by 500 rematings, FOTP-21,
- nominal fiber outer diameter of 125 mm,
- tensile strength jacketed cable of 44 N, change \leq 0.2 dB, FOTP-6 (11 lb, change \leq 0.2 dB FOTP-6)
- Tensile strength 900 mm cable of 4.9 N, change \leq 0.2 dB, FOTP-6 (1.1 lb, change \leq 0.2 dB, FOTP-6)

The optical specifications shall be:

- Insertion loss, typical 0.2 dB
- Insertion loss, max 0.5 dB
- Reflectance: ≤ -55 dB

- (3) For certain approved application, when the newer style LC connector is to be used inside a building: The connectors must be high precision zirconia ceramic ferrule connectors. The connector must be for 50 mm multimode (OM2). The temperature range shall be 0 C to 60 C, meets TIA/EIA 568-B.3.

The mechanical specifications shall be:

- durability ≤ 0.2 dB change by 500 rematings, FOTP-21,
- nominal fiber outer diameter of 125 mm,
- tensile strength jacketed cable of 44 N, change ≤ 0.2 dB, FOTP-6 (11 lb, change ≤ 0.2 dB FOTP-6)
- Tensile strength 900 mm cable of 4.9 N, change ≤ 0.2 dB, FOTP-6 (1.1 lb, change ≤ 0.2 dB, FOTP-6)

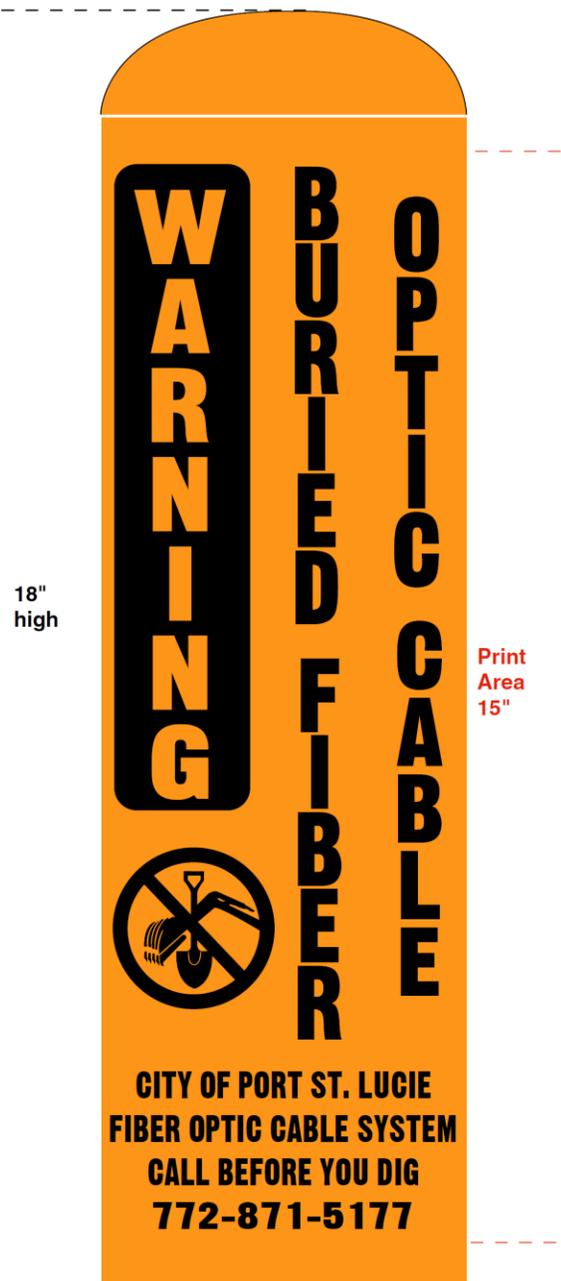
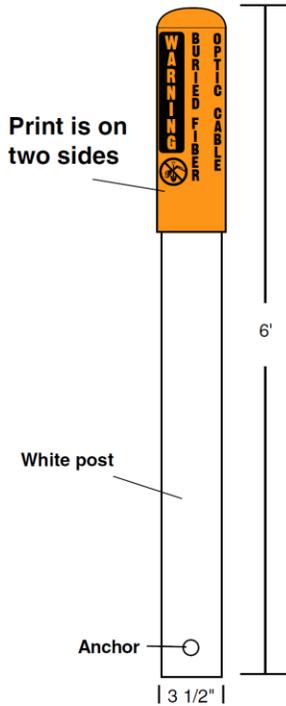
The optical specifications shall be:

- Insertion loss, typical 0.2 dB
- Insertion loss, max 0.5 dB
- Reflectance: ≤ -55 dB

11. 6 Indoor Splice Trays

The indoor splice tray shall be able to provide optimum physical protection for fusion and mechanical splicing methods. The trays shall be engineered for indoor splice hardware with both loose tube and tight buffered optical cable designs. The tray shall consist of rugged aluminum base and cover with crimpable metal tabs for buffer tube strain-relief. The tray shall be black powder coated. The design hardware shall have heat shrink splice protectors, splice tray category of 2S, splice tray capacity for 12 fibers. The unit dimensions shall be (11.7 in x 3.9 in x 0.2 in) to fit into the rack.

Appendix A



Qty: 50 each
 Size: 6'
 Material: Polydome
 Color: Orange with black text
 Scale: Shown @ 50%

Please inspect this proof carefully. We cannot be responsible for misspelled words, information or layout if Ok'd by the customer. This shows how your custom print job will be printed. Colors are a representation only and may vary from actual manufactured product.

FINAL ARTWORK APPROVAL O.K. to print? _____ YOUR P. O. #SNS010001180940
 Date: _____ Name: _____ DRAWING # 09-0510

Appendix B

Sample Shop Drawing Cut Sheets

Allied **PVC Electrical Conduit**



Formerly Georgia Pipe

UL LISTED RIGID SCH-40 & SCH-80 PVC ELECTRICAL CONDUIT

Allied ½" through 6" PVC Electrical Conduit is Underwriters Laboratories listed and is subject to in-process quality control testing to assure compliance with the appropriate manufacturing standards.

Allied PVC Electrical Conduit is manufactured to conform to NEMA TC-2 specifications and is UL listed.

For Commercial, Industrial and Utility usage:

Allied PVC Electrical Conduit is proven durable and effective for years of maintenance-free performance in underground, encased and exposed applications in accordance with the National Electrical Code.

Corrosion Proof:

Resistant to most chemicals, PVC is not affected by any corrosive soils or salts.

Non-Magnetic and Non-Galvanic:

Properties of Allied PVC Electrical Conduit assure good insulation and no power loss or conductor heating.

Self Extinguishing:

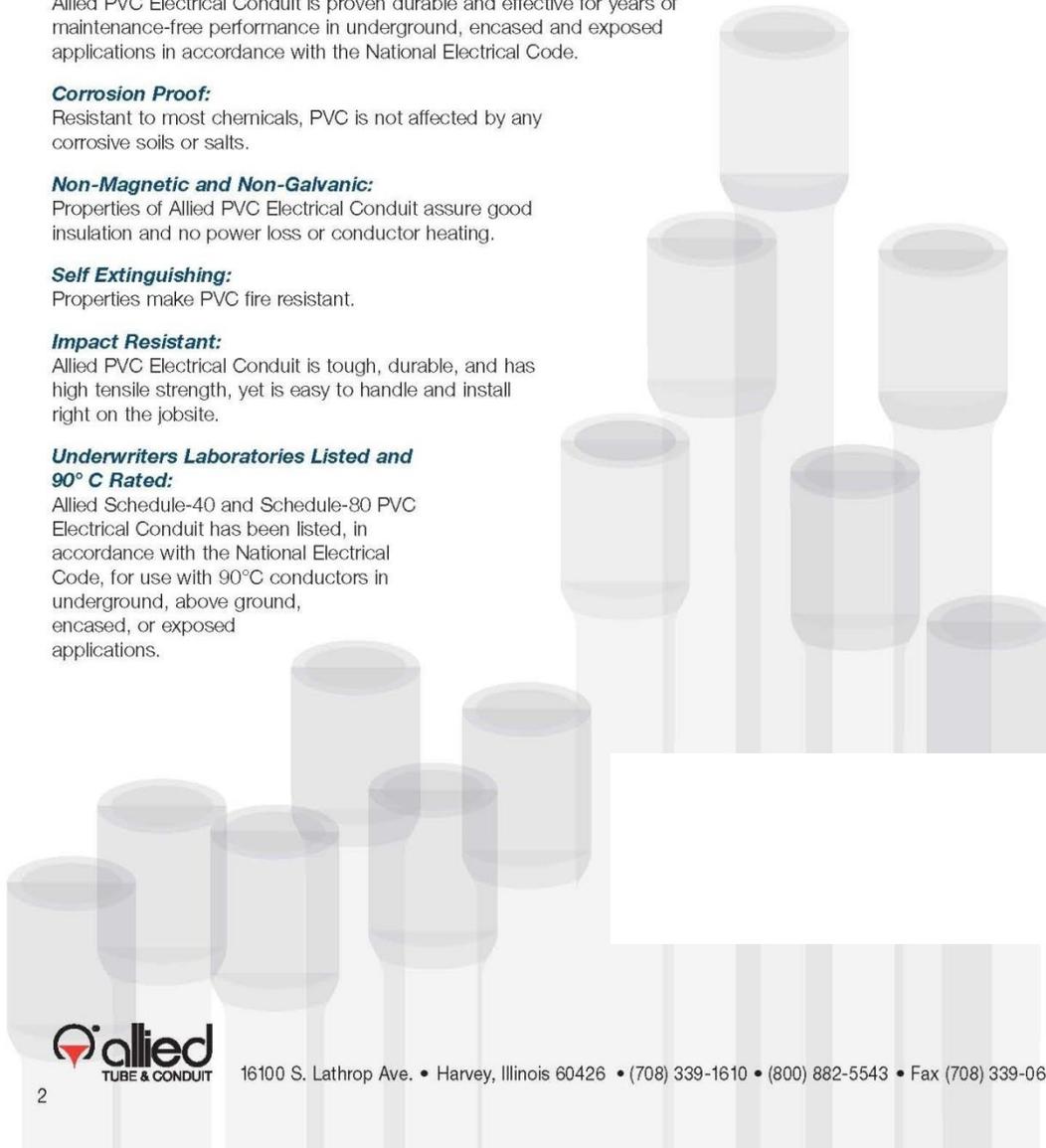
Properties make PVC fire resistant.

Impact Resistant:

Allied PVC Electrical Conduit is tough, durable, and has high tensile strength, yet is easy to handle and install right on the jobsite.

Underwriters Laboratories Listed and 90° C Rated:

Allied Schedule-40 and Schedule-80 PVC Electrical Conduit has been listed, in accordance with the National Electrical Code, for use with 90°C conductors in underground, above ground, encased, or exposed applications.



16100 S. Lathrop Ave. • Harvey, Illinois 60426 • (708) 339-1610 • (800) 882-5543 • Fax (708) 339-0615

Allied **PVC Electrical Conduit**

Formerly Georgia Pipe

UL LISTED RIGID SCH-40 ELECTRICAL CONDUIT RATED FOR 90 DEGREE CELSIUS WIRING

Allied Schedule-40 is sunlight resistant and manufactured in accordance and complies to:

Underwriters Laboratories, Inc. UL-651

NEMA

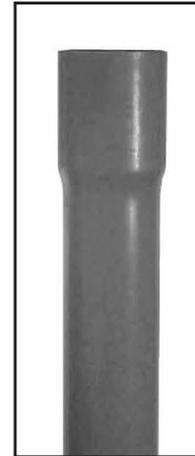
TC-2



Meets or exceeds the requirements of NEMA TC-2 and UL-651 for Schedule 40 Conduit.

Schedule 40 PVC Conduit Dimensions (10' lengths with belled ends)

Trade Size	No.	O.D.	Min. I.D.	Wall	Wt/Ft	Ft/Pallet
1/2	8102	.840	.622	.109	.164	6000
3/4	8103	1.050	.824	.113	.218	4400
1	8104	1.315	1.049	.133	.321	3600
1 1/4	8105	1.660	1.380	.140	.434	3300
1 1/2	8106	1.900	1.610	.145	.518	2250
2	8108	2.375	2.067	.154	.695	1400
2 1/2	8110	2.875	2.469	.203	1.096	930
3	8112	3.500	3.068	.216	1.435	880
3 1/2	8114	4.000	3.548	.226	1.729	630
4	8116	4.500	4.026	.237	2.043	570
5	8120	5.563	5.047	.258	2.776	380
6	8124	6.625	6.065	.280	3.600	260



SPECIAL INFORMATION

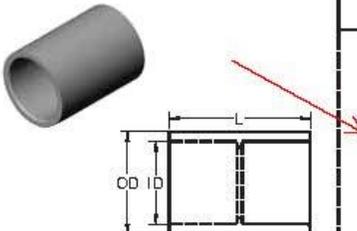
1. 20' lengths available on special request.
2. Minimum shipment: full pallet quantity per size.

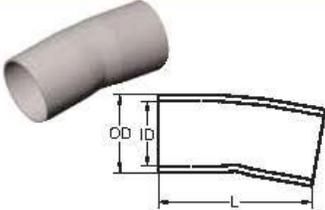
16100 S. Lathrop Ave. • Harvey, Illinois 60426 • (708) 339-1610 • (800) 882-5543 • Fax (708) 339-0615

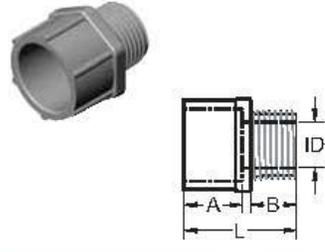


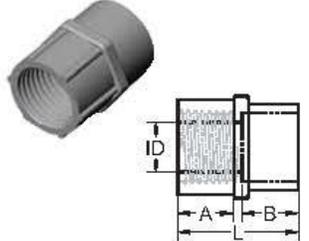
3

FITTINGS - Couplings and Adapters

COUPLINGS						
	Size (in)	Part Number	Unit Quantity	Outside Diameter (OD) (in)	Inside Diameter (ID) (in)	Length (L) (in)
	1/2	59601	150	1.080	0.840	1.437
3/4	59602	100	1.300	1.050	1.703	
1	59603	50	1.590	1.315	2.031	
1 1/4	59604	50	2.000	1.660	2.156	
1 1/2	59605	25	2.230	1.900	2.281	
2	59606	40	2.720	2.375	2.406	
2 1/2	59607	20	3.320	2.875	3.187	
3	59608	30	4.000	3.500	3.437	
3 1/2	59609	20	4.500	4.000	3.625	
4	59610	20	5.000	4.500	3.750	
5	59611	10	6.120	5.565	4.187	
6	59612	5	7.370	6.625	4.562	

5° COUPLINGS						
	Size (in)	Part Number	Unit Quantity	Outside Diameter (OD) (in)	Inside Diameter (ID) (in)	Length (L) (in)
	2	802731	15	2.375	2.049	4.0
2 1/2	802732	12	2.875	2.445	5.5	
3	802733	10	3.500	3.042	6.0	
3 1/2	802734	15	4.000	3.521	7.0	
4	802735	15	4.500	3.998	7.0	
5	802736	4	5.565	5.018	7.5	
6	802737	6	6.625	6.031	11.0	

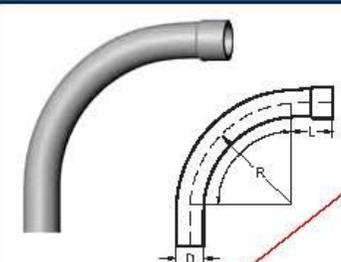
TERMINAL ADAPTERS							
	Size (in)	Part Number	Unit Quantity	A (in)	B (in)	Inside Diameter (ID) (in)	Length (L) (in)
	1/2	59615	200	0.750	0.700	0.591	1.550
3/4	59616	150	1.000	0.675	0.790	1.750	
1	59617	100	1.115	0.625	1.000	1.860	
1 1/4	59618	50	1.300	0.640	1.311	2.125	
1 1/2	59619	30	1.425	0.725	1.530	2.250	
2	59620	50	1.150	0.800	1.970	2.100	
2 1/2	59621	25	1.900	0.800	2.346	2.930	
3	59622	50	2.000	0.815	2.915	3.055	
3 1/2	59623	30	1.715	1.000	3.385	3.055	
4	59624	30	1.990	0.815	3.850	3.215	
5	59625	12	2.000	1.725	5.015	5.985	
6	59626	10	2.130	1.875	6.025	6.500	

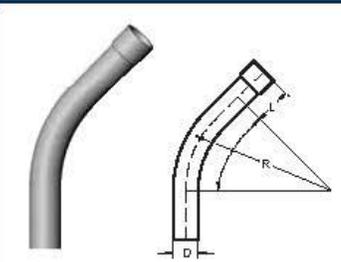
FEMALE ADAPTERS (NPT Tapered Thread)							
	Size (in)	Part Number	Unit Quantity	A (in)	B (in)	Inside Diameter (ID) (in)	Length (L) (in)
	1/2	59630	150	0.800	0.825	0.620	1.725
3/4	59631	100	0.800	1.000	0.820	1.900	
1	59632	50	1.000	1.200	1.065	2.300	
1 1/4	59633	30	1.015	1.300	1.395	2.425	
1 1/2	59634	25	1.050	1.290	1.575	2.440	
2	59635	30	1.075	1.375	2.050	2.550	
2 1/2	59636	20	1.675	1.985	2.470	3.780	
3	59637	25	1.630	2.150	3.090	4.100	
3 1/2	59638	20	1.800	2.000	3.540	3.985	
4	59639	15	1.765	2.185	4.025	4.210	
5	59640	10	2.065	3.000	5.035	5.240	
6	59641	6	2.065	3.000	6.045	5.235	

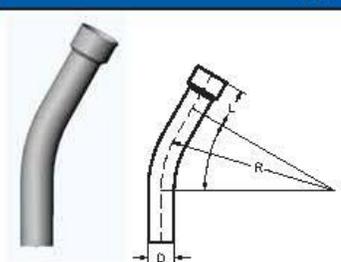
RIGID PVC CONDUIT FITTINGS

www.tycoelectrical.com

FITTINGS - Bends (Bell End Elbows)

90° ELBOWS - Bell End						
	Size	Part	Unit	Diameter (D)	Length (L)	Radius (R)
	(in)	Number	Quantity	(in)	(in)	(in)
	1/2	802752	35	0.840	1.500	4.00
	3/4	802753	50	1.050	1.500	4.50
	1	802754	25	1.315	1.875	5.75
	1 1/4	802755	20	1.660	2.000	7.25
	1 1/2	802756	15	1.900	2.000	8.25
	2	802757	10	2.375	2.000	9.50
	2 1/2	802758	100	2.875	3.000	10.50
	3	802759	50	3.500	3.125	13.00
	3 1/2	802761	50	4.000	3.250	15.00
	4	802762	50	4.500	3.375	16.00
	5	802763	25	5.565	3.622	24.00
	6	802764	25	6.625	3.740	30.00

45° ELBOWS - Bell End						
	Size	Part	Unit	Diameter (D)	Length (L)	Radius (R)
	(in)	Number	Quantity	(in)	(in)	(in)
	1/2	802765	70	0.840	1.500	4.00
	3/4	802767	50	1.050	1.500	4.50
	1	802768	50	1.315	1.875	5.75
	1 1/4	802769	30	1.660	2.000	7.25
	1 1/2	802770	15	1.900	2.000	8.25
	2	802771	10	2.375	2.000	9.50
	2 1/2	802772	12	2.875	3.000	10.50
	3	802773	10	3.500	3.125	13.00
	3 1/2	802774	1	4.000	3.250	15.00
	4	802775	1	4.500	3.375	16.00
	5	802776	1	5.565	3.625	24.00
	6	802777	1	6.625	3.750	30.00

45° ELBOWS - Bell End ELBOWS - Bell End						
	Size	Part	Unit	Diameter (D)	Length (L)	Radius (R)
	(in)	Number	Quantity	(in)	(in)	(in)
	1/2	802778	50	0.840	1.500	4.00
	3/4	802779	35	1.050	1.500	4.50
	1	802780	50	1.315	1.875	5.75
	1 1/4	802781	30	1.660	2.000	7.25
	1 1/2	802782	50	1.900	2.000	8.25
	2	802783	30	2.375	2.000	9.50
	2 1/2	802784	10	2.875	3.000	10.50
	3	802785	10	3.500	3.125	13.00
	3 1/2	802786	1	4.000	3.250	15.00
	4	802787	1	4.500	3.375	16.00
	5	802788	1	5.565	3.625	24.00
	6	802789	1	6.625	3.750	30.00

ELECTRICAL CONDUIT



SUBMITTAL AND DATA SHEET

SCHEDULE 40 AND SCHEDULE 80 CONDUIT NSF NRTL* ANSI/UL 651 AND NEMA TC-2

RIGID NON-METALLIC CONDUIT FOR USE IN BOTH ABOVE GROUND AND UNDERGROUND INSTALLATIONS

SCHEDULE 40 CONDUIT

Rated for 90°C Conductors

SIZE	AVERAGE O.D.	NOM. I.D.	MIN. T.	APPROX. WT/100 FT
1/2	0.840	0.622	0.109	18
3/4	1.050	0.824	0.113	24
1	1.315	1.049	0.133	33
1-1/4	1.660	1.380	0.140	45
1-1/2	1.900	1.610	0.145	56
2	2.375	2.067	0.154	76
2-1/2	2.875	2.469	0.203	126
3	3.500	3.068	0.216	163
3-1/2	4.000	3.548	0.226	197
4	4.500	4.026	0.237	234
5	5.563	5.047	0.258	319
6	6.625	6.065	0.280	411
8 ::	8.625	7.942	0.322	622

Schedule 40 is furnished in standard 10' lengths with one bell end.
20' lengths are available upon request.
:: Non-UL or -NSF listed

SCHEDULE 80 CONDUIT

Rated for 90°C Conductors

SIZE	AVERAGE O.D.	NOM. I.D.	MIN. T.	APPROX. WT/100 FT
1/2	0.840	0.546	0.147	22
3/4	1.050	0.742	0.154	30
1	1.315	0.957	0.179	42
1-1/4	1.660	1.278	0.191	60
1-1/2	1.900	1.500	0.200	72
2	2.375	1.939	0.218	98
2-1/2	2.875	2.323	0.276	160
3	3.500	2.900	0.300	213
3 1/2	4.000	3.364	0.318	256
4	4.500	3.826	0.337	310
5	5.563	4.813	0.375	430
6	6.625	5.761	0.432	590

Schedule 80 is furnished in standard 10' lengths with one bell end.
20' lengths are available upon request.

* NATIONAL RECOGNIZED TESTING LABORATORY (NRTL) BY OCCUPATIONAL HEALTH AND SAFETY ADMINISTRATION (OHSA)

Allied RIGID Specifications

PROVIDES FULL ELECTRICAL SYSTEM PROTECTION

Allied RIGID is precision manufactured for dependable, long-lasting value and protection for the electrical raceway system.

Manufactured from high-strength steel, Allied RIGID combines damage-resistant strength with ductility to assure easy bending, cutting and joining. It also provides smooth, continuous raceways for fast wire-pulling. No need to worry about damage to the conduit system even when pulling through multiple 90° bends.

Allied RIGID is hot-dipped galvanized inside and out. It is top-coated with a compatible organic layer to inhibit white rust and increase corrosion resistance.

Allied RIGID is impact and crush resistant for maximum conductor protection.

The 3/4" taper NPT threads (ANSI B1.20.1) are full cut and hot galvanized after cutting. Color-coded end-cap thread protectors keep the threads clean and sharp and also provide instant trade size recognition. Even-inch sizes are color-coded blue, 1/2-inch sizes are black, and 1/4-inch sizes are red.

EMI SHIELDING

Allied RIGID greatly reduces electromagnetic fields, effectively shielding computers and sensitive electronic equipment from the electromagnetic interference caused by power distribution systems. For further information, visit our website for a free download of the GEMI (Grounding and Electromagnetic Interference) analysis software and related research papers.

FULL CODES AND STANDARDS COMPLIANCE

Allied RIGID is U.L. listed and is recognized by the National Electrical Code. It meets Underwriters Laboratories Safety Standard U.L. 6, and is manufactured to ANSI C80.1, both of which have been adopted as Federal Specifications in lieu of WWC 581. Allied RIGID is recognized as an equipment grounding conductor by NEC Article 250. Documentation for compliance with NEC Article 250 is available from Allied.

Installation of Rigid Metal Conduit shall be in accordance with the National Electrical Code and U.L. General Information card #DYIX.

Master bundles conform to NEMA standard RN2.

SPECIFICATION DATA

RIGID Metal Conduit shall be hot-dip galvanized steel equal to that manufactured by Allied Tube & Conduit Corporation. Threads shall be hot galvanized after cutting. RIGID shall be produced in accordance with U.L. Safety Standard #6 and ANSI C80.1 and shall be listed by a nationally recognized

testing laboratory with follow-up service. Where **Kwik-Couple RIGID** is used it shall also meet U.L. Safety Standard #514-B. It is noted that these U.L. standards have been adopted by the federal government and separate military specifications no longer exist.

For more information, contact Allied at (800) 882-5543, or visit our website at www.atcelectrical.com

Weights and Dimensions for Galvanized Rigid Tubing

Trade Size Designator		Approx. Wt. * Per 100 Ft. (30.5M)		Nominal Outside Diameter ¹		Nominal Wall Thickness		Quantity In Master Bundle	
U.S.	Metric	lb.	kg	in.	mm	in.	mm	ft.	m
1/2	16	82	37.2	0.840	21.3	0.104	2.60	2500	762.5
3/4	21	109	49.4	1.050	26.7	0.107	2.70	2000	610.0
1	27	161	73.0	1.315	33.4	0.126	3.20	1250	381.3
1-1/4	35	218	98.9	1.660	42.2	0.133	3.40	900	274.5
1-1/2	41	263	119.3	1.900	48.3	0.138	3.50	800	244.0
2	53	350	158.7	2.375	60.3	0.146	3.70	600	183.0
2-1/2	63	559	253.5	2.875	73.0	0.193	4.90	370	112.9
3	78	727	329.7	3.500	88.9	0.205	5.20	300	91.5
3-1/2	91	880	399.1	4.000	101.6	0.215	5.50	250	76.3
4	103	1030	467.1	4.500	114.3	0.225	5.70	200	61.0
5	129	1400	634.9	5.563	141.3	0.245	6.20	150	45.8
6	155	1840	834.5	6.625	168.3	0.266	6.80	100	30.5

¹ For more information only; not a spec requirement.

NOTE: Length = 10 ft. (3.05m) with a tolerance of +/- .25" (6.35mm).
* NEMA Standard

Weights and Dimensions for K

Trade Size Designator		Approx. Wt. Per 100 Ft. (30.5M)							
U.S.	Metric	lb.	kg						
2-1/2	63	559	253.5						
3	78	727	329.7	3.500	88.9	0.205	5.20	300	91.5
3-1/2	91	880	399.1	4.000	101.6	0.215	5.50	250	76.3
4	103	1030	467.1	4.500	114.3	0.225	5.70	200	61.0

¹Outside diameter tolerances: +/- .025 in. (.64mm) ²For more information only; not a spec requirement.



Electrical & Metal Products

AFC Cable Systems® • Allied Tube & Conduit • Cope® Cable Tray • Power-Strut® Metal & Fiberglass Framing



AFC Cable Systems, Allied, Cope, Power-Strut, Kwik-Couple® and Tyco are trademarks or registered trademarks of Tyco and/or its affiliates in the United States and in other countries. All other brand names, product names, or trademarks belong to their respective owners.

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Appendix C

QPL- Fiber Optic Products

CASING SPACERS - 12" Width min.

APS - Advance Products Systems
PSI - Pipeline Seal and Insulator

Cascade

CONTROL CABINET FASTENERS

Stainless Steel Tapcons

FIBER OPTIC CABLE

CORNING/SIECOR – 096EU4-T4701D20 - 96 Fiber ALTOS Gel-Free Cable Non Armored SMFe 1.4/0.4/0.3 dB/km 12f/tube Print in ft

CORNING/SIECOR – 012EU4-T4701D20 - 12 Fiber ALTOS Gel-Free Cable Non Armored SMFe 1.4/0.4/0.3 dB/km 12f/tube Print in ft

FIBER OPTIC SWITCH

Ruggedcom/Siemens rs900g. RS900G-HI-D-2SC10-XX

HDPE-High Density Polyethylene Pressure Pipe-w/PE 3408 resin 2" IPS ASTM D-3305-directional bores

Dura-line Smoothwall DR 11

HUB CABINET – FIBER OPTIC

Cabinet-Transportation Control Systems- SMF605036B2TFLRD
Power Supply- Power Sonic-PG-12V103 FR 12 Volt 103 AH
Air Conditioner- Kooltronic RP33 Advantage Air-Cooled Panel Mounted Air Conditioner- KA4C4RP33R or K2A4C4RP33R

LOCATE TRACER WIRE

CME THWN -2 – 14 gauge, 19 Strand , 25 Ampacity, Orange Coated

LOCATE TRACER WIRE CONNECTORS

Copperhead Ind. DRYCONN Direct Bury Lug #CH90120

LUBRICANT – (ANTI-SEIZE)

Oxlic Never Seize

MDF-Main Distribution Frame-Indoor Facilities/Lift Station Panels-MIS

Panel & Modules: 12F Corning CCH-CP12-19T

6F Corning CCH-CP08-19T

Modular Coupler: Corning CCH-RM12-19T-P03RH

Enclosures: Inside Building- Corning CCH-04U(open)

Lift Station- Corning-SPH-01P

Outside fiber to inside fiber: Corning CSH-03U
Fan Out kits: Indoor-Corning-FAN-BT25-12
Outdoor- Corning-FAN-OD25-12

Connectors: Camera outdoor- Corning 95-000-50-Z
Lift Station Panel-Corning 95-200-51-Z
Indoor- Corning 95-050-51-Z

Splice Tray: Indoor-Corning M67-048

PIG TAILS & CONNECTORS

Corning 00610R31310mST-Fiber Optic Pig Tails (Single mode 2.9mm 1 meter length)
Corning ST/ST Simplex-Fiber Optic Patch Cord (Single mode 3mm Yellow PVC Jacket 3 meter length)

PULL BOX – FIBER OPTICS-Tier 15 (min)

For installation in concrete or grass

Box - Quazite – PG1730BB18 – 17” x 30” x 18”d
Box- Synertech--S1730B18FA- 17” x30” x 18”d

Cover – Quazite – PG1730CA00
Cover- Synertech- S1730HBBOA

PULL TAPE – FIBER OPTIC

Traceable pull tape, 1800 lbs tensile strength
Fibertek – WPT1800

PVC (Polyvinyl Chloride) PIPE -2” schedule 80

North American Pipe
Silver Liner Plastics Inc.
National American

Diamond Plastic Corporation
J-M

RIGID CONDUIT

Tyco-

SPLICE BOX – FIBER OPTIC-Tier 15 (min)

Box - Quanzite – PG3048BB – 30” x 48”x 36”d
Box- Oldcastle- 3048-36- 30” x 48” x 36”d

Cover – Quazite – PG3048HC00
Cover- Oldcastle-Uni-half 3048

SPLICE CLOSURES

Tyco FOSC-450-C6-6-NT-0-C6V-Fiber Optic Enclosure
Splice Tray- FOSC-ACC-C-Tray-24
Basket- FOSC-ACC-C-Basket
3M TELCOM 8423-EXP-Fiber Optic Expansion Modules (for 8400 series enclosure)

UNDERGROUND TAPE – FIBER OPTIC

Detectable underground tape, “caution fiber optic cable buried below” 6” wide, black on orange
Harris Ind – DU-10-6