

Project: US 6 over Garrison Street
Project Sub Acct. No: 19478
July 10, 2014
DRAFT Technical Requirements

Section 19 – ITS – Appendix A – Special Provisions

SECTION 19, APPENDIX A

Project Special Provisions

Section 19 – ITS – Appendix A – Special Provisions
REVISION OF SECTION 604
MANHOLE (TRAFFIC MANAGEMENT SYSTEM)

Section 604 of the Standard Specifications is hereby revised for this project as follows:

DESCRIPTION

The Traffic Management System (TMS) manhole shall include the installation of manholes for the Traffic Management System for locations shown on the plan sheets, or as approved by the Engineer.

MATERIALS

Manhole (TMS) shall consist of a pre-cast concrete, 4-foot square vault with a base and cast iron frame ring and cover. The manhole shall be designed to provide a pre-cast conduit entrance depth of 3 foot. Each manhole, frame and cover shall conform to AASHTO HS20-44. Each Manhole shall be equipped with a removable ladder that is engineered to support 300 pounds. The ladder support shall be permanently fixed to the manhole.

CONSTRUCTION

Pre-cast manhole shall be provided with Corbels (knockouts) to accommodate six (6) 2-inch conduits which shall remain intact unless otherwise required for conduit installation. Contractor shall install conduit in order from bottom to top. Contractor shall seal all voids surrounding conduits in knockouts with epoxy. The manhole shall have a detachable cover that has a skid-resistant surface and have the words "CDOT COMM" physically impressed, (not painted) on its top. The cover shall be attached to the manhole body by screw-in bolts. Each Manhole shall include fiber management canister hangers and cable hooks for proposed fiber. Hangers and hooks for fiber coils and splice canisters shall be of sufficient quantity for each backbone and lateral cable. Fiber optic cable coils shall be tied to each cable hook with plastic cable ties. Caution shall be taken to coil the fiber cable per the manufacturer's recommendations. If hangers are not factory installed in the manhole, bolts for attaching hangers and hooks shall be installed in the manhole walls by means of either an epoxy compound or expansion type fitting. Conduit entering manhole shall have sweeps attached so conduit entrance is elevated.

METHOD OF MEASUREMENT

Manhole (TMS) will be measured by the complete unit in place and accepted by the Engineer. Manhole (TMS) shall include but not be limited to the manhole, excavation and backfill, hooks for coils, hangers for splice canister, knockout sealing, as well as all equipment and labor necessary for a complete manhole installation per project detail sheet.

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REVISION OF SECTION 604 MANHOLE (TRAFFIC MANAGEMENT SYSTEM)

PAYMENT

Payment will be made under:

Pay Item

Pay Unit

Manhole (Traffic Management System)

Each

Conduit plugs shall be included in the cost of the conduit.

END OF SECTION REVISION

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REVISION OF SECTION 612

LOCATION MARKERS

Section 612 of the Standard Specifications is hereby revised for this project as follows:

Description

Contractor shall furnish and install location markers for identifying fiber optic cable and other utilities at locations shown on the plans.

Material

Location Marker (Fiber Optic) (Dome) shall be made of non-conductive high-density polymer, and shall be integrally white in color with an orange cap. All colors shall be stabilized against ultraviolet light such that they will not fade under continuous exposure to direct sunlight. The marker shall retain dimensional stability in temperatures ranging between -40° F and 175° F. In some instances when markers are installed on National Forest Service Lands the fiber optic marker shall be brown in color.

Location Marker (Utility) (Flat Slat) shall be made of fiberglass reinforced composite, and shall orange in color. The marker shall retain dimensional stability in temperatures ranging between -40° F and 175° F. In some instances when markers are installed on National Forest Service Lands the fiber optic marker shall be brown in color.

Concrete footing for dome marker shall be 18 x 18 x 12 inches per project detail. Concrete footing shall be Concrete Class B and shall be in accordance with Section 601.

Location Marker Electronic (Ball) shall be a Full Range Electronic Marker Ball operating at the frequency of 101.4 kHz for communication line locating. The electronic marker ball shall be compatible with a Dynatel cable locator. These electronic markers shall be installed within 12 inches of the lid of said pull box, manhole or open trench. Electronic Markers may be fabricated into the pull box or manhole.

Construction

Location Marker (Fiber Optic) (Dome) shall be installed at appropriate Pull Box and Manhole (TMS) locations as shown on the plans to identify both the backbone fiber cable and lateral fiber cable. To additionally designate the fiber cable, intermediate markers shall be installed at 1000-foot spacing along the running line.

The marker shall include a label with CDOT contact information and the designation of “FIBER OPTIC CABLE”. The label shall have black lettering on an orange background. The label shall include the highway milepost of the Pull Box or Manhole (TMS).

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REVISION OF SECTION 612 LOCATION MARKERS

The mile post shall be to the nearest hundredth. This label shall be placed below the “FIBER OPTIC CABLE” warning label. In some instances when markers are installed on Forest Service Lands the dome marker label shall have black letting on a brown background. The Contractor shall provide the label submittal to the Project Engineer.

Location Marker (Utility) (Flat Slat) shall be installed at utility pull box/manhole locations and utility point of service to identify both electric and telephone communication lines. Contractor shall designate the utility line with a marker installed mid-point between the utility point of service and the device.

The markers shall include a label with CDOT contact information and the designation of “ELECTRICAL CABLE” or “TELEPHONE CABLE”. The label shall have black lettering on an orange background. In some instances when markers are installed on Forest Service Lands the flat marker label shall have black letting on a brown background. The Contractor shall provide the label submittal to the Project Engineer.

Location Marker Electronic (Ball) shall be installed inside each pull box, manhole or open trench at locations shown on the plan sheets. The Marker Ball shall be securely positioned for optimal output and prevent accidental removal.

The Contractor shall provide the Engineer with three copies of detailed As-Built drawings showing the installed locations of all markers and the associated utilities. These drawings shall include but not be limited to the following:

- (1) Type of location marker installed
- (2) Distances between location markers
- (3) Distances between pull boxes and manholes to ITS devices
- (4) The distance and location to each CDOT utility point of service connection source point which the local utility companies have provided, including electrical power, transformer source, and telephone pedestals.

Method of Measurement

Location markers, labels and footing will be measured by the actual number of markers that are placed and accepted.

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REVISION OF SECTION 612 LOCATION MARKERS

Method of Payment

<u>Pay Item</u>	<u>Pay Unit</u>
Location Marker (Fiber Optic) (Dome)	Each
Location Marker (Utility) (Flat Slat)	Each

Payment will be full compensation for all work, materials and equipment required to place the markers at the locations shown on the plans, including excavation, backfill, and patching.

Concrete for footing will not be measured and paid for separately but shall be included in the Marker.

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REVISION OF SECTION 613
ELECTRICAL CONDUCTOR IDENTIFICATION

Section 613 of the Standard Specifications is hereby revised for this project as follows:

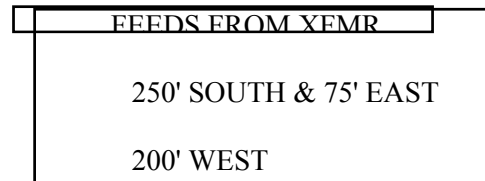
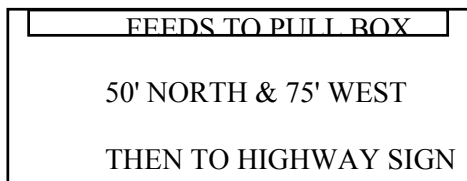
Section 613.08 shall include the following:

All electrical conductors shall be tagged as follows:

Electrical conductor cable tags shall be located below the termination in the base of the street light, in the pull box, in the pedestal and at the point of termination to existing facilities of the Local Utility Company supplying electrical service. The tags shall be attached with a cable tie. The information written on the tag shall include the direction and approximate length of cable feeds running from where to, etc.

Each incoming conductor shall be individually color coded with 1 tape mark, while outgoing conductors shall have 2 tape marks.

Example:



Uniform tags are available in a Tag Kit. The Tag Kit consists of: 100 tags, 3 part yellow with 1 hole, 100 black nylon ties and 1 black sharpie pen.

Size	2-1/2" X 5"
Standard Package	Kit
Weight, Kit, Approx.	1.5 Pounds
Color	Yellow

Electrical conductor tagging will not be paid for separately, but shall be included in the cost of the Electrical Conduit and all associated equipment installation.

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REVISION OF SECTION 613

PULL BOXES

Section 613 of the Standard Specifications is hereby revised for this project as follows:

DESCRIPTION

Contractor shall furnish and install fiberglass reinforced, polymer concrete pull boxes.

MATERIALS

Pull boxes installed in dirt or landscaped areas shall have a concrete apron with 3 sides, 12 inches wide by 6 inches deep and a top side of 18 inches wide by six inches deep for marker installation. Pull boxes shall not be installed above the grade of the apron. Concrete apron shall have a 1% slope away from the top of pull box. All concrete aprons shall be Class B and shall be in accordance with Section 601.

Pull boxes shall have a detachable cover with a skid-resistant surface and have the words “CDOT COMM” cast into the surface. Painting of words shall not be accepted. The cover shall be attached to the pull box body by means of 3/8 x 7 inch lag head stainless steel hex head bolts and shall have two (2) lift slots to aid in the removal of the lid.

Wire mesh shall be installed in a manor to completely surround the box. The wire mesh shall meet the material standard ANSI/ASTM A555-79 and made of T-304 stainless steel, 0.025 inch wire diameter minimum and shall have a spacing of 12 mesh per inch.

Pull boxes shall be verified by a 3rd Party Nationally Recognized Independent Testing Laboratory as meeting all test provisions of ANSI/SCTE 77 2007 Specification for Underground Enclosure Integrity, Tier 22 rating. Pull boxes shall be UL listed. Certification documents shall be submitted with material submittals.

CONSTRUCTION

A minimum of 12 inches of 3/4 inch granite-gravel shall be installed as a base for the pull box to aide in drainage. The 3/4 inch granite-gravel shall be free of dirt and debris and spread evenly to facilitate a level base for the pull box. The Contractor shall ensure that sufficient compacting is made prior to the installation of 3/4 inch granite-gravel to help alleviate future settling.

Wire mesh shall be installed in a manor to completely surround the box. The wire mesh shall be installed prior to the installation of the pull box above the bed of 3/4” granite-gravel and extending one foot past the outer edges of the concrete apron.

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REVISION OF SECTION 613 PULL BOXES

The wire mesh shall be gently cut to allow only the entrance of the conduit at the bottom of the box. Any openings cut in the wire mesh larger than the diameter of the conduit shall be remedied by the installation of additional wire mesh to obtain a completely sealed pull box enclosure.

Pull Box (Surface Mounted) shall be aluminum type with a hinged front door and have at least a NEMA 3R rating. The hinged door shall be provided with both a weather tight seal and an aluminum hasp. Surface mounted pull boxes shall be of the dimensions shown in the plans, and shall be mounted on or embedded into hard surfaces

such as bridge decks, concrete barriers, retaining walls, or buildings, as shown on the plans. Surface mounted pull boxes shall be attached using 3/8-inch epoxy anchors or other methods, as approved by the Engineer. Surface mounted pull boxes shall not be used for ground installations.

METHOD OF MEASUREMENT

Pull Boxes will be measured by the actual number that are installed and accepted, and will include base, lid, excavation, backfill, concrete apron, wire mesh and 3/4" granite-gravel. Pull Boxes shall also include the removal and patching of pavement, sidewalks, curb and gutters and their replacement in kind to match existing grade.

BASIS OF PAYMENT

Pay Item

Pull Box (24x36x24)

Pay Unit

Each

Concrete will not be measured and paid for separately, but shall be included in the cost of the pull box.

Section 19 – ITS – Appendix A – Special Provisions **REVISION OF SECTION 613**

ELECTRICAL CONDUIT

Section 613 of the Standard Specifications is hereby revised for this project as follows:

DESCRIPTION

This work includes furnishing and installing either (HDPE) High Density Polyurethane or PVC electrical conduit. All materials furnished, assembled, fabricated and installed under this item shall be new, corrosion resistant and in strict accordance with the plan sheets and these Special Provisions.

MATERIALS

All conduits shall be Schedule 80 in the diameters, quantities and colors as shown on the project detail sheet and shall be compliant with all ASTM and Bellcore TW-NWT-000356 requirements.

All HDPE conduit shall be factory lubricated, low friction, high-density conduit constructed of virgin high-density polyethylene resin. Conduit shall be capable of being coiled on reels in continuous lengths, transported, stored outdoors, and subsequently uncoiled for installation, without affecting its properties or performance.

PVC conduit shall be certified by the manufacturer as meeting ANSI/UL 6 and 651. The manufacturer shall be ISO 9000 compliant.

CONSTRUCTION

Electrical Conduit (Bored) shall be HDPE and installed using a trenchless technology of either jacked conduit or directional boring.

Electrical Conduit (Plastic) shall be PVC or HDPE and installed by direct burial methods such as plowing, open trenching, or other excavation methods. When PVC is used, expansion fittings shall be installed at 100' intervals.

One conduit per bundle shall have a copper tracer wire of at least 12-gauge in a single conduit. In trenches containing multiple conduits, the tracer wire shall not be installed in the same conduit as the fiber.

Each individual conduit shall be equipped with a pull tape of 1250 pounds tensile strength and be of a design to prevent cutting or burning of conduit walls during cable installation.

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REVISION OF SECTION 613 ELECTRICAL CONDUIT

CONSTRUCTION REQUIREMENTS

The installation of conduit shall be performed in such a manner as to avoid unnecessary damage to streets, sidewalks, utilities, landscaping, and sprinkler systems. Excavations and conduit installation shall be performed in a continuous operation. All trenches shall be backfilled by the end work day. The material from trenching operations shall be placed in a location that will not cause damage or obstruction to vehicular or pedestrian traffic or interfere with surface drainage.

The Contractor shall take all necessary precautions to avoid heaving any existing asphalt/concrete mat or over-excavating a trench, whether caused by equipment directly or by dislodging rocks and boulders. Any such heaving or over-excavation shall be repaired or replaced at the Contractor's expense. The Contractor shall bear the cost of backfilling all over-excavated areas with the appropriate backfill material as approved by the project engineer.

The Contractor shall restore all surface materials to their preconstruction condition, including but not limited to pavement, sidewalks, sprinkler systems, landscaping, shrubs, sod, or native vegetation that is disturbed by the conduit installation operation. All repairs shall be included in the cost of the conduit.

If the Contractor is unable to bore the conduit at the lengths shown on the plans from access point to access point, all splice couplings and associated work to splice conduit shall be included in the cost of this item. The coupling technology shall allow the conduit to be connected without the need for special tools, and shall form a watertight, airtight seal. Breaking force between segments shall exceed 250 pounds of force. No metal fittings shall be allowed. No elevation difference between the conduit run and the splice location will be allowed. Conduit splices shall be kept to a minimum and all locations shall be approved by the project engineer. Additional pull boxes shall not be substituted for splices.

Conduit plugs shall be supplied and installed in all conduit ends as soon as the conduit is installed. Conduit shall be plugged at all termination points such as pull boxes, manholes, controller cabinets, and node buildings. Conduits containing cable shall be plugged with durable and reusable split type plugs, fabricated without metallic parts, and allow easy removal and reinstallation around in-place cables. Split type plugs shall provide a water and air-tight seal of at least 50 psi and shall be installable by hand without using special tools and without damaging the cable. All plugs shall be correctly sized to fit the conduit being plugged. Empty conduits shall be sealed with removable type duct plugs that provide a watertight barrier.

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REVISION OF SECTION 613 ELECTRICAL CONDUIT

All conduits shall use sweeps to elevate the buried conduits to within 4 inches of the bottom of the pull box or manhole, as shown in project details. The sweeps shall be terminated within the pull boxes and manholes to allow for easy installation and removal of the conduit plugs. The sweeps shall be set above the ground surface within the pull box at a height that does not interfere with the coiling of the fiber optic cable.

All conduit runs containing fiber optic cable shall have a limited number of bends. The sum of the individual conduit bends on a single conduit run between two pull boxes shall not exceed 360°. The preferred limit is 270°. No individual bend shall be greater than 90°. All conduit bends shall have a minimum acceptable radius. The minimum radius for 90° bends is 48 inches, and the minimum radius for all other bends is 24 inches.

If new conduits are installed in existing pull boxes, manholes or cabinet bases the Contractor shall carefully excavate around the pull box or manhole and install the new conduit as shown in the plans. The Contractor shall not damage the existing pull box, manhole or their contents. If the existing pull box, lid, or the concrete collars are cracked or damaged during conduit installation, the Contractor shall restore the damaged section to preconstruction condition at no additional cost.

METHOD OF MEASUREMENT

Electrical Conduit shall include all electrical wire and/or telephone wire per end equipment requirements. Conduit shall also include anchors, bands, skids, sweeps, pull tape, copper tracer wire, adapters, expansion couplings, conduit plugs, installation equipment, adhesives, labor, and all other items necessary to complete the work.

BASIS OF PAYMENT

Electrical Conduit contract unit price shall be full compensation for work described above, specified in the plans, and complete and in place.

Payment will be made under:

Pay Item

2-Inch Electrical Conduit (Bored)
2-Inch Electrical Conduit (Plastic)

Pay Unit

Linear Foot
Linear Foot

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REVISION OF SECTION 614

ETHERNET SWITCH 3930

Section 614 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

Ethernet Switch shall be a Ciena 3930 Carrier Ethernet Service Delivery Switch (SDS) to be installed at each individual Intelligent Transportation Systems (ITS) device communication cabinet and Variable Message Sign (VMS) cabinet on this project. These Ethernet switches shall be used to transport Ethernet data to and from roadway ITS devices to adjacent regeneration node buildings. All Ethernet switches shall be manufactured by Ciena.

Optical Transceivers or Ethernet extension equipment shall not be used in lieu of an Ethernet switch to transport ITS device communications back to a common Ethernet switch location. If the communications distance between the ITS device and Ethernet switch is greater than can be sent on a standard Cat-5e / Cat 6 Ethernet cable, an Ethernet switch shall be installed at that location.

The Ethernet switch shall utilize Coarse Wavelength Division Multiplexing (CWDM), Small Form-Factor Pluggable (SFP) optic modules. Each switch shall be provided with both a Coarse Wavelength Division Multiplexing SFP optic module and a 1310nm optic module. Optic modules shall be provided as described in the Project Specifications, 614 - Coarse Wave Division Multiplexing SFP and 614 – Small Form-Factor Pluggable – 1310nm SFP as part of the ITS specification package section.

A single mode, 9/125um CWDM wavelength independent attenuator to match the wavelength of the SFP optic modules shall be provided and installed in the communications cabinet or VMS cabinet termination patch panel. Optical attenuators shall be provided as described in the Project Specification, 614 - Coarse Wavelength Division Multiplexing Attenuator as part of the ITS specification package section.

MATERIALS

The Ethernet switch shall be configured with two (2) 1GIG/10GIG SFP+ Small Form-Factor Pluggable ports, four (4) 100M/1000M Small Form-Factor Pluggable ports and four (4) 10/100/1000M RJ-45 Ethernet ports.

The Contractor shall furnish and install the Ethernet switch and associated items shown in Item Table A below. The Contractor shall also furnish the Ethernet switch software and maintenance licenses show in Item Tables B and C. Tables A, B and C describe items for a single Ciena 3930 SDS Ethernet switch.

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**REVISION OF SECTION 614
 ETHERNET SWITCH 3930**

Item Table A – Ciena 3930 SDS Ethernet Switch, Hardware Description

ITEM DESCRIPTION	ITEM NUMBER	QUANTITY
3930,(4)100M/1000M SFP,(4)100/1000M SFP/RJ-45,(2)1G/10G SFP+,EXT.TEMP,(2)SLOTS AC/DC PWR SUP	170-3930-900	1
3930/3932/5142,AC PLUGGABLE POWER SUPPLY,WIDE RANGE 120/240V	170-0014-900	2
AC POWER CORD, IEC C13, NORTH AMERICA	CABL-PW01NA	2
100M/1GIG, SM SFP OPTIC, LC CONNECTOR, 10 KM, 1310 NM,EXTENDED TEMPERATURE	XCVR-A10Y31	1
100M/1 GIG, SM SFP OPTIC, LC CONNECTOR, 80 KM, (XXXX) NM, EXT. TEMP	XCVR-A80D(XX)	1
10/100/1000M,SFP TRANSCEIVER,RJ45 CONNECTOR,SGMII,100 METERS, RX LOS,EXTENDED TEMPERATURE	XCVR-B00CRJ	4

Matching coarse wavelength division multiplexing, small form-factor pluggable optic modules shall also be provided for the existing Ciena Ethernet aggregation switches in each of the regeneration node buildings to which the sub ring switches communicate.

Item Table B – Ciena 3930 SDS Ethernet Switch, Software Description

ITEM DESCRIPTION	ITEM NUMBER	QUANTITY
SAOS ADVANCED ETHERNET PERPETUAL SOFTWARE LICENSE FOR 3930	S70-0001-900	1
SAOS ADVANCED OAM PERPETUAL SOFTWARE LICENSE FOR 3930	S70-0001-901	1
SAOS ADVANCED SECURITY PERPETUAL SOFTWARE LICENSE FOR USE WITH SAOS 6.X	170-0204-900	1
ESM CARRIER ED RIGHT TO MANAGE PERPETUAL SOFTWARE LICENSE FOR 3930	S70-0005-900	1

Item Table C – Ciena 3930 SDS Ethernet Switch, Maintenance License

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REVISION OF SECTION 614 ETHERNET SWITCH 3930

ITEM DESCRIPTION	ITEM NUMBER	QUANTITY
GLOBAL 3930 SMARTSUPPORT - 3 YEARS	80M-3930-SSP	1
GLOBAL 3930 STANDARD HARDWARE REPAIR 10-DAY - 3 YEARS	80M-3930-HWM	1
GLOBAL 3930 NEXT BUSINESS DAY SHIP MANAGED SPARES - 3 YEARS	80M-3930-NBS	1

All associated hardware and materials not listed in the item tables are considered subsidiary and are required for a complete installation and shall be included as part of the work.

Each Ethernet Switch shall be furnished and installed with a G.8032 ring protection configuration in conformance with Ciena's Ethernet Design and Configuration Services per the Colorado Department of Transportation requirements either prior to installation or at the individual installation sites.

Final configuration including all IP schema design for data transport will be conducted by CDOT personnel after installation and G.8032 configuration.

If field changes are made which affect the original Contractor's material order for the Ethernet switches and require any reconfiguration of the original Ethernet switch order, the Contractor shall ensure that the Ciena representative is contacted and made aware of such changes to alleviate any possible delays in delivery and installation. If for any reason the switch or associated materials are defective or are damaged at the time of installation by either the Contractor or by Ciena, the item shall be removed and replaced at no additional cost to the project. Items shall also be replaced if any failures occur do to manufacture's defects, at no additional cost to the project prior to the final acceptance.

CenturyLink is the direct contracted equipment supplier of Ciena Corporation for the State of Colorado, Colorado Department of Transportation for networking equipment and associated network materials. For project equipment estimate quotations and purchasing, Contractors shall contact the following distributor representative:

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REVISION OF SECTION 614 ETHERNET SWITCH 3930

State of Colorado, Colorado Department of Transportation project equipment estimate quotations and purchasing distributor representative.

Keith A. Glose
Premier Account Manager
CenturyLink Government
930 15th Street, 4th Floor, Denver, Colorado 80202
Telephone: 303-992-5567 Fax: 720-578-2694
E-Mail: keith.glose@centurylink.com

CONSTRUCTION REQUIRMENTS

The 3930 SDS Ethernet switch will be installed in an ITS device communications cabinet or variable message sign and connected via the fiber optic backbone to a communications node building in a protected ring design. The switch shall have both a Coarse Wavelength Division Multiplexing (SFP) optic module and a 1310nm SFP optic module. In the final design and implementation, this switch shall share a single wavelength with one (1) other Ciena 3930 Carrier Ethernet Service Delivery Switches making a two (2) Ethernet switch configuration and part of creating a single Carrier Ethernet diverse path sub-ring.

For connection of the switch to the optical fiber network, one (1) lateral fiber optic cable shall be terminated and patch cables shall be installed and connected to the optical ports of the Ethernet switch. A total of four (4) lateral fiber strands shall be used for data communications to the Ethernet switch. Two (2) lateral fiber strands shall be used for communications connecting the SFP optics carrying CWDM traffic, and two (2) lateral fiber strands shall be used for communications connecting the 1310nm SFP optics. Each pair of fiber strands shall be designed for transmitting data on one backbone fiber optic strand and receiving data on a second backbone strand.

Additional splicing is required for the coarse wavelength division multiplexing (CWDM) optical filters at each Ethernet switch location.

The Contractor shall provide single mode, bend insensitive, pre-connectorized duplex patch cables with a polyurethane jacket for connection from the coarse wavelength division multiplexing SFP optic module and the 1310nm SFP optic module. Connectors for the patch cable shall be LC on the Ethernet switch end and ST on the termination end.

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REVISION OF SECTION 614 ETHERNET SWITCH 3930

The patch cable shall be of sufficient length to span from the existing termination patch panel to the Ethernet switch SFP ports with a maximum of two (2) feet of slack. They shall be installed in a manner which will not interfere with internal device equipment in the switch enclosure and will include cable management so as not to interfere with future maintenance within the enclosure.

If a protected area inside of the variable message sign cabinet cannot be found for the Ethernet switch installation, the contractor shall install an aluminum backplane on the internal structural supports of the sign housing. It shall be mounted in a location which will not interfere with internal equipment and future maintenance of the variable message sign electronics and cabling.

A field site survey for final placement of the Ethernet switch in the variable message sign cabinet shall be conducted prior to installation.

The Contractor shall arrange to provide for a certified Ciena representative either on site or via remote access through the Colorado Transportation Management Center network to aid in the configuration and installation of the Ethernet switch.

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REVISION OF SECTION 614

CLOSED CIRCUIT TELEVISION

Section 614 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

This work consists of furnishing and installing an Internet Protocol (IP) Closed Circuit Television (CCTV) camera at the locations shown on the Plans.

MATERIALS

The CCTV camera shall include: camera with weatherproof dome housing, pole mount adapter, Power over Ethernet (PoE) midspan module, manufacturer supplied management software, Cat-6 Ethernet cables, and all attachment hardware to complete installation.

Camera Specifications –

The pan-tilt-zoom camera shall be of dome type construction and shall be enclosed in a sealed, heated environmental video dome housing to operate in 100% humidity at a minimum operating temperature of -40° to 122°F carrying both IP66 and NEMA 4x ratings. The camera shall utilize Ethernet protocol for native communications and be capable of sending multiple individually configurable video streams in H.264 and MJPEG format up to 30fps and capable of gathering a minimum of 50 preset color video still frame images with a minimum 176x120 resolution and maximum 704x480. The camera shall have an internal web interface for configuration with security functionality allowing multiple user access levels with password protection. The camera shall support Ipv4/v6, HTTP, HTTPS, SSL/TSL, QOS Layer 3 DiffServ, FTP, SMTP, SNMP v1/2/3, UpnP, DNS, DynDNS, NTP, RTSP, TCP, UDP, IGMP, RTCP, ARP, SOCKS.

Technical specifications for the camera shall be as follows:

- The lens shall be $f=3.4$ to 119mm, F1.4 to 4.2, autofocus; focus range of 35 mm (wide) to 800 mm (telephoto) to infinity. The angle of view shall be 2.8°- 48° horizontal with minimum zoom capability of 35x optical and 12x digital
- Minimum illumination color 0.5 lux at 30 IRE and B/W 0.005 lux at 30 IRE
- The camera shall provide dual mode, day (color) and night (monochrome) video down to 0.008 lux
- Shutter speed shall be variable from 1/30000 to 0.5 seconds at 60Hz.

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REVISION OF SECTION 614 CLOSED CIRCUIT TELEVISION

- The pan function shall provide 360° of continuous rotation at 0.05 – 450°/s and a 220° tilt range allowing for 20° view above the horizon at 0.05 – 450°/s

Pole mount adapter arm and bracket -

The adapter shall have a minimum 33 lb load rating and have provisions that allow mounting directly to the weatherproof dome housing without modification to the housing. The adapter bracket shall have slots for a minimum of 2 straps or banding material for mounting to the poles from 3 inches to 6 inches in diameter. The bracket shall have cable strain relief in at least two locations on the reverse side, (between the bracket and the pole).

PoE midspan module-

Power for the camera shall be by means of a high power over Ethernet midspan module with a pass through port for all Ethernet communications. The module shall meet IEEE 802.3at and 802.3af standards and operate at temperatures from -40°F to +122°F. The PoE module shall allow 100-240 VAC input and 55 VDC output at 60W and operate at temperatures from -40°F to +122°F.

Manufacturer's supplied management software-

Management software shall give the user access to discover and configure the camera using standard network protocols. Software shall allow for network setup and firmware updates.

Cat6 Ethernet cable-

Cable shall be a UTP cable, Category 6 rated and constructed of 24 AWG stranded copper wires. The outer jacket shall be UV resistant PVC insulation. The Ethernet cable shall be terminated with male 8P8C connectors as a 'straight through' cable using the Telecommunications Industry Association / Electronic Industries Alliance (TIA/EIA) T- 568B pin/pair assignments.

CONSTRUCTION REQUIREMENTS

The CCTV camera shall be installed in accordance with these specifications, the details shown in the Plans, and in accordance with manufacturer's recommendations. The Contractor shall make all arrangements for a qualified manufacturer's representative to be on-site to ensure proper installation of the CCTV camera.

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REVISION OF SECTION 614 CLOSED CIRCUIT TELEVISION

The weatherproof dome housing shall be attached to the pole mount adapter using the materials supplied from the manufacturer.

For the attachment of the adapter bracket to the pole, a ¾ inch type 201 stainless steel strap used in conjunction with type 201 stainless steel buckles at a mounting height shown on the Plans. The attachment shall be banded to the pole at an orientation to achieve the optimal view of both the main roadway and crossroad or as directed by the Engineer.

A maximum 1 inch hole shall be drilled in the mounting pole to allow passage of the Ethernet cable. The hole shall be free of burs and sharp edges prior to the installation of the Ethernet cable. The Ethernet cable shall be attached to the reverse side of the mounting bracket to ensure proper strain relief or damage caused to the camera or housing. The Ethernet cable shall run down the interior of the pole and exit through non-metallic flexible conduit to the communication cabinet. The non-metallic flexible conduit shall be weather sealed on each end to eliminate exterior liquid entry. The Contractor shall also provide a weather seal for the adapter bracket at the 1 inch hole at the top of the pole per the manufacturer's recommendations.

The PoE midspan module shall be securely mounted in the communication cabinet and plugged into the communications power outlet. The Ethernet cable attached to the camera shall be connected to the PoE midspan output jack. A separate Cat 6 Ethernet cable shall be provided for connection to the field communication device.

METHOD OF MEASUREMENT

Closed Circuit Television will be measured by the actual number of Closed Circuit Televisions installed and accepted for a complete installation. Also included shall be all configuration, cabling, dome housing, adaptor arm, adaptor bracket, and PoE midspan module. All costs associated with arranging for the manufacturer's representative to be on-site will not be measured and paid for separately, but shall be included with the cost of the CCTV.

BASIS OF PAYMENT

Payment will be made under:

<u>PayItem</u>	<u>PayUnit</u>
Closed Circuit Television	Each

Payment will be full compensation for all labor, materials and equipment required to complete the work.

Section 19 – ITS – Appendix A – Special Provisions
REVISION OF SECTION 614
COMMUNICATION CABINET

Section 614 of the Standard specifications is hereby revised for this project to include the following:

DESCRIPTION

This work consists of furnishing and installing communications cabinets at designated Intelligent Transportation System (ITS) field device locations to house and protect electrical power components as shown on the Plans.

MATERIALS

Communications Cabinets. Communications cabinets shall be UL 508A Industrial Control Panels listed and conform to a NEMA Type 4X rating. Communications cabinets shall be constructed of 0.125 inch Type 5052 H-32 aluminum conforming to the requirements of ASTM B209 Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate. The dimensions shall be as shown in Table 1 below.

Table 1

COMMUNICATIONS CABINET TYPES

Communications Cabinet	Dimensions	Maximum Weight (w/o back panel)
Type 1	30 inches (H) × 24 inches (W) × 8 inches (D)	30 lb
Type 2	36 inches (H) × 24 inches (W) × 12 inches (D)	40 lb

All bolts, clamps, fasteners, hinges, latches, nuts and screws shall be stainless steel, unless an alternative corrosion proof material is approved in writing by the Department.

A cabinet grounding stud shall be provided in the vicinity of the ground bus mounted on the back panel as shown on the Plans.

Each communications cabinet, designated for mounting on a pole, shall include a pole mounting kit suitable for pole diameters ranging from seven to 12 inches. Each pole mounting kit shall include channel bars (for attachment to factory mounting holes on the back of the communications cabinet), pole shims (to prevent cabinet movement against pole), stainless steel straps and all other associated mounting and sealing hardware. The stainless steel straps and buckles shall be constructed of Type 201 stainless steel and have a width of ¾ inch. The channel bars, pole shims and associated mounting hardware shall be manufactured from either galvanized steel or stainless steel.

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REVISION OF SECTION 614 COMMUNICATION CABINET

Each communications cabinet shall include the following:

(a) *Back Panel.* Each back panel shall be constructed of either 12 gauge steel with a conductive, corrosion-resistant coating or ≥ 0.19 inch Type 5052-H32 aluminum alloy. One back panel and associated mounting hardware shall be included with each communications cabinet and be rated for use in NEMA 4X cabinets. The back panel shall be not less than 27 inches (h) \times 21 inches (h). The back panel shall be mounted within the communications cabinet with a minimum of four screws that are provided with each communications cabinet. A ground bus shall also be provided with each back panel for mounting at the location shown on the plans.

(b) *Device Box with GFCI Receptacles.* Each communications cabinet shall contain a single gang device box attached to the back panel as shown in the Plans. Each device box shall be constructed of metal in conformance with Articles 314.40 and 314.44 of the NEC. The depth of each device box shall be sufficient to accommodate the depth of the GFCI receptacle and provide adequate free space for all enclosed conductors as specified in Article 314.16 of the NEC. Each junction box shall include knockouts and clamps for conduit and cables. Covers shall be provided for each device box as appropriate for the duplex GFCI receptacles and shall be consistent with the requirements of Article 314.41 of the NEC.

Duplex NEMA 5-15R GFCI receptacles shall be provided within the device box as specified in the Plans. NEMA 5-15R GFCI receptacles shall be rated for 125 VAC, 0.5 HP and 15 A. It shall be of commercial grade quality and manufactured from high strength nylon. NEMA 5-15R GFCI receptacles shall have two poles, three wires, a manual reset button and a self-test button.

Duplex NEMA 5-15R GFCI receptacles shall conform to Article 210.8 of the NEC and be UL listed.

(c) *Power Conditioner with Power Strip.* The power conditioner shall be a Clary SP400U Universal Power Conditioner. The power conditioner has a unit weight of 5 pounds and its dimensions are 1.7 inches (H) \times 11 inches (W) \times 8.5 inches (D).

An integral component of the power conditioner shall be a factory-installed power strip. The power strip shall have six front facing NEMA Type 5-15R outlets. The power strip shall be rated for 15 A at 120 VAC. It shall have an energy rating of 630 Joules, clamping voltage of 500 V and EMI/RFI noise filter of 150 KHz to 100 MHz at up to 43 dB. The power strip shall have a recessed power switch and a power cord of not less than 2.5 feet. The dimensions of the power strip shall be 10 inches (L) \times 1.63 inches (W).

One power conditioner with power strip shall be provided with each communications cabinet.

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REVISION OF SECTION 614 COMMUNICATION CABINET

(d) *Deutsche Institut fur Normung (DIN) Rails.* Each communications cabinet shall utilize standard 1.38 inch DIN rails. The DIN rails shall be of steel construction with a coating for corrosion resistance. The DIN rails shall utilize 0.25 inch × 0.71 inch slots for fastening to the back panel located in each communications cabinet. The spacing of the DIN rail slots shall be 0.98 inch center-to-center. DIN rails and associated mounting hardware for attachment to the back panel shall be provided with each communications cabinet in the lengths and quantities specified in the Plans.

(e) *12 VDC Power Supply.* The 12 VDC power supply shall support an input voltage range of 85-264 VAC and frequency range of 47-63 Hz. It shall have a typical efficiency of at least 76% and typical AC current of 1.6 A at 115 VAC. The 12 VDC power supply shall provide an output voltage of 12 VDC and have a minimum current rating of 6.3 A. It shall support an output current range of 0 to 6.3 A (minimum) and have a rated power of 75 W (minimum). The 12 VDC power supply shall have overload protection of 105-150% for its rated output power and overvoltage protection for voltages of 15-16.5 VDC. It shall be designed for an operating temperature of +14°F to +140°F and humidity levels of 20% to 90% (non-condensing). The 12 VDC power supply shall conform to the following standards: IEC 60068-2-6 Environmental Testing (Vibration) and UL 508 Industrial Control Equipment. It shall be DIN rail mountable, have dimensions not exceeding 5 inches (H) × 2.25 inches (W) × 4 inches (D) and a weight of not more than 1.5 pounds. One 12 VDC power supply shall be provided with each communications cabinet.

(f) *Fiber Optic Patch Panel.* Where communications cabinets are shown on the Plans to be connected with fiber optic cables, the Contractor shall provide one 6-port fiber optic patch panel mounted to the back panel as shown on the Plans. The panels shall have hinged doors to provide future access to both the fiber fan out and the termination bulkheads. The panel shall be sized to accommodate the entry of the lateral fiber optic cable, fiber fan out, bulkheads, and the fiber patch cable with access doors closed. The fiber optic patch panel shall be suitable for wall mounting and have dimensions not exceeding 5 inches (W) × 6 inches (L) × 2 inch (D). Each fiber optic patch panel shall include a flat polypropylene cassette, adapters, 6-fiber buffer tube fan-out kit (with 25 inch furcation tubing), strain relief boot, grommet tape, zip ties and wall mounting bracket. Terminations within the patch panel shall be for ST-UPC connectors and must be compliant with the Telcordia GR-326 Generic Requirements for Single Mode Optical Connectors and Jumper Assemblies. The manufacturer shall perform acceptance testing for insertion loss and return loss with the test certification provided with each patch panel.

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REVISION OF SECTION 614 COMMUNICATION CABINET

Each communications cabinet shall come with a warranty. The warranty shall cover all communication cabinet materials and workmanship, including pole mounting kits, for two years after delivery of each communication cabinet.

Service Disconnect. The service disconnect shall have factory installed main lugs. It shall have an ampere rating of 70 A , a voltage rating of 120/240 VAC (3-wire, single phase) and a short circuit current rating of 10 kA. The service disconnect shall accommodate up to four single pole circuits or two tandem circuit breakers. It shall accept aluminum wire sizes of #12 AWG to #3 AWG and copper wire sizes of #14 AWG to #4 AWG. The service disconnect shall utilize a tin plated aluminum bus and include a grounding bar. It shall have been specifically designed for industrial requirements to protect electrical systems, equipment and people and must be UL listed.

The service disconnect shall be NEMA 3R rated with the following maximum dimensions: 5 inches (W) × 9.5 inches (H) × 4 inches (D). It shall be constructed of galvanized steel with knockouts on the sides, bottom and back and a rainproof closing cap for any hub opening on the top of the enclosure. The service disconnect shall have a gray baked enamel finish electrodeposited over cleaned, phosphatized, galvanized steel. The complete service disconnect shall include the interior trim and door. The door shall open upward and be equipped with a hasp and staple for padlocking.

The Contractor shall be responsible for sizing the circuit breakers in the service disconnect in accordance with Article 240 of the NEC and circuit breakers must conform to UL 489 Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures. The Contractor shall consider all loads within the communications cabinet to be continuous except for the duplex GFCI receptacles which shall be non-continuous.

One service disconnect and corresponding circuit breakers shall be provided with each communications cabinet.

CONSTRUCTION REQUIREMENTS

Communications Cabinet. All fabricated materials and added components must be free from burrs and sharp edges. Exterior seams of the cabinet shall be continuously welded with edges ground smooth to a 0.03 inch radius. All welding shall be done with gas tungsten arc welds that comply with AWS B2.1-22-015 Standard Welding Procedure Specification for Gas Tungsten Arc Welding of Aluminum and C5.6 Recommended Practices for Gas Metal Arc Welding. All welds shall be neatly formed and free of blisters, blowholes, cracks and other irregularities.

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REVISION OF SECTION 614 COMMUNICATION CABINET

The cabinet door opening shall be designed to prevent dust and moisture intrusion. All flange joints shall be welded or continuously formed. The door shall have an adequately sized, oil-resistant gasket that provides a uniform seal with the door frame surface and shall be permanently bonded to the door. The door shall utilize a continuous stainless steel hinge that allow for door removal from the hinge side. Hinges shall be mounted such that the cabinet door opens out to the left, unless otherwise specified on the Plans or as mandated by the Department. Hinges shall be mounted with appropriately sized stainless steel hardware. The door shall be equipped with a hasp and staple for padlocking. The Department prefers that a Corbin #2 key lock be utilized in place of the hasp and staple if the NEMA 4X rating can be maintained. A document holder constructed of high-impact thermoplastic shall be provided for each communications cabinet and permanently mounted to the lower portion of the inside door. The Contractor shall insert a copy of the communications cabinet bill of materials, individual communications cabinet component specification sheets and an asbuilt electrical/fiber optic/low-voltage wiring and cabling diagram of the communications cabinet in the document holder.

Mounting holes on the back of the communications cabinet shall be installed at the factory (communications cabinet Manufacturer) to assure NEMA 4X integrity along with all factory-recommended mounting and sealing hardware for use with the pole mounting kit. Field installation or modification of mounting holes shall be prohibited.

Two tapped conduit access holes shall be made on the bottom of the communications cabinet to provide access for electrical wiring, specific field device low-voltage control cabling, waveguides and fiber optic cabling, as applicable for each communications cabinet application. The conduit access holes shall be sized and positioned at locations shown in the Plans to ensure the proper, safe routing of cabling entering the cabinet. The holes shall be free of burrs and sharp edges prior to the installation of LFMC, fittings and nipples. Drilled and tapped conduit access holes and appropriate sealing strategies to maintain a NEMA 4X integrity shall be performed at the factory and no field installation or modification of the conduit access holes shall be permitted.

Each communications cabinet shall have tapped pads to provide for the mounting of a back panel as specified herein.

Both the power conditioner and power strip shall be mounted on the back panel. Mounting locations shall be as shown in the Plans.

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REVISION OF SECTION 614 COMMUNICATION CABINET

Mounting of equipment and hardware onto the back panel shall be through the use of self-tapping screws or Velcro as required per the Plans. Self-tapping screws shall be of appropriate size for the equipment or hardware being installed onto the back panel. The length of the self-tapping screw shall not exceed a ½ inch and the bit recess in the screw head shall be hexagonal.

Where fiber optic communications is utilized, the Contractor shall install the lateral fiber optic cable into the communications cabinet. The buffer tube fan-out kit supplied with the fiber optic patch panel will be installed so that the six fibers in the buffer tube are inserted into the 900 µm diameter furcation tubes that are color-coded to match the fiber color scheme. ST-UPC connectors shall be installed per the requirements of the Fiber Optic Cable specifications. The connectors shall be terminated within the fiber optic patch panel with the upper connector position being #1 (blue) and the lower connector position being #6 (white). Fiber optic jumpers shall be installed between the patch panel and fiber optic communication equipment as shown in the Plans.

Cable management and strain relief shall be employed within the communications cabinet. Cables shall be labeled and neatly organized using cable ties and/or Velcro. Velcro shall be used on fiber optic jumper cables or bundles of cables containing fiber optic jumper cables. Unused spaces within the back panel and interior wall of the communications cabinet may be used to facilitate cable management, but installation of cable management hardware that penetrate the interior walls of the communications cabinet shall not be permitted in order to maintain NEMA 4X integrity.

The communications cabinet manufacturer shall affix a permanent label on the inside of the door that identifies the cabinet type, date of manufacture, warranty expiration date and manufacturer's name. The warranty expiration date shall be expressed in the (mm/dd/yyyy) format.

- (a) *Grounding.* Connection to the grounding electrode system shall be provided to place the equipment, hardware, back panel and communications cabinet at earth ground potential. The Contractor shall bolt mount a ground bus to the back panel of the communications cabinet at the location shown in the Plans and depicted in Figure 1.

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REVISION OF SECTION 614 COMMUNICATION CABINET

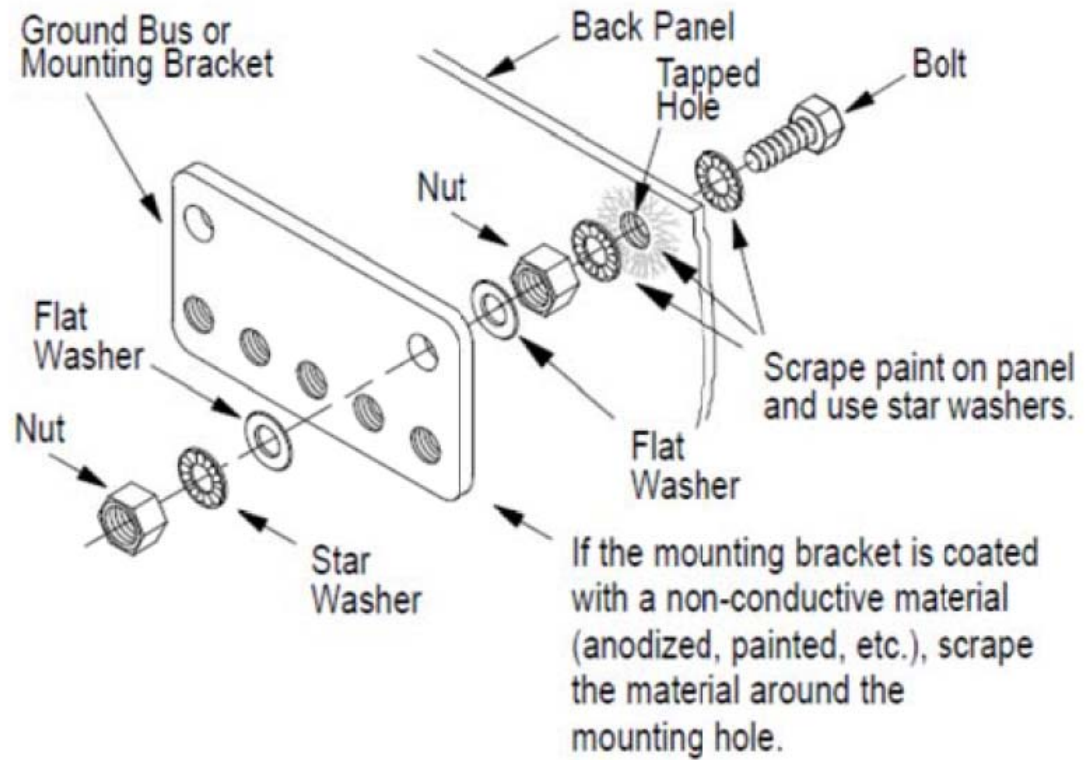


Figure 1

BOLT MOUNTING OF A GROUND BUS TO BACK PANEL

The Contractor shall make good electrical connections between the back panel and communications cabinet through the back panel mounting screws and the cabinet's grounding stud. Wherever contact is made, remove paint or other non-conductive finish from around tapped holes. The ground bus and number of tapped hole positions within the ground bus shall be sized by the Contractor as needed for each communications cabinet. Equipment grounding conductors shall be run from each powered device to the grounding bus using stranded copper wire as required per Article 250 of the NEC. DIN rails shall be connected to the ground bus using a minimum #8 AWG stranded copper wire. Figure 2 shows the ground bus connection details.

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REVISION OF SECTION 614 COMMUNICATION CABINET

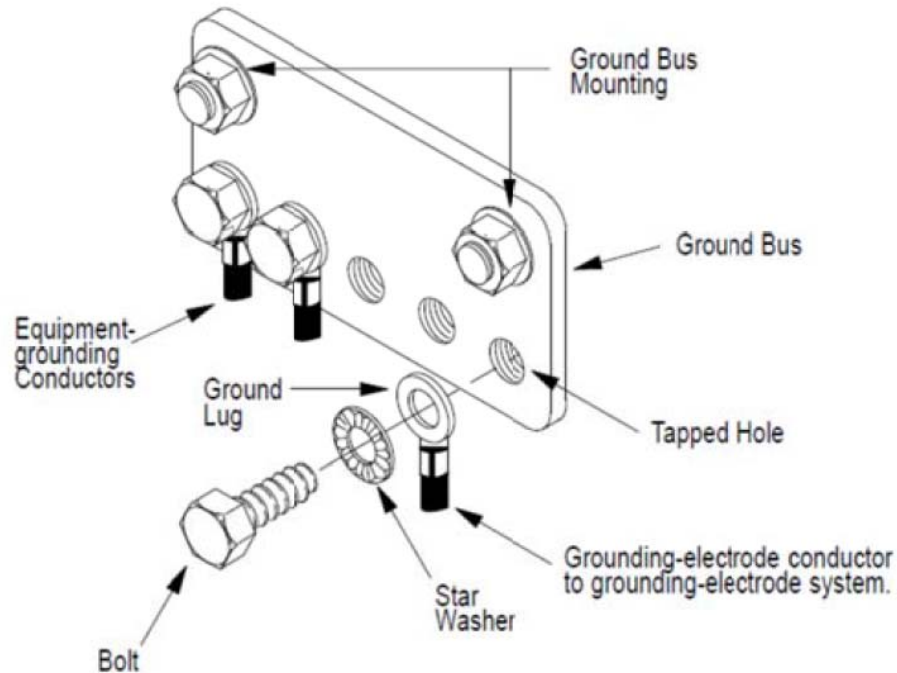


Figure 2

GROUND BUS CONNECTION DETAILS

Service Disconnect. Each service disconnect shall be readily accessible and installed on the pole as shown in the Plans so that the center of the grip of the operating handle of the circuit breaker, when in its highest position, is not more than 6 feet 7 inches above the ground or as required per Article 240.24 of the NEC.

The neutral from the power source or service enclosure shall be connected to the ground bar in the service disconnect. The ground bar shall be connected to the service disconnect using a bonding strap. The ground bar shall be connected to a grounding electrode using grounding conductors conforming to the requirements of Article 250.122 of the NEC. The grounding electrode shall conform to the requirements of Articles 250.52 through 250.70 of the NEC.

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REVISION OF SECTION 614 COMMUNICATION CABINET

METHOD OF MEASUREMENT

Communications cabinets shall be measured by the actual number of units installed and accepted, and full compensation shall include all document holders, pole mounting kits, back panels, factory installed mounting and conduit access holes, LFMC conduit, conduit fittings, outlet boxes, receptacles, power conditioners with power strips, DIN rails, 12 VDC power supplies, fiber optic patch panels, mounting and sealing hardware, grounding system, service disconnect and warranties as described herein, including all labor, low voltage cabling, fiber optic cable jumpers, electrical wiring, materials, tools, equipment and incidentals required to perform the work. Number of each type of communications cabinet shall be as listed in the project tabulations.

BASIS OF PAYMENT

The accepted quantities will be paid for at the contract price per unit of measurement for each of the pay items listed below that appear in the bid schedule.

Payment will be made under:

Pay Item

Communications Cabinet – Type 2

Pay Unit

Each

Section 19 – ITS – Appendix A – Special Provisions

REVISION OF SECTION 614

FIBER OPTIC CABLE (Single Mode)

Section 614 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

This work consists of furnishing and installing single mode fiber optic cable.

Fiber optic cable shall be used for either main backbone cable or lateral cables that connect to equipment field cabinets. The main backbone cable shall be terminated in a Communications Node or Regeneration Building. Lateral fiber cables shall be terminated using fan-out kits in a termination patch panel in the field equipment cabinet.

All fiber optic cables shall be suitable for outdoor conduit installation.

MATERIALS

All fiber optic cable shall have compatible chromaticistics with proposed and existing cables. All optical cables furnished on this project shall meet the following fiber optic industry standards:

- a) International Telecommunications Union Recommendation G.652 Table D
- b) Electronic Industries Alliance (EIA) Telecommunications Industry Association (TIA)
- c) International Organization for Standardization (ISO)
- d) Telecommunication industry Association (TIA)
- e) International Telecommunications Union (ITU)
- f) Insulated Cable Engineers Association (ICEA)

All cables shall be new and unused non-armored outdoor cable consisting of dispersion-unshifted, low water peak single-mode fiber strands free of surface imperfections and inclusions. Each single mode fiber shall consist of a doped silica core surrounded by a concentric silica cladding. The fiber shall be of matched clad design.

(a) Fiber Strands

- a) Typical core diameter of 8.3 μ m
- b) Cladding Diameter of 125.0 \pm 1 μ m

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REVISION OF SECTION 614 FIBER OPTIC CABLE (Single Mode)

- c) Core-to-Cladding Offset: \square 0.5 μm
- d) Cladding Non-Circularity: \square 1 %
- e) Coating Diameter (Colored): $245 \pm 10 \mu\text{m}$.
- f) Maximum Attenuation (Loose Tube): 0.35 dB//km at 1310 nm wavelength and 0.22 dB/km at 1550 nm wavelength
- g) Mode-Field Diameter: $9.20 \pm 0.30 \mu\text{m}$ at 1310 nm wavelength and $10.40 \pm 0.50 \mu\text{m}$ at 1550 nm wavelength
- h) Attenuation at the Water Peak: 0.32 to 0.34 dB/km at $1383 \pm 3 \text{ nm}$ wavelength
- i) Cutoff Wavelength: 1260 nm.
- j) Zero Dispersion Wavelength: 1300nm to 1322 nm
- k) Zero Dispersion Slope: $0.090 \text{ ps} / (\text{nm}^2 \square \square \square \text{km})$
- l) Polarization Mode Dispersion: $0.06 \text{ ps} / \square_{\text{km}}$
- m) Maximum Polarization Mode Dispersion at 0.01% distribution (PMDq): $0.20 \text{ ps} / \square_{\text{km}}$
- n) Maximum Fiber Dispersion: $3.5 \text{ ps}/(\text{nm} \square \square \square \text{km})$ for 1285 nm through 1330 nm and shall be \square 18 ps/(nm \square km) at 1550 nm.
- o) Fiber Curl: \square 4.0 m

All optical fibers shall be proof tested by the manufacturer to a minimum load of 0.7 GN/m^2 (100 ksi).

The fibers shall not adhere to the inside of the buffer tube.

The coating shall be a dual layered, UV cured acrylate applied by the fiber manufacturer. The coating shall be capable of being mechanically stripped with a force of 0.3 – 2.0 lbf (1.3 – 8.0 N).

Each single mode fiber strand shall be color coded with distinct and recognizable colors in accordance with the most recent version of EIA/TIA-598, Optical Fiber Cable Color, as shown in the plans.

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REVISION OF SECTION 614 FIBER OPTIC CABLE (Single Mode)

(b) Buffer Tubes

Each buffer tube shall contain 6 or 12 fibers as appropriate for the respective size cable.

Optical fibers shall be placed inside a loose buffer tube. The nominal outer diameter of the buffer tube shall be 3.0 mm

Each buffer tube shall be color coded with distinct and recognizable colors in accordance with the most recent version of EIA/TIA-598, Optical Fiber Cable Color, as shown in the plans.

In buffer tubes containing multiple fibers, the coloring shall be stable during temperature cycling as stated under “Fiber Specification Parameters” and shall not be subjected to fading or smearing onto each other or into the buffer tube gel filling material. Colorings shall not cause fibers to stick together.

Buffer tubes shall be of a dual-layer construction with the inner layer made of polycarbonate and the outer layer made of polyester.

Each buffer tube shall be filled with a non-hygroscopic, non-nutritive to fungus, electrically non-conductive, homogenous gel. The gel shall be free from dirt and foreign matter. The gel shall be readily removable with conventional nontoxic solvents.

Buffer tubes shall be stranded around a central member of the cable using a reverse oscillation stranding process.

The buffer tubes shall be resistant to external forces and shall meet the buffer tube cold bend and shrink requirements of EIA/TIA standards.

(c) Fiber Cable

Fillers may be included in the cable core to lend symmetry to the cable cross-section where needed.

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

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REVISION OF SECTION 614 FIBER OPTIC CABLE (Single Mode)

For single layer cables, a water blocking tape shall be applied longitudinally around the outside of the strand tubes/fillers. The tape shall be held in place by a single polyester binder yarn. The water blocking tape shall be non-nutritive to fungus, electrically non-conductive homogenous. It shall also be free from dirt and foreign matter. Gel filled water-blocking compound shall not be allowed in the cable core interstices in either the backbone cable or the lateral cables.

Binders shall be applied with sufficient tension to secure the buffer tubes to the central member without crushing the buffer tubes. The binders shall be non-hygroscopic, non-wicking (or rendered so by the flooding compound), and dielectric with low shrinkage.

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

Tensile strength shall be provided by high tensile strength dielectric yarns and shall be helically stranded evenly around the cable core.

Outer cable jacket shall have a consistent thickness throughout the entire cable length and shall be sheathed with medium density polyethylene, (MDPE). The minimum nominal jacket thickness shall be 1.4 mm. Jacketing material shall be applied directly over the tensile strength members and water blocking tape. The MDPE shall contain carbon black to provide ultraviolet light protection and shall not promote the growth of fungus.

The cable jacket shall be free of holes, splits and blisters.

Cable jackets shall be marked with sequential foot markings, year of manufacture and a telecommunication handset symbol, as required by Section 350G of the National Electrical Safety Code (NESC). The actual length of

the cable shall be within 0 to 1% of the length markings. The marking shall be in contrasting color to the cable jacket. The height of the marking shall be easily readable.

(d) Environmental Parameters

- a) Shipping, storage and operating temperature range of the cable as defined by Bellcore GR-12 shall be;
-40°C to +75°C (-40°F to +167°F)
- b) Operating temperature range of the cable as defined by Bellcore GR-12 shall be; -40°C to +70°C (-40°F to 158°F)

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REVISION OF SECTION 614 FIBER OPTIC CABLE (Single Mode)

- c) Installation temperature range of the cable as defined by Bellcore GR-12 shall be; -30°C to +60°C (-22°F to +140°F)

(e) Quality Assurance

- a) All optical fibers shall be 100% attenuation tested. The attenuation of each fiber shall be provided with each cable reel.
- b) The cable manufacturer shall be ISO 9001 registered.

(f) Packaging

- a) The complete cable shall be packaged for shipment on non-returnable wooden reels.
- b) Top and bottom ends of the cable shall be available for testing.
- c) Both ends of the cable shall be sealed to prevent the ingress of moisture.
- d) Each reel shall have a weatherproof reel tag attached identifying the reel and cable.
- e) Each cable shall be accompanied by a cable data sheet that contains significant information on the cable.

CONSTRUCTION REQUIREMENTS

The Contractor shall provide the Engineer with two copies of the cable manufacturer's installation instructions for all fiber optic cable. All installations shall be in accordance with the manufacturer's recommendations except as otherwise directed by the Engineer. All additional costs including fiber optic cable associated to damages caused by the Contractor's neglect of recommended procedures shall be the Contractor's responsibility.

The Contractor shall submit a Method Statement to the Engineer indicating cable routing, splice points and cable end splicing locations. Installation of the cable will not be permitted until the schematic diagram has been approved by the Engineer.

Fiber optic cable including both backbone cables and lateral cables shall be installed in continuous runs. Under no conditions shall fiber optic cable be cut or spliced at intermediate points without express written direction from the Engineer.

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REVISION OF SECTION 614 FIBER OPTIC CABLE (Single Mode)

Blowing cable is an acceptable alternative to pulling cable. If the Contractor chooses to use this method, submittals for cable installation shall be submitted along with complete information on fiber installation equipment.

The maximum pulling tension shall be 2700 N (600 lbs) during installation (short term) and 890 N (200 lbs) long term installed.

All cables shall have a minimum bending radius based on the diameter of the cable and shall meet the following;

- a) Pulled under tension, (Short Term) – 20 (Twenty times the cable diameter)
- b) Pulled not under tension, (Long Term) – 10 (Ten times the cable diameter)

The fiber optic cable shall be installed in the conduit with a split-mesh cable grip to provide a firm hold on the exterior covering of the cable.

The manufacturer's recommended limits for cable pull lengths shall not be exceeded. The Contractor shall use a pulley system with a numerical readout indicating the cable tension. The pulley system shall be capable of alerting the installer when the cable pulling tension approaches the manufacturer's maximum allowable tension. The Contractor may supplement this procedure with a breakaway tension limiter set below the lowest recommended tensile limit of the cables being pulled. Intermediate pulleys shall be used at all pull boxes or manholes along the installation run to prevent cable damage.

If cable installation limits are met and the entire length cannot be installed completely from the shipping reel, installation shall be continued from the mid-point of the run. The Contractor shall first pull one-half of the cable from the reel at the mid-point through the conduit to one end of the run. The other half of the cable shall be removed from the reel and carefully placed on the ground in a figure eight pattern with a minimum loop diameter of 10 feet. While installing the remaining cable, care shall be taken to avoid any dragging against the ground resulting in damage or excess bending of the cable. The Contractor shall not kink, twist or bend the cable during installation coiling or uncoiling.

The cable shall be continuously lubricated as it enters the conduit. The Contractor shall only use pulling lubricants recommended by the cable manufacturer. Liquid detergent shall not be used.

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REVISION OF SECTION 614 FIBER OPTIC CABLE (Single Mode)

If the Contractor must install new cable in conduits which contain existing fiber or electrical wiring, the Contractor shall be responsible for any damage to the existing cables or wires. After this installation the Contractor shall perform a functional test of all the equipment connected by the existing fiber cables or electrical wiring to ensure proper working conditions.

If an existing fiber optic cable is damaged during construction, it shall be removed from both points of termination and replaced, at no cost to the project. In no case shall the fill of any new conduit exceed the requirements of the National Electrical Code. The Contractor shall provide documentation to the Engineer

supporting the conduit fill. All costs associated with equipment testing and repairs shall be included in the cost of the Fiber Optic Cable.

Lateral cables shall be installed in continuous runs from the backbone splice location to the field equipment cabinet. Odd length cables and reel ends are acceptable for lateral cables provided they are pre-tested and free of defects and are of sufficient lengths to archive continuous runs.

Lateral cables shall have slack and include a maximum of three locations of appropriate strain relief within all field equipment cabinets.

All fiber optic cables shall include identification labels attached to the cable in each pull box, manhole or field equipment cabinet. The label shall be provided with information as shown on the Project Detail Sheet.

The Contractor shall splice fiber cables at locations shown on the plans. All splices shall be enclosed within a splice closure as approved by the Engineer. Following successful splicing, the splice closure shall be placed inside the pull box or manhole. The Contractor shall use tools and hardware recommended by the cable manufacturer.

Only proposed active (lit) fibers shall be spliced in the closure and terminated in the field communications cabinet. All unused (dark) fibers of both the backbone and lateral cables shall remain uncut and be neatly coiled in the splice tray within the closure. All unused buffer tubes shall remain uncut and neatly coiled along with the buffer tubes used for splicing in appropriate location in the splice closure.

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REVISION OF SECTION 614 FIBER OPTIC CABLE (Single Mode)

Backbone and lateral buffer tubes and fiber strands shall be labeled on the splice tray prior to sealing of the closure as shown on the Project Detail Sheet.

The Contractor shall coil 100 feet of backbone cable in the manholes. The Contractor shall coil 50 feet of backbone cable in pull boxes.

The Contractor shall coil 50 feet of lateral cable in the manholes. The Contractor shall coil 25 feet of Lateral cable in pull boxes.

The Contractor shall ensure that all cable coils and splice canisters are attached to the cable management hardware in all pull boxes and manholes.

The Contractor shall terminate the lateral cable at the field equipment cabinet using a buffer tube fan-out kit. Fanned-out fiber strands shall be terminated in a termination block with ST connectors.

The Contractor shall submit a final documentation package. The final documentation package shall include the cable manufacturer's installation procedures, technical support documentation and material documentation. These documents shall match the original submittals provided to the Engineer.

METHOD OF MEASUREMENT

Fiber Optic Cable shall be measured by the Linear Foot for both backbone and lateral cable and shall include all labor and materials required to install, splice and terminate the cable to make a complete and operational system and shall include the following items:

1. All required splicing, splice closures, splice kits, hardware, splicing tools and labor to accomplish the splices.
2. All required termination panels in field equipment cabinets.
3. All required fan-out kits, hardware and labor to accomplish fan-out.
4. All required termination connectors, adapters, jumpers, pigtails, hardware and labor required to accomplish lateral cable terminations.
5. Identification labels for both backbone and lateral fiber cables in each pull box, manhole and field equipment cabinet.
6. As Built Documentation

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REVISION OF SECTION 614 FIBER OPTIC CABLE (Single Mode)

METHOD OF PAYMENT

Payment for Fiber Optic Cable will be made according to the following schedule:

50% upon completion of cable installation

50% upon the review and acceptance of all fiber test results showing the conformance to this specification and the Revision of Section 614 Test Fiber Optic Cable Specification included in this plan package.

Payment will be made under:

Pay Item

Fiber Optic Cable (Single-Mode) (12 Strands)

Fiber Optic Cable (Single-Mode) (96 Strands)

Pay Unit

Linear Foot

Linear Foot

Testing Fiber Optic Cable will not be measured or paid for separately. See Revision of Section 614 Test Fiber Optic Cable specification included in this plan package.

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REVISION OF SECTION 614
COARSE WAVELENGTH DIVISION MULTIPLEXING ATTENUATOR

Section 614 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

Coarse Wavelength Division Multiplexing Attenuator shall be installed in all Ciena 3930 Carrier Ethernet Service Delivery Switches (SDS) and the Ciena aggregation switches in regeneration node buildings to reduce optical signal power to a level specified by the coarse wavelength division multiplexing (CWDM) small form factor pluggable (SFP) optic modules. The attenuator shall be installed in the receive port of the CWDM SPF. All coarse wavelength division multiplexing attenuators shall be compatible with the CIENA CWDM SFP optic modules.

MATERIALS

The Contractor shall furnish and install single mode, 9/125um CWDM wavelength independent attenuators to match the wavelength of the SFP optic modules installed in the Ethernet switch in wavelengths of:

1430nm, 1450nm, 1470nm, 1490nm, 1510nm, 1530nm, 1570nm, 1590nm and 1610nm. In the design of the network, the 1550nm wavelength will not be used.

Attenuators for 1310nm wavelength SFP optic modules will not be required.

The Contractor shall furnish and install a female to male plug type fiber optic attenuator. The types of fiber optic attenuators to be supplied shall match both the CWDM SFP port and the fiber optic pre-connectorized patch cable connectors.

The attenuators shall meet the following minimum specifications:

- Return Loss: Less than 65dB (APC)
- Attenuation Accuracy: +/-0.5 (1~10) +/-1.0(11~30)
- Polarization Dependent Loss: Less than 0.2dB
- Maximum Optical Input Power: 200mW
- Operating Temp Range: -40~80°C
- Low Polarization Dependent Loss (PDL)
- Tolerate high power UPC polished
- Minimum 500 connect/disconnecting tested

The CWDM attenuators to be provided shall be Bellcore Compliant.

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REVISION OF SECTION 614 COARSE WAVELENGTH DIVISION MULTIPLEXING ATTENUATOR

CONSTRUCTION REQUIREMENTS

After all splicing and testing is completed the Contractor shall test the optical power of the incoming, (Receive) signal at each field Ethernet switch location. To obtain the most accurate values of optical power, the testing equipment shall be attached to the SFP optic end of the pre-connectorized patch cable to be installed at that location.

Once the optical power has been tested, the Contractor shall install the appropriate CWDM attenuator in the receive port of the CWDM SFP to meet the receive values of the CWDM SFP optic module.

Prior to installation, all attenuators shall be cleaned with lint-free fiber wipes moistened with Isopropyl Alcohol 99% U.S.P. After cleaning with alcohol, the bulkhead shall be cleaned with an optical connector cleaner to ensure that all residue is removed.

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REVISION OF SECTION 614
COARSE WAVELENGTH DIVISION MULTIPLEXING SFP

Section 614 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

For this project the Coarse Wavelength Division Multiplexing SFP shall be a single wavelength Coarse Wavelength Division Multiplexing (CWDM) Small Form-Factor Pluggable (SFP) optic module for installation in a Ciena 3930 Carrier Ethernet Service Delivery Switch (SDS). There shall also be matching coarse wavelength division multiplexing, small form-factor pluggable optic modules provided for the existing Ciena Ethernet aggregation switches in each of the regeneration node buildings to which the sub ring switches communicate. All coarse wavelength division multiplexing SFP shall be provided from a manufacturer recommended by Ciena.

MATERIALS

The Contractor shall furnish and install the CWDM SFP optic modules in the wavelengths as shown in the item table below. This table describes optic modules for installation in Ciena 3930 Carrier Ethernet SDS Ethernet switches and Ciena 5150 Carrier Ethernet SAS switches.

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**REVISION OF SECTION 614
 COARSE WAVELENGTH DIVISION MULTIPLEXING SFP**

Item Table – CWDM SFP Optic Modules for Ciena 3930 Carrier Ethernet SDS switches, Ciena 5150 Carrier Ethernet SAS switches and a 5142 Carrier Ethernet SAS switch.

ITEM DESCRIPTION	ITEM NUMBER
100M/1 GIG, SM SFP OPTIC, LC CONNECTOR, 80 KM, 1430 NM, EXT. TEMP	XCVR-A80D43
100M/1 GIG, SM SFP OPTIC, LC CONNECTOR, 80 KM, 1450 NM, EXT. TEMP	XCVR-A80D45
100M/1 GIG, SM SFP OPTIC, LC CONNECTOR, 80 KM, 1470 NM, EXT. TEMP	XCVR-A80D47
100M/1 GIG, SM SFP OPTIC, LC CONNECTOR, 80 KM, 1490 NM, EXT. TEMP	XCVR-A80D49
100M/1 GIG, SM SFP OPTIC, LC CONNECTOR, 80 KM, 1510 NM, EXT. TEMP	XCVR-A80D51
100M/1 GIG, SM SFP OPTIC, LC CONNECTOR, 80 KM, 1530 NM, EXT. TEMP	XCVR-A80D53
100M/1 GIG, SM SFP OPTIC, LC CONNECTOR, 80 KM, 1570 NM, EXT. TEMP	XCVR-A80D57
100M/1 GIG, SM SFP OPTIC, LC CONNECTOR, 80 KM, 1590 NM, EXT. TEMP	XCVR-A80D59
100M/1 GIG, SM SFP OPTIC, LC CONNECTOR, 80 KM, 1610 NM, EXT. TEMP	XCVR-A80D61

In the design of the network, the 1550nm wavelength will not be used.

If for any reason the CWDM SFP optic modules are defective or are damaged at the time of installation by either the Contractor or by Ciena, the optic module shall be removed and replaced at no additional cost to the project. CWDM SFP optic modules shall also be replaced if any failures occur do to manufacture’s defect, at no additional cost to the project prior to the final network acceptance.

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REVISION OF SECTION 614 COARSE WAVELENGTH DIVISION MULTIPLEXING SFP

CenturyLink is the direct contracted equipment supplier of Ciena Corporation for the State of Colorado, Colorado Department of Transportation for networking equipment and associated network materials. For project equipment estimate quotations and purchasing, Contractors shall contact the following distributor representative:

State of Colorado, Colorado Department of Transportation project equipment estimate quotations and purchasing supplier representative.

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CONSTRUCTION REQUIREMENTS

For Ciena 3930 Carrier Ethernet SDS switch installations, a single CWDM SFP optic module shall be installed in each switch for CWDM data communications.

The Contractor shall ensure that the wavelengths of the CWDM SFP optic modules installed in the Ciena 3930 Carrier Ethernet SDS Ethernet switches match those installed in the corresponding Ciena 5150 Carrier Ethernet SAS Ethernet switch to ensure proper data communications.

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REVISION OF SECTION 614

EQUIPMENT PROCUREMENT AND CONFIGURATION

Section 614 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

To ensure that the Colorado Transportation Management Center (CTMC) Network personnel have sufficient time for configuration of the Ethernet switches for this project, the Contractor shall submit all network equipment cut sheets in a timeframe that will ensure timely configuration. This submittal shall include but not be limited to the follow project network equipment items;

- Ethernet Switches; Ciena 3930
- Coarse Wavelength Division Multiplexing Small Form-Factor Pluggable Optic Modules
- 1310nm Wavelength Small Form-Factor Pluggable Optic Modules
- Fiber Optic Attenuators
- All Network Licensing And Warranty Documentation
- All Telemetry (Field) Items - Coarse Wavelength Division Multiplexing Single Wavelength Filters
- All Telemetry (Master) Items – Coarse Wavelength Division Multiplexing Multiplexors
- Fiber Optic Splice Closures
- All Associated Materials Associated With Above Items For The Installation Of The Ethernet Optical Network

CDOT will review and comment of after receiving the submittals.

After the review and approval of the networking equipment cut sheets by CDOT, the Contractor shall place the order for the approved equipment to the CenturyLink representative listed in the project specifications to ensure the timely delivery of the above listed items.

The network equipment as part of this project requires both CTMC personnel and Ciena technical network representatives to jointly configure each individual Ethernet switch in addition to the configuration of this project network into the CTMC statewide intelligent transportation optical network.

The Contractor shall coordinate with the Project Engineer to schedule the Ciena technical representative and the CTMC personnel for a window of time that the configuration may occur, dependent on anticipated equipment delivery. All costs associated with the Ciena technical representative assistance shall not be paid for separately but will be included in the Ethernet Switch item.

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REVISION OF SECTION 614 EQUIPMENT PROCUREMENT AND CONFIGURATION

The Contractor shall provide all required information to the CTMC for the Ethernet switches. This includes but not limited to the Highway Mile Point of the Ethernet switch, the Project stationing of the Ethernet switch along with the devices to which they are connected. This information shall be submitted on a spreadsheet at the time that the Contractor delivers the Ethernet switches to the CTMC for configuration.

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REVISION OF SECTION 614

FIBER OPTIC PRE-CONNECTORIZED CABLE

Section 614 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

This work consists of the installation of fiber optic pre-connectorized patch cables in communication cabinets, variable message signs and communications node buildings from the termination patch panel to the optical communication device optics.

At Ethernet switch locations, coarse wavelength division multiplexing (CWDM) is to be utilized and shall require bend insensitive fiber optic pre-connectorized patch cables. Bend insensitive pre-connectorized patch cables shall also be required for CWDM optical connections in communications node buildings.

The bend insensitive cable shall be used to enable a tight bend radius and routing to help alleviate data loss.

MATERIALS

The measured attenuation of the connector (inclusive of coupler and mated test connector) shall not exceed an average of 0.3 dB for all connectors provided. Any connector found in excess of 0.5 dB shall be rejected. Reflectance shall be less than -40 dB from 14° F to 140° F (-10°C to +60°C). The manufacturer shall have a program that periodically tests connectors to ensure that after 1000 re-matings, the attenuation will not change more than 0.2 dB.

The measured insertion loss shall be a maximum of 0.25 dB with a typical loss of 0.15dB. Return loss shall be a maximum of -65 dB (APC) and -55 dB (UPC) with a typical loss of -68 dB (APC) and -58 dB (UPC). The minimum cable bend radius shall be less than 15 mm.

The connector shall be able to withstand an axial pull of 25 lbs. with no physical damage to the connector and no permanent optical degradation more than 0.3 dB.

The CWDM pre-connectorized cables shall be jacketed for extra protection and shall be provided with pre-connectorized connectors on both ends to match the termination patch panel bulkheads and coarse wavelength division multiplexing, small form-factor pluggable optic modules of the Ethernet switch. Connectors shall be terminated by the manufacturer.

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REVISION OF SECTION 614 FIBER OPTIC PRE-CONNECTORIZED CABLE

The connectors shall be nickel-plated with a ceramic ferrule and shall be polished with a physical contact (PC) finish end to reduce reflection.

The bend insensitive pre-connectorized patch cable shall meet the following specifications:

Patch Cable Connectors

- EIA, TIA-55 (FOCIS)
- UL94 V-O
- GR-326, Issue 3 Specifications

Fiber Cable

- Telcordia GR-409

CWDM patch cable bend insensitive fiber shall satisfy International Telecommunication Union (ITU) -T G.657 category A1 standards. The cable shall have a ‘tactical’ polyurethane jacket to resist bending and shall be blue in color.

The cables shall contain the exact number of loose tube fibers and bulkhead connectors to connect from the termination patch panel to the optical modules. If the optical equipment transmits and receives data with a single optic, the pre-connectorized cable shall contain a single optical fiber, (simplex). When the optical device transmits and received data with two or four optics, or a network Ethernet switch small form factor pluggable optic module, a pre-connectorized cable shall be provided with 2 (two) optical fibers, (duplex) per pair of transmit and receive optics.

CONSTRUCTION REQUIREMENTS

Pre-connectorized cables shall be installed from the termination panel bulkheads to the optical modules of the communication devices.

At the communications node building, the pre-connectorized cables shall be installed in the cable management hardware attached to equipment racks. The Contractor shall provide patch cables of sufficient length to span from the fiber termination patch panel bulkheads to the communications device or network device optical port. This length shall include a maximum of four (4) feet of slack cable. Appropriate cable management shall be used.

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REVISION OF SECTION 614 FIBER OPTIC PRE-CONNECTORIZED CABLE

At communication cabinets, the Contractor shall provide pre-connectorized cables of sufficient length to span from the fiber termination patch panel bulkheads to the equipment device or network device optical port. This length shall include a maximum of two (2) feet of slack cable. Appropriate cable management shall be used.

Prior to installation, all pre-connectorized cable bulkhead connectors shall be cleaned with lint-free fiber wipes moistened with Isopropyl Alcohol 99% U.S.P. After cleaning with alcohol, the bulkhead shall be cleaned with an optical connector cleaner to ensure that all residue is removed.

Manufacturer testing reports for pre-connectorized cables shall be submitted as part of the as-built documentation. The installation location shall be noted on the test report for future reference.

At communication node buildings, pre-connectorized patch cables shall have identification labels applied on each end. Information indicating the patch panel number, device being connected, CWDM wavelength and Ethernet switch port number. CDOT personnel will aid in the labeling as it pertains to the proper nomenclature to be provided and/or Ethernet port connectons.

At all field device locations, each cable shall have individual labels indicating the CWDM wavelength, termination panel port and the data transmitting description, (example: Tx or Rx).

Patch cable labeling shall be as shown on the Project Detail Sheet.

The pre-connectorized cables shall be provided in the following lengths.

Field Device Cabinets.....	4 Feet – 0 Inch maximum
Node Buildings	Cable shall be of sufficient length to accommodate connection of termination patch panel bulkhead to each individual optical device while allowing for 4 feet of slack.

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REVISION OF SECTION 614
SMALL FORM-FACTOR PLUGGABLE – 1310NM SFP

Section 614 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

For this project the Small Form-Factor Pluggable – 1310NM SFP shall be a single wavelength Small Form-Factor Pluggable (SFP) optic module for installation in a Ciena 3930 Carrier Ethernet Service Delivery Switch (SDS). All Small Form Factor-Pluggable – 1310NM SFP optic modules shall be provided from a manufacturer recommended by Ciena.

MATERIALS

The Contractor shall furnish and install the 1310nm SFP optic module shown in the item table below. This table describes the optic module for installation in the Ciena 3930 Carrier Ethernet SDS switch.

Item Table – 1310nm SFP Optic Modules for a Ciena 3930 Carrier Ethernet SDS Switch.

ITEM DESCRIPTION	ITEM NUMBER
100M/1 GIG, SM SFP OPTIC, LC CONNECTOR, 10 KM, 1310 NM, EXTENDED TEMPERATURE	XCVR-A10Y31

If for any reason the 1310nm SFP optic modules are defective or are damaged at the time of installation by either the Contractor or by Ciena, the optic module shall be removed and replaced at no additional cost to the project. 1310nm SFP optic modules shall also be replaced if any failures occur do to manufacture’s defects, at no additional cost to the project prior to the final network acceptance.

CenturyLink is the direct contracted equipment supplier of Ciena Corporation for the State of Colorado, Colorado Department of Transportation for networking equipment and associated network materials. For project equipment estimate quotations and purchasing, Contractors shall contact the following representative:

Project: US 6 over Garrison Street
Project Sub Acct. No: 19478
July 10, 2014
DRAFT Technical Requirements

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REVISION OF SECTION 614 SMALL FORM-FACTOR PLUGGABLE – 1310NM SFP

State of Colorado, Colorado Department of Transportation project equipment estimate quotations and purchasing supplier representative.

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CONSTRUCTION REQUIREMENTS

For Ciena 3930 Carrier Ethernet SDS switch installations, a single 1310nm SFP optic module shall be installed in each switch for data communications between 2 adjoining Ethernet switches.

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REVISION OF SECTION 614

FIBER OPTIC SPLICE CLOSURE

Section 614 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

Fiber optic splice closure shall be used to enclose fiber splices of both fiber optic backbone and fiber optic lateral cables at locations shown in the plans. The splice closures shall be provided for underground installations.

At field Ethernet switch locations two splice closures shall be required. Both closures shall be of the same size with the capacity for the proposed or existing fiber optic backbone cable and the associated fiber optic lateral cable.

One splice closure will be used for splicing the backbone fiber optic cable to a single lateral fiber optic cable. The second splice closure will be used for splicing two (2) separate lateral fiber cables to the coarse wavelength division multiplexing single wavelength filters.

MATERIALS

The fiber optic splice closures shall be furnished by the Contractor.

The splice closures shall be stand-alone, dome type and shall meet the following minimum requirements:

- (a) The closures shall seal, anchor and protect fiber optic cable splices, coarse wavelength division multiplexing single wavelength filters.
- (b) The closures shall have a maximum of six (6) total cable entries.
- (c) The closures shall be suitable for underground applications and shall be watertight and airtight.
- (d) The closures splice trays shall have a hinged design with an upright locking mechanism for all splice trays to provide ease of access for future maintenance to lower trays.
- (e) The closures shall have a gel compression ring type sealing design. A gluing or sealant design for sealing of the closure shall not be accepted.

The closures shall be sized to provide the capacity equal to the total number of strands for all cables entering the closure. All fiber optic cables shall be secured to prevent the ingress of water per the manufacture's recommendations. All remaining access holes not utilized shall be plugged to prevent water from entering the closure.

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REVISION OF SECTION 614 FIBER OPTIC SPLICE CLOSURE

CONSTRUCTION REQUIREMENTS

All splices shall be performed using the fusion splicing method. The fusion splicer shall be calibrated and certified at least once within the previous year from this project. All certification documentation shall be presented to the Project Engineer prior to start of splicing.

The Contractor shall cut and splice only those fiber strands shown to be spliced on the fiber splice plan sheets. All unused buffer tubes and fiber strands shall remain uncut. After the fiber cable and proposed buffer tube is prepped for splicing, all fiber strands in the buffer tube shall be cleaned of all homogeneous gel. All uncut fiber strands shall be coiled in the tray. Remaining buffer tubes shall be neatly coiled, secured and stored in the storage area within the closure under the splice trays per the manufacturer's recommendations. Buffer tubes proposed for splicing shall be wrapped and secured to the splice tray with ties per the manufacturer's recommendations.

The completed splices and coarse wavelength division multiplexing single wavelength filters shall be secured in the splice tray foam splice chips per manufacturer's recommendations.

Bare fiber strands shall not be taped to the splice tray.

At field Ethernet switch splice locations; two (2) closures shall be required. One closure shall be used for splicing of the backbone fiber optic cable to one end of a lateral cable. A second closure shall be required for splicing two (2) lateral fiber optic cables to the coarse wavelength division multiplexing single wavelength filters.

If the closure requires re-entry, it shall be conducted per the manufacturer's recommendation for re-entry and resealing. The Contractor shall use caution not to damage the fiber strands, splices, coarse wavelength division multiplexing filters or buffer tubes existing inside. When sealing the closure for a second time, the Contractor shall follow all re-entry requirements of the manufacturer.

The Contractor shall ensure that the fiber optic splice enclosures and associated fiber cable coils fit adequately within the manhole or pull box splice locations specified on the plans.

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REVISION OF SECTION 614 FIBER OPTIC SPLICE CLOSURE

The optical fibers shall be fusion spliced and shall meet the following minimum requirements:

- (a) Splice loss <0.15 dB
- (b) Reflection <50 dB
- (c) Completed splice shall be stable from -40° F to +185° F (-40°C to +85°C)

The Contractor shall label each individual splice and buffer tube in all splice trays per the Project Detail Sheet included in the project plans. The coarse wavelength division multiplexing single wavelength filter position and its working wavelength shall also be labeled.

The Contractor shall inform the Project Engineer two days before and the morning of proposed splicing locations for that day. While the splicing procedures are occurring and within four (4) hours prior to sealing the closure and installation in the pull box, the Contractor shall again contact the Project Engineer for inspection. In the event that the Project Engineer cannot be on site, a minimum of eight (8) digital pictures shall be taken at varying angles of the interior of the splice closure showing all completed work as stated in this specification and shown on the Project Detail Sheet. These pictures shall include exposed fiber stands, (both spliced and uncut) in all splice trays, coarse wavelength division multiplexing filter storage, fiber tray labeling and remaining buffer tubes showing appropriate coiling. One picture shall also include the complete re-assembly of all interior parts prior to final sealing. Once the closure and fiber coils are installed in the pull box or manhole, two (2) pictures shall be taken showing the final installation of both the closure and the coiled fiber cable attached to the fiber management hardware.

All pictures shall be organized per location and shall be submitted to the Project Engineer along with all final testing result documentation.

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REVISION OF SECTION 614

TELEMETRY (MASTER)

Section 614 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

For this project Telemetry (Master) shall be a rack mounted 10-Channel Coarse Wavelength Division Multiplexing Module for wavelengths of 1430nm to 1610nm with LC/APC Port Bulkheads, Extension Ports and outgoing / incoming Mux and DeMux ports to be installed in communication node building equipment racks. The unit shall have the capabilities of passively multiplexing and de-multiplexing multiple wavelengths to and from field Ciena 3930 Ethernet switches and communications node building Ciena Ethernet Switch small form-factor pluggable optic modules. All 10-channel Coarse Wavelength Division Multiplexing Modules shall be provided from a manufacturer recommended by Ciena. In the design of the network, the 1550nm wavelength will not be used.

MATERIALS

The 10-channel Coarse Wavelength Division Multiplexing (CWDM) module shall have twelve (12) transmit / receive ports. 10 of the 12 ports shall be for individual wavelength matching the Ethernet switch coarse wavelength division multiplexing, small form-factor pluggable optic modules.

The 10-channel CWDM module shall have the ability of multiplexing and de-multiplexing the following wavelengths;

1430nm, 1450nm, 1470nm, 1490nm, 1510nm, 1530nm, 1550nm, 1570nm, 1590nm and 1610nm. In the design of the network, the 1550nm wavelength will not be used. The dust covers for the 1550nm port shall remain installed to prevent dirt and dust from entering the CWDM multiplexing module.

The 10-channel CWDM modules shall also include a chassis capable of mounting in a 19 inch communications equipment rack. The chassis shall have an integrated cable management tray on the front side to house the optical patch cables installed from the CWDM multiplexing module ports to the Ethernet switch optic modules.

CenturyLink is the direct contracted equipment supplier of Ciena Corporation for the State of Colorado, Colorado Department of Transportation for networking equipment and associated network materials. For project equipment estimate quotations and purchasing, Contractors shall contact the following representative:

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REVISION OF SECTION 614 TELEMETRY (MASTER)

State of Colorado, Colorado Department of Transportation
equipment estimate quotations and purchasing supplier representative.

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CONSTRUCTION REQUIREMENTS

The 10-channel CWDM multiplexing modules and chassis shall be installed in 19 inch equipment racks in communication node buildings and in a communications cabinet on Interstate 25.

Single mode, bend insensitive, pre-connectorized duplex patch cable with a polyurethane jacket shall be installed from the 10-channel CWDM module to the backbone termination patch panel for communications to the field Ciena 3930 SDS Ethernet switches. Connectors for the patch cable shall be LC on the 10-channel CWDM module end and ST on the termination patch panel end.

Single mode, bend insensitive, pre-connectorized duplex patch cables with a polyurethane jacket shall be installed from each 10-channel CWDM module wavelength Tx/Rx port to the matching CWDM small form-factor pluggable optic module on the Ciena 5150 Carrier Ethernet SAS Ethernet switch. A duplex patch cable shall be installed for each wavelength. Connectors for the patch cables shall be LC on the 10-channel CWDM module end and LC on the Ethernet switch SFP optic module end.

In communication node buildings, the patch cables shall be of sufficient length to span from the termination patch panel to the 10-channel CWDM module and from the 10-channel CWDM module to the Ciena 5150 Ethernet switch with a maximum of four (4) feet of slack for each cable. They shall be installed in a manner which will not interfere with equipment in the equipment racks and will include cable management so as not to interfere with future maintenance within the rack.

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Project Sub Acct. No: 19478
July 10, 2014
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REVISION OF SECTION 614 TELEMETRY (MASTER)

If for any reason the 10-channel CWDM module is defective or is damaged at the time of installation by the Contractor, the item shall be removed and replaced at no additional cost to the project. Modules shall also be replaced if any failures occur do to manufacture's defect at no additional cost to the project prior to the final network acceptance.

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REVISION OF SECTION 614

TELEMETRY (FIELD)

Section 614 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

For this project Telemetry (Field) shall be a Single Wavelength Coarse Wavelength Division Multiplexing (CWDM) optical filter manufactured for use in coarse wavelength division multiplexing at all Ciena 3930 Carrier Ethernet Service Delivery (SDS) Ethernet Switch device location. All coarse wavelength division multiplexing single channel filters shall be provided from a manufacturer recommended by Ciena.

MATERIALS

The CWDM optical filter shall have the capability of splitting a single CWDM wavelength from the multiple wavelengths being transmitted along the fiber strands including passing a 1310nm wavelength between Ethernet switch pairs. All remaining wavelengths other than those being added or dropped at the designated location shall be allowed to travel from Ethernet switch to Ethernet switch or communications node building to Ethernet switch.

The CWDM optical filters shall be provided with industry standard operating ranges of 1430nm to 1610nm to match wavelengths of the Coarse Wavelength Division Multiplexing Small Form-Factor Pluggable optic modules of the Ethernet switches. The individual filters shall have the following channel center wavelengths;

1430nm, 1450nm, 1470nm, 1490nm, 1510nm, 1530nm, 1570nm, 1590nm and 1610nm. In the design of the network, the 1550nm wavelength will not be used.

1310nm wavelength filters shall also be provided.

If for any reason the single wavelength filter is defective or is damaged at the time of installation by the Contractor, the filter shall be removed and replaced at no additional cost to the project. Filters shall also be replaced if failures occur do to manufacture's defect, at no additional cost to the project prior to the final network acceptance.

CenturyLink is the direct contracted equipment supplier of Ciena Corporation for the State of Colorado, Colorado Department of Transportation for networking equipment and associated network materials. For project equipment estimate quotations and purchasing, Contractors shall contact the following representative:

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REVISION OF SECTION 614 TELEMETRY (FIELD)

State of Colorado, Colorado Department of Transportation
equipment estimate quotations and purchasing supplier representative.

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At each Ethernet switch location a total of four (4) single wavelength filters will be required. The Contractor shall splice two (2) matching single wavelength CWDM optical filters and two (2) 1310nm optical filters. The filters shall match the industry standard wavelength of the Ethernet switch's Coarse Wavelength Division Multiplexing Small Form-Factor Pluggable (SFP) optic module and the 1310nm SFP optic module.

The CWDM optical filters shall have three (3) fiber pigtailed to be fusion spliced to lateral fiber optic cable strands and secured in the foam splice chips on splice tray in the splice closure. The pigtailed shall be provided with distinctive buffer tube colors designating "Pass", "Reflect" and "Common". If the filter pigtail buffer tubes are all of the similar color, The Contractor shall color code each individual tube for future maintenance.

The filters shall be provided with the optical wavelength printed on the filter body.

Bare fiber strands shall not be taped to the splice tray.

All splices and optical filter wavelengths shall be labeled on the splice tray.

If for any reason the Contractor installs or splices any single wavelength optical filter in a location which does not match the Ethernet switch coarse wavelength division multiplexing SFP optic modules, the Contractor shall replace the filter and re-splice all fibers at no additional cost to the project.

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REVISION OF SECTION 614 TELEMETRY (FIELD)

Prior to splicing of the filters, the Contractor shall submit to the Project Engineer a Microsoft Excel spreadsheet containing the following information:

- a) Splice Location for the CWDM and 1310nm filters (manhole milepost as shown on the fiber splice project plan sheets).
- b) Serial Number of the CWDM and 1310nm filters.
- c) Wavelength of the filter.
- d) Usage and color of filter pigtails.

Once the spreadsheet has been submitted and approved by the Project Engineer the splicing may begin.

The pigtails of the filters shall be labeled inside the splice closure per the Project Detail sheet included in the project plan set.

Section 19 – ITS – Appendix A – Special Provisions
REVISION OF SECTION 614
BUFFER TUBE FAN OUT KIT

Section 614 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

For this project, the Buffer Tube Fan Out Kit shall be furnished and installed on fiber lateral cable ends in field termination panels mounted within communication cabinets.

MATERIALS

The Contractor shall use fiber optic fan out kits on the fiber lateral cable in the communication cabinet termination panels. Fan out buffer tubes for the lateral fiber strands shall be 9mm minimum and shall be neatly coiled after installation and secured within the field termination panels. Fan out kits shall be supplied with buffer tubes matching the lateral fiber strand colors. ST type bulkhead connectors shall be terminated on the ends of the lateral cable fiber strands and installed on the back side of the termination panel bulkheads. The connectors shall have a ceramic ferrule with a nickel-plated nut and body. The connector shall be polished with a physical contact (PC) finish.

METHOD OF MEASUREMENT

Buffer Tube Fan Out Kit will not be measured or paid for separately, but will be considered subsidiary to the Fiber Optic Cable (Single Mode) pay item. This item shall include all labor, materials and equipment required to complete the work.

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REVISION OF SECTION 614
FIBER OPTIC CABLE INSTALLATION

Section 614 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

Fiber optic cable installed on this project will be installed in electrical conduits, pull boxes and equipment communication cabinets which contain existing electrical cable or electronic equipment currently carrying communications data from existing intersection traffic signals and roadway devices. The new fiber cable shall be installed in a manner which will not interfere with the integrity of the existing cable and or equipment. Slack fiber cable shall be coiled in pull boxes, manholes and communications cabinets using proper fiber management as noted on the plans. Fiber optic cable installed in traffic controller cabinets shall be placed in a manner which will not interfere with the maintenance or the traffic signal cable, wiring or equipment. All OTDR testing shall be conducted as stated in this specification and in accordance with the Project Special Provision, Test Fiber Optic Cable, included in this plan set.

The Contractor shall install all fiber optic cables in accordance with the splicing diagrams as shown in the plans. The Contractor shall conduct an on-reel test prior to installing any fiber cables. After the on-reel test the Contractor shall provide the Project Engineer with all resultant documentation prior to actual cable installation. No installation shall commence until the Project Engineer reviews and accepts all test results showing all fibers in the cables are undamaged, containing no breaks or micro bends. Once the results are accepted, the fiber cable may be installed. If the test results show damage to any strand or strands within a reel, that reel shall be rejected, replaced and retested at no additional cost to the project.

Once the fiber cable is accepted by the Project Engineer, the cable may be installed. The fiber cable is to be installed in reel lengths that minimize cable end splices, in turn minimizing fiber cable loss. Once the entire cable is installed and all cable end splices are complete, bi-directional testing shall be conducted to assure that no damage occurred in the installation process.

For backbone fiber cable, if any strand(s) of the fiber cables show damage from the Contractor's installation, that entire section of fiber cable shall be removed, re-installed and re-spliced from the cable end splice point at no additional cost to the project.

For lateral fiber cable, if any strand (s) of the fiber cables show damage from the Contractor's installation, the entire length of fiber cable shall be removed, re-installed and re-splices form the splice point to the device communication cabinet at no additional cost to the project.

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REVISION OF SECTION 614 FIBER OPTIC CABLE INSTALLATION

Prior to any fiber optic work, the Contractor shall give the Project Engineer a detailed installation and splicing schedule a minimum of one week, prior to commencing work. All installation, splicing, termination, and testing shall be listed on the schedule and any revisions to this schedule shall be re-submitted to the Project Engineer as soon as the changes are made.

After completing all splicing and termination work, a final inspection of the fiber network will be conducted. If damage exists to the fiber optic cable system due to Contractor negligence, all costs associated with the cable, pulling of the cable, splicing, splice canisters and testing of the network shall be at the Contractor's expense

Section 614 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

This work consists of furnishing and installing fiber optic termination panels in Intelligent Transportation System (ITS) device communication cabinets, traffic signal controller cabinets, ramp metering controller cabinets and/or automated traffic recorder station cabinets for single mode fiber.

MATERIALS

The units shall meet the design requirements of ANSI/TIA/EIA-568 and the plastics flammability requirements of UL 94 V-0.

Termination panels shall be manufactured using 16-gauge aluminum or equivalent and shall be finished with powder coat for durability. The termination panel shall have a slide out interior for future access of the remaining lateral fibers and the back side of the bulkheads while minimizing disturbance to existing fiber and terminations.

Termination panels for ITS communication cabinets shall be a single six (6) port panel with ST type bulkheads. The panels shall have hinged doors to provide future access to both the fiber fan out and the termination bulkheads. The panel shall be sized to accommodate the entry of the lateral fiber optic cable, fiber fan out, bulkheads, and the fiber patch cable with access doors closed. The fiber optic patch panel shall be suitable for wall mounting and have dimensions not exceeding 5 inches (W) × 6 inches (L) × 2 inch (D). Each fiber optic patch panel shall include a flat polypropylene cassette, adapters, 6-fiber buffer tube fan-out kit (with 25 inch furcation tubing), strain relief boot, grommet tape, zip ties and wall mounting bracket.

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REVISION OF SECTION 614 FIBER OPTIC CABLE INSTALLATION

Terminations within the patch panel shall be for ST-UPC connectors and must be compliant with the Telcordia GR-326 Generic Requirements for Single Mode Optical Connectors and Jumper Assemblies. The manufacturer shall perform acceptance testing for insertion loss and return loss with the test certification provided with each patch panel.

Termination panels for traffic signal controller cabinets, ramp metering controller cabinets and automated traffic recorder station cabinets shall be sized to accommodate twenty four (24) ports and mounted in the cabinets' 19-inch rack rails. The panels shall be provided with two (2) ST termination bulkhead 6 pack modules for fiber terminations as shown in the plans. The panel shall be provided with covers for the remaining spaces for future bulkhead installations. All bulkheads shall be metal. Plastic bulkheads will not be accepted.

CONSTRUCTION REQUIREMENTS

Termination panels within cabinets shall be mounted in locations which will allow for ease of access and shall not interfere with maintenance of the internal equipment.

The Contractor shall use proper strain relief inside the termination panel for the fiber cable and fiber fan out strands per the manufacturer's recommendations. The use of tape to secure the individual fanned out strands to the bottom of the termination panel shall not be allowed.

All hardware shall be installed in accordance with manufacturer's recommendations. All termination panels shall have a labeling scheme that complies with ANSI/TIA/EIA-606 and the details as shown on the Project Details Sheet.

METHOD OF MEASUREMENT

Fiber Optic Termination Panels will not be measured or paid for separately but will be considered subsidiary to the Fiber Optic Cable (Single Mode) pay item.

Fiber Optic Termination Panels shall include all bulkheads, covers for empty spaces, labeling panels and all materials, hardware, labor and equipment necessary to complete the work.

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REVISION OF SECTION 614
FIBER OPTIC CABLE AS-BUILT DOCUMENTATION

Section 614 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

The Contractor shall complete and forward to the Project Engineer the Fiber Cable As-Built Documentation Sheet as part of their final submittals on the project. This form is an aide to document information as it pertains to the installation of fiber optic cable along the project corridors as part of this project.

At each pull box and manhole location, fiber optic cable information to be provided shall include the following:

- 2) Cable sequential foot marking measurements stamped on the cable jacket as the cable enters and exits the pull box
- 3) Type of splices, lateral cables or cable end splices
- 4) Number of lateral cables at the pull box location
- 5) Fiber cable ID serial number
- 6) Identification or location of pull boxes or manholes as they are shown on the final as-built documentation

As part of the as-built documentation, any revised fiber optic splices shall also be provided as marked up copies of the original splice diagrams. If changes are made during the splicing procedures, those changes shall be documented by the Contractor and submitted to the Project Engineer as final as-built drawings.

BASIS OF PAYMENT

Fiber Optic Cable As-Built Documentation will not be measured or paid for separately but will be considered subsidiary to the Fiber Optic Cable (Single Mode) pay item.

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REVISION OF SECTION 614 FIBER OPTIC CABLE AS-BUILT DOCUMENTATION FIBER OPTIC CABLE AS-INSTALLED DOCUMENTATION SHEET

TO NEXT PULL BOX or
MANHOLE

CABLE MEASUREMENT OUT _____

PULL BOX LOCATION _____
MANHOLE NUMBER _____

CABLE ID NUMBER _____

CABLE MEASUREMENT IN _____

SPLICE POINT YES ___ NO ___
CABLE END SPLICE YES ___ NO ___
NUMBER OF LATERAL CABLES _____

CABLE MEASUREMENT OUT _____

PULL BOX LOCATION _____
MANHOLE NUMBER _____

CABLE ID NUMBER _____

CABLE MEASUREMENT IN _____

SPLICE POINT YES ___ NO ___
CABLE END SPLICE YES ___ NO ___
NUMBER OF LATERAL CABLES _____

CABLE MEASUREMENT OUT _____

PULL BOX LOCATION _____
MANHOLE NUMBER _____

CABLE ID NUMBER _____

CABLE MEASUREMENT IN _____

SPLICE POINT YES ___ NO ___
CABLE END SPLICE YES ___ NO ___
NUMBER OF LATERAL CABLES _____

FROM PREVIOUS PULL BOX or
MANHOLE

Section 19 – ITS – Appendix A – Special Provisions
REVISION OF SECTION 614
TEST FIBER OPTIC CABLE

Section 614 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

This project includes the installation of a Dense Wavelength Division Multiplexing (DWDM) and Coarse Wavelength Division Multiplexing (CWDM) optical fiber network for the transport of Intelligent Transportation System highway device data communications. A combination of edge, distribution and high speed backbone Ethernet switches will be used for the network transport of this data.

For this project all fiber optic cable shall be tested with the following testing equipment;

Optical Time Domain Reflectometer
Power Meter Set
Coarse Wavelength Division Multiplexor - Optical Time Domain Reflectometer
Spectrum Analyzer

CWDM wavelengths used on this project range from 1430nm to 1610nm as follows:

1430nm, 1450nm, 1470nm, 1490nm, 1510nm, 1530nm, 1570nm, 1590nm and 1610nm. The 1550nm wavelength is not in use. This wavelength is reserved for any possible testing by using a non CWDM optical time domain reflectometer.

Industry stand nomenclature for the identifying of individual wavelength (ex 1490nm = 1491nm) shall be observed on the project.

Due to the nature of DWDM and CWDM optical networks, strict adherence to industry standards and this specification will be required for all CWDM testing. All testing results shall be submitted to the Project Engineer as details in the Project Plans and Project Specifications.

Prior to any splicing and testing on the project the Contractor shall submit a detailed Method Statement to the Project Engineer explaining their planned splicing plan and testing schedule and methods. No fiber optic splicing shall begin until the Method Statement is submitted and approved. Once the splicing and testing begins, the Method Statement shall be updated if necessary to address any required changes in the original planned and approved procedures.

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REVISION OF SECTION 614 TEST FIBER OPTIC CABLE

MATERIALS

Test fiber optic cable shall include an OTDR on reel test on all fiber optic cable strands installed on the project by the Contractor. In addition, an optical power meter test shall be conducted on fiber strands from all device locations to the communications node buildings. These tests shall be for all “dark” fiber optic strands not being used for the coarse wavelength division multiplexing optical network as part of the final network acceptance.

The Contractor shall use a Coarse Wavelength Division Multiplexor – Optical Time Domain Reflectometer (CWDM-OTDR) purchased as part of this project to test all fiber optic cable for use in the coarse wavelength division multiplexing (CWDM) optical network. Testing shall be conducted for all CWDM wavelengths applicable to the individual fiber stands used for data communications. This testing shall commence after all fiber splicing has been completed as part of the final network acceptance. If

required, testing shall also be conducted at Colorado Transportation Management Center (CTMC) for troubleshooting purposes.

The Contractor shall use an Optical Spectrum Analyzer to test all CWDM. Testing shall be conducted for all CWDM optics at the communications node buildings to individual field Ethernet field switches and from the field switches to the node buildings. This testing shall commence after all fiber splicing has been completed as part of the final network acceptance. If required, testing shall also be conducted at the Colorado Transportation Management Center (CTMC) for troubleshooting purposes.

Bidirectional wavelengths shall be tested for optics to ensure the proper wavelength is being dropped at the Ethernet switches and in turn sent to the communications node buildings.

As part of the CWDM design all wavelengths will travel on single fibers, and dropped to individual Ethernet switches in the field. Tests shall be required at all switch locations to ensure the proper wavelength is delivered and transmitted.

CONSTRUCTION

For fiber optic cables and/or cable strands not utilized for coarse wavelength division multiplexing the following requirements shall be followed.

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REVISION OF SECTION 614 TEST FIBER OPTIC CABLE

Test Fiber Optic Cable. For this project this work shall consist of the testing of either multimode or Single Mode fiber optic cable as shown and tabulated in the plans. The testing procedures involve an OTDR test and an Optical Power Meter Test.

Guidelines for fiber optic cable testing include:

- (1) Test jumpers and patch cords must be of the same fiber core size and connector type as the cable system:
Multimode fiber 62.5/125 μm
Single Mode fiber 8.3/125 μm
- (2) The light source and OTDR must operate within the range of 850 ± 30 nm or 1300 ± 20 nm for multimode testing in accordance with ANSI/EIA/TIA-526-14.
- (3) The light source and OTDR must operate with the range of 1310 ± 10 nm or 1550 ± 20 nm for Single Mode testing in accordance with ANSI/EIA/TIA-526-7.
- (4) The power meter and the light source must be set to the same wavelength during testing.
- (5) The power meter must be calibrated and traceable to the National Institute of Standards and Technology (NIST).
- (6) All system connectors, adapters and jumpers must be cleaned as per manufacturer's instructions before measurements are taken.

A) Fiber Optic Cable Testing Equipment. The following is required to perform fiber optic cable tests:

- (1) An OTDR
- (2) A test reel, if necessary
- (3) A light source at the appropriate wavelength
- (4) Optical Power Measurement Equipment
- (5) Test Jumpers as specified below

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REVISION OF SECTION 614 TEST FIBER OPTIC CABLE

Multimode Fiber Testing

CPR Test Jumper-1 shall be 1-5 meters long with connectors compatible with the light source and power meter and have the same fiber construction as the link segment being tested.

CPR Test Jumper-2 shall be 1-5 meters long with connectors compatible with the light source and power meter. Test Jumper-2 shall contain Class IV a single-mode fiber for tests on 1300 nm light sources and from which is single-moded at 850 μm for tests on 850 nm light sources.

Single Mode Fiber Testing

CPR Test Jumper-1 and Test Jumper-2 shall be 1-5 meters long with connectors compatible with the light source and power meter and have the same fiber construction as the link segment being tested.

B) Optical Fiber Cable Testing with OTDR. The Contractor shall perform an OTDR test of all fibers in all tubes on the reel prior to installation of the fiber. The test results shall be supplied to the Project Engineer prior to installation of the cable. Once the test results have been reviewed and approved, the final fiber optic cable installation may commence.

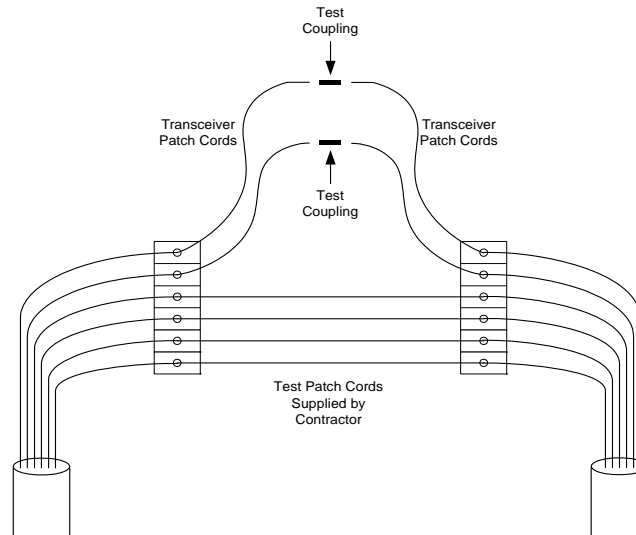
If the fiber is specified as “Install Only”, the Contractor shall test the fiber on the reel and provide the test results to the Project Engineer prior to accepting the cable. After installation, if there are unused portions of cable remaining on the reel, the Project Engineer may request the Contractor or other qualified technician to perform a reel test. The Contractor shall provide the Project Engineer the test results prior to delivering the cable to the Project Engineer. Any cable damaged while in the Contractor’s possession shall be replaced at the Contractor’s expense.

All fiber testing shall be performed on all fibers in the completed end-to-end system. Testing shall consist of a bi-directional end-to-end OTDR trace performed per TIA/EIA-455-61. The system margin loss measurements shall be provided at 850 and 1300 nm for multimode fibers and 1310 and 1550 for Single Mode fibers. If the Plans require installation of a fiber optic patch panel, the Contractor shall supply patch cords to patch all terminated fibers through the panel for all fiber testing. If patch cords are specified in the Plans for final equipment installation, these patch cords shall be connected using a test coupling for the end-to-end test.

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REVISION OF SECTION 614 TEST FIBER OPTIC CABLE



OTDR readings will be used to ensure proper installation and to troubleshoot faults. OTDR signature traces will be used for documentation and maintenance. An OTDR provides an indirect estimate of the loss of the cable plant, generally, more accurate or reliable values will be obtained by using an Optical Power Meter. For fibers that are identified in the Plans to be left unterminated, an OTDR shall be used to test end-to-end attenuation.

Loss numbers for the installed link shall be calculated by taking the sum of the bi-directional measurements and dividing that sum by two.

The Contractor shall use an OTDR that is capable of storing traces electronically and shall save each final trace.

To ensure the traces identify the end points of the fiber under test and the fiber designation, the Contractor shall use a test reel, if required, to eliminate the “dead zone” at the start of the trace so that the start of the fiber under test can be identified on the trace. Indicate the length of the test reel for all test results.

If the fiber designation is not indicated on the trace itself, the Contractor shall provide a cross-reference table between the stored trace file name and the fiber designation.

In compliance with EIA/TIA-455-61 “Measurement of Fiber or Cable Attenuation Using an OTDR” the Contractor shall record the following information during the test procedure:

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REVISION OF SECTION 614 TEST FIBER OPTIC CABLE

- (1) Names of personnel conducting the test.
- (2) Type of test equipment used (manufacturer, model, serial number, calibration date).
- (3) Date test is being performed.
- (4) Optical source wavelength and spectral width.
- (5) Fiber identification.
- (6) End point locations.
- (7) Launch conditions
- (8) Method of calculation for the attenuation or attenuation coefficient.
- (9) Acceptable link attenuation.

C) Optic Fiber Cable Testing with Optical Power Meter. The Contractor shall conduct an Optical Power Meter Test for each fiber installed.

Multimode segments shall be tested in one direction at both the 850 nm and the 1300 nm wavelength.

Single Mode segments shall be tested in one direction at both the 1310 nm and 1550 nm wavelength.

In compliance with TIA/EIA-526-14A “Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant” and TIA/EIA-526-7 “Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant,” the following information shall be recorded during the test procedure:

- (1) Names of personnel conducting the test.
- (2) Type of test equipment used (manufacturer, model, serial number, calibration date).
- (3) Date test is being performed.
- (4) Optical source wavelength, spectral width, and for multimode, the coupled power ratio (CPR).
- (5) Fiber identification.
- (6) End point locations.
- (7) Test direction.
- (8) Reference power measurement (when not using a power meter with a Relative Power Measurement Mode).
- (9) Measured attenuation of the link segment.
- (19) Acceptable link attenuation.

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REVISION OF SECTION 614 TEST FIBER OPTIC CABLE

The minor attenuation differences due to test direction are on par with the accuracy and repeatability of the test method. Lateral segments within a building are limited to 90 meters. Therefore, attenuation differences caused by wavelength are insignificant, and as a result, single wavelength testing is sufficient.

D) Acceptable Attenuation Values. Acceptable attenuation values shall be calculated for each fiber tested. These values represent the maximum acceptable test values.

1) Multimode Fiber. The general attenuation equation for any multimode link segment is as follows:

$$\text{Acceptable Link Attn.} = \text{Cable Attn.} + \text{Connection Attn.} + \text{Splice Attn.} + \text{CPR Adj.}$$

62.5 μm Multi-mode Attenuation Coefficients:

$$\text{Cable Attn.} = \text{Cable Length (km)} \times (3.40 \text{ dB/km@850 nm or } 1.00 \text{ dB/km@1300 nm})$$

$$\text{Connection Attn. (ST or SC connectors)} = (\text{No. of Connections} \times 0.39 \text{ dB}) + 0.42 \text{ dB.}$$

$$\text{Connection Attn. (LC connectors)} = (\text{No. of Connections} \times 0.14 \text{ dB}) + 0.24 \text{ dB.}$$

$$\text{Splice Attn. (Mechanical or Fusion)} = \text{Splices} \times 0.30 \text{ dB.}$$

$$\text{CPR Adj.} = \text{See table below.}$$

A connection is defined as the joint made by mating two fibers terminated with re-mateable connectors (e.g. ST, SC, LC).

<i>Multi-mode Light Source CPR Adjustment</i>					
	Cat. 1 Overfilled	Cat. 2	Cat. 3	Cat. 4	Cat. 5 Underfilled
Links with ST or SC Connections	+0.50	0.00	-0.25	-0.50	-0.75
Links with LC Connections	+0.25	0.00	-0.10	-0.20	-0.30

The Coupled Power Ratio of a light source is a measure of the modal power distribution launched into a multimode fiber. A light source that launches a higher percentage of its power into the higher order modes of a multimode fiber produces a more over-filled condition and is classified as a lower category than a light source that launches more of its power into just the lower order modes producing an under-filled

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REVISION OF SECTION 614 TEST FIBER OPTIC CABLE

condition. Under-filled conditions result in lower link attenuation, while over-filled conditions produce higher attenuation. Therefore, adjusting the acceptable link attenuation equation to compensate for a light source's launch characteristics increases the accuracy of the test procedure.

- 7) Singlemode Fiber. The general attenuation equation for any Single Mode link segment is as follows:

$$\text{Acceptable Link Attn.} = \text{Cable Attn.} + \text{Connector Attn.} + \text{Splice Attn.}$$

8.3 μm Single-mode Attenuation Coefficients:

Cable Attn.=Cable Length (km) x (0.34 dB/km@1310 nm or 0.25 dB/km@1550 nm)

Connection Attn. (ST or SC connectors)=(No. of Connections x 0.39 dB)+0.42 dB.

Connection Attn. (LC connectors)=(No. of Connections x 0.14 dB)+0.24 dB.

Splice Attn. (Mechanical or Fusion)=Splices x 0.30 dB.

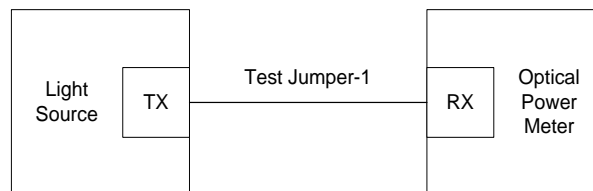
- E) Test Procedures. All fiber testing shall be performed on all fibers in the completed end-to-end system.

- (1) Multimode Fiber. The multimode fiber cable test shall be conducted as follows:

Clean the test jumper connectors and the test coupling per manufacturer's instructions.

Follow the test equipment manufacturer's initial adjustment instructions.

Connect Test Jumper-1 between the light source and the power meter. Avoid placing bends in the jumper that are less than 100 mm (4 inches) in diameter.



If the power meter has a Relative Power Measurement Mode, select it. If it does not, reduce the Reference Power Measurement (P_{ref}). If the meter can display power levels in dBm, select this unit of measurement to simplify subsequent calculations.

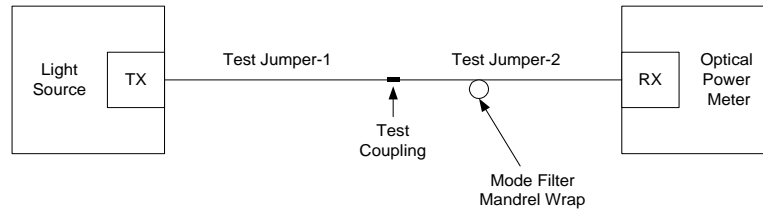
Disconnect Test Jumper-1 from the power meter. Do NOT disconnect the test jumper from the light source.

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REVISION OF SECTION 614 TEST FIBER OPTIC CABLE

Connect Test Jumper-2 between the power meter and Test Jumper-1 using the test coupling. Test Jumper-2 should include a high order mode filter. This can be accomplished by wrapping the jumper three times around a 30 mm (1.2 inches) diameter mandrel.



Record the Power Measurement (P_{sum}). If the power meter is in Relative Power Measurement Mode, the meter reading represents the CPR value. If the meter does not have a Relative Power Measurement Mode, perform the following calculation:

If P_{sum} and P_{ref} are in the same logarithmic units (dBm, dBu, etc.):

$$CPR (dB) = P_{sum} - P_{ref}$$

If P_{sum} and P_{ref} are in watts:

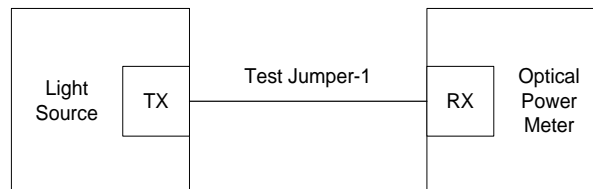
$$CPR (dB) = 10 \times \log_{10} [P_{sum}/P_{ref}]$$

- (2) Single Mode Fiber. The Single Mode Optical Power Meter fiber test shall be conducted as follows:

Clean the test jumper connectors and the test coupling per manufacturer's instructions.

Follow the test equipment manufacturer's initial adjustment instructions.

Connect Test Jumper-1 between the light source and the power meter. Avoid placing bends in the jumper that are less than 100 mm (4 inches) in diameter.



If the power meter has a Relative Power Measurement Mode, select it. If it does not, reduce the Reference Power Measurement (P_{ref}). If the meter can display power levels in dBm, select this unit of measurement to simplify subsequent calculations.

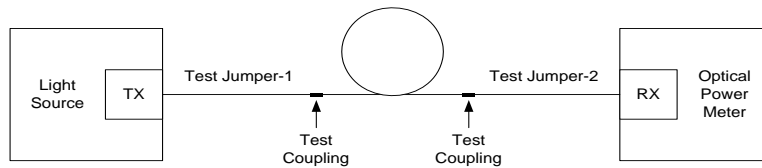
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REVISION OF SECTION 614 TEST FIBER OPTIC CABLE

Disconnect Test Jumper-1 from the power meter. Do NOT disconnect the test jumper from the light source.

Attach Test Jumper-1 to one end of the cable plant to be measured and Test Jumper-2 to the other end.



Record the Power Measurement (P_{sum}). If the power meter is in Relative Power Measurement Mode, the meter reading represents the true value. If the meter does not have a Relative Power Measurement Mode, perform the following calculation:

If P_{sum} and P_{ref} are in the same logarithmic units (dBm, dBu, etc.):

$$CPR (dB) = P_{sum} - P_{ref}$$

If P_{sum} and P_{ref} are in watts:

$$CPR (dB) = 10 \times \log_{10} [O_{sum}/P_{ref}]$$

- F) Test Acceptance. The Contractor shall demonstrate that each Optical Power Test results in acceptable attenuation values.

The Contractor, solely at the Contractor's cost, shall remake any fusion splices that have test results exceeding acceptable attenuation values.

The Contractor, solely at the Contractor's cost, shall retest any fiber links that have been re-spliced.

The Contractor, solely at the Contractor's cost, shall bring any link not meeting the requirements of this specification into compliance.

- G) Testing for CWDM single wavelength filters (CWDM filter) shall be conducted in the following manner to ensure that the filter Pass, Reflect and Common pigtails are spliced to proper lateral fiber strands. Testing procedures and CWDM data flow information is included in the project plan set.

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REVISION OF SECTION 614 TEST FIBER OPTIC CABLE

- a) After completion of fiber optic cable installation and prior to the CWDM filter splicing, all backbone cable to lateral cable splices shall be completed in the individual Ethernet switch sub-rings. Required steps shall include:
 - (a) Splicing of backbone end of lateral cable number 1 shall be spliced to the fiber optic backbone cable in splice canister number 1. Once this splice is complete no future access to the closure shall be made unless a re-splice is required.
 - (b) The opposite end of lateral cable number 1 shall be splice in a manner to achieve continuity in the backbone strands from the beginning of the sub-ring, (first communication node building) to the far end of the sub-ring, (next adjacent communications node building).
 - (c) An OTDR test shall be conducted on the sub-ring to ensure proper splicing of the lateral cable (cable number 1) to the individual backbone fiber strands.

Once the OTDR test is complete the results shall be submitted to the Project Engineer for approval. After review to ensure continuity, the splicing of the CWDM filters may begin.

The Contractor shall be required to break the lateral fiber optic strands used in the continuity test and conduct the actual CWDM filter splice per the project fiber splice plans. This will include splicing of both lateral fiber cable number 1 and number 2 along with the termination of lateral cable number 2 in the communications cabinet.

During the splicing at the individual CWDM Ethernet switch sites, the Contractor may use one of the following methods to ensure the proper CWDM filter splicing.

- 1) By using a fiber identifier, testing of the incoming signal from either the upstream or downstream CWDM location, the Contractor shall show the Project Engineer that proper CWDM filter pigtail splicing is being achieved.
- 2) By using a spectrum analyzer to test the incoming wavelength to ensure proper splicing and wavelength of the CWDM signal.

Once all splicing of the individual sub-ring is complete the Contractor shall conduct the CWDM-OTDR and spectrum analyzer testing and submit the results to the Project Engineer. At the acceptance of these tests, the Contractor shall determine the proper optical attenuator to install at both the communications cabinet termination panel and the communications node building termination panel. After installation one final test of optical power shall be conducted to determine if the proper signal strength is being achieved by the Ethernet switch CWDM optic.

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REVISION OF SECTION 614 TEST FIBER OPTIC CABLE

At this point the Colorado Department of Transportation, Colorado Transportation Management Center personnel along with Ciena network engineers will configure the sub-ring into the overall CDOT ITS network. If for any reason network communications cannot be achieved, a review of the CWDM materials will be begin.

G) Submittals. The Contractor shall submit test results documentation as both a hard copy and electronic copy.

After each reel test, the Contractor shall submit one (1) hard copy of the OTDR trace for every fiber on the reel.

After installation, the Contractor shall submit two (2) hard copies and one (1) electronic copy of the following tests;

- 1) Continuity OTDR trace for every spliced fiber which the CWDM optical network will utilize.
- 2) OTDR trace for every fiber the high speed DWDM optical network will utilize.
- 3) CWDM-OTDR trace for every fiber which the CWDM optical network will utilize.
- 4) Spectrum analyzer test results for every fiber which the CWDM optical network will utilize.
- 5) OTDR traces and power meter results for all “dark” unused fiber strands in the backbone fiber optic cable from communications node buildings.

Hard copy traces shall be organized and bound in logical order in an 8 ½” x 11” 3 ring hard cover binder in addition to other documentation listed in this Special Provision and other splicing documentation listed in the project Special Provision package.

The Contractor shall submit, after approval of the hard copy traces, electronic copies of all traces and appropriate software to allow reading the traces.

The Contractor shall submit one (1) copy of the complete contract plan set, including additional drawings issued as part of any change orders, revisions to the project plans during fiber optic work with any deviations clearly marked in color. Deviations to be noted and shall include but not be limited to the following:

- (1) Fiber Splice location
- (2) Fiber Splice configuration
- (3) Termination layout