SECTION 19, APPENDIX A

Project Special Provisions

REVISION OF SECTION 210
RESET CLOSED CIRCUIT TELEVISION AND WIRING

Section 210 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

This work consists of protecting and relocating the Closed Circuit Television (CCTV) camera at the locations shown on the Plans, to accommodate construction phasing.

MATERIALS

The CCTV camera shall include the camera, weatherproof dome housing, pole mount adapter, composite cable, camera transformer, attachment hardware, wiring and all other hardware, cables, and test equipment necessary for a complete installation as the camera is relocated to a temporary location. All existing materials and hardware associated with the camera and the camera mounting shall be reused in the process of relocation. This hardware may include but is not limited to the following:

Weatherproof Dome Housing
Pole Mount Adapter
Composite Cable
Camera Transformer

All hardware associated with mounting/remounting the camera and activating the camera will not be paid for separately but will be included in the work.

CONSTRUCTION REQUIREMENTS

The CCTV camera shall be relocated 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 and relocation of the CCTV camera for each phase of work.

As illustrated in the plans, the Camera, located on the I-225 Off Ramp and Colfax Ave, will require relocation to a temporary span wire pole prior to the placement of a new camera being furnished, installed and activated as shown in the plans in the final configuration. The new camera shall be paid for separately and is not included in the reset work required for each temporary construction phase. Each of the pole locations (existing, interim and permanent) are all within 20 feet of one another. Locating and aiming the camera during each phase shall be directed by the engineer and shall be in conformance with the manufacture's recommendations. Temporary camera locations shall maintain existing line of sight. All work associated with moving the camera shall coincide with the relocation of the Fiber Optic cable which provides communication to the camera. Neither the camera nor the fiber optic line and associated fiber optic network shall be inoperable more than a total of 96 hours total during the project. This allowable downtime shall be coordinated a minimum of three days in advance of each anticipated inoperable time period with the Engineer. Durations in which the camera is not operable beyond the allowable 96 hour time period will result in an assessment of liquidated damages in the amount of $50 per day. Damages will not be assessed in hourly or pro-rated time periods, but rather will be assessed for a full 24 hour duration even if the camera is inoperable for a lesser time period. All liquidated damages will be assessed per Section 108 of the *Standard Specifications for Road and Bridge Construction* – CDOT Latest Version.

REVISION OF SECTION 210
RESET CLOSED CIRCUIT TELEVISION AND WIRING

The reset camera shall remain operable until the new, permanent camera is installed on the new mast arm pole and is operating in a manner acceptable to the Engineer. Prior to the removal of the temporary pole, the reset camera shall be removed and returned to CDOT. No additional fee shall be paid for the removal and delivery of the existing camera but shall be included in the work.

The CCTV and weatherproof dome housing shall be re-assembled per manufacture's instructions. The weatherproof dome housing shall be bolted to the pole mount adapter using the stainless steel bolts supplied with the pole mount adapter. A 1 inch hole may be drilled in the pole mount adapter to allow the composite cable to pass through after removal of burrs and sharp edges. The composite cable may be connected to the weatherproof dome housing before or after the housing is attached to the pole. In either case, the composite cable to weatherproof dome housing electrical connections shall be sealed using a non-conductive solvent resistant conformable mastic sealing tape. Composite cable strain relief shall be accomplished by attaching the composite cable to the pole mount adapter with a 0.5 inch EPDM insulated stainless steel cable clamp. One inch type 201 stainless steel strap used in conjunction with type 201 stainless steel buckles shall be used to band the camera to the pole.

A maximum 1 inch hole shall be drilled in the mounting pole to allow passage of the composite cable. The hole shall be tapped to accept a threaded compression fitting 'cable gland' that shall act as strain relief and seal for the cable entry into the pole. The composite cable shall be installed with a drip loop located between the pole mount adapter and the entry into the pole. The composite cable shall run down the interior of the pole and exit through non-metallic flexible conduit to the communication cabinet or VMS. The non-metallic flexible conduit shall be sealed on each end to eliminate exterior liquid entry.

The camera transformer shall be mounted to Contractor supplied or reused din-rail in the communications cabinet. The camera transformer input power shall be wired to a non-GFCI outlet. The camera power cable shall terminate at the camera transformer with all connections in accordance with manufacturers' recommendations and NEC guidelines. The BNC connector of the coaxial cable shall terminate on the video input of the video communication device. The contractor is responsible for any adapters needed to convert the BNC connection of the coaxial cable to the native video connection on the video communication device. The RJ-25 on the UTP cable shall plug into the RS-485 serial data port/s on the video communication device such that four wire full duplex serial communications is possible. The contractor is responsible for any adapters needed to convert the RJ-25 connection of the UTP cable to the native serial data connections on the video communication device. All camera cables terminating in the communication cabinet shall be labeled for easy identification. The camera transformer shall be mounted per manufacturer's recommendation in the location specified on the Plans.

The CCTV communication parameters shall be configured (per manufactures set-up procedure) as follows:

- Baud Rate: 19,200kbps, Data Bit: 8 bit, Parity Check: None, Stop Bit: 1
- Unit Number: configurable 1-96.
- 4-line RS-485 Communication
- Termination: Off

REVISION OF SECTION 210
RESET CLOSED CIRCUIT TELEVISION AND WIRING

The following modifications and additions to the camera configuration shall be made once the system is operational and coordinated with the engineer to insure system compatibility and operability:

- Set AFMODE: AUTO M
- Set CLEANING: ON
- Set CAM ID: ON – Program Cam ID to name designated on the Plans and position the Cam ID to the upper left corner of the video screen.
- Set AREA TITLE: ON (NESW) – Set the northerly direction for the camera and position the directional indicator in the upper left corner of the video screen, right below Cam ID.

METHOD OF MEASUREMENT

Reset closed circuit television camera shall be measured as each for the actual number of closed circuit television cameras that are relocated and accepted.

BASIS OF PAYMENT

Payment will be made under:

Pay Item	Pay Unit
Reset Closed Circuit Television and Wiring	**Each**

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

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.

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 -40º F and 175º 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 -40º F and 175º 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). 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.

-2-
REVISION OF SECTION 612
LOATION MARKERS

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.

Method of Payment

Pay Item	Pay Unit
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.

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:

FEEDS TO PULL BOX
50' NORTH & 75' WEST
THEN TO HIGHWAY SIGN

FEEDS FROM XFMR
250' SOUTH & 75' EAST
200' WEST

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.

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 ¾ inch granite-gravel shall be installed as a base for the pull box to aide in drainage. The ¾ 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 ¾ 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. 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	Pay Unit
Pull Box (24x36x24)	Each

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

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.

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.

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.

-3-

REVISION OF SECTION 613
ELECTRICAL CONDUIT

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	Pay Unit
2-Inch Electrical Conduit (Bored)	**Linear Foot**
2-Inch Electrical Conduit (Plastic)	**Linear Foot**

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 chrematistics 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 8.3µm
b) Cladding Diameter of 125.0 ± 1µm
c) Core-to-Cladding Offset: ≤ 0.5 µm
d) Cladding Non-Circularity: ≤ 1 %
e) Coating Diameter (Colored): 245 ± 10 µm.
f) Maximum Attenuation (Loose Tube): 0.35 dB//km at 1310 nm wavelength and 0.22 dB/km at 1550 nm wavelength

REVISION OF SECTION 614
FIBER OPTIC CABLE (Single Mode)

g) Mode-Field Diameter: 9.20 ± 0.30 µm at 1310 nm wavelength and 10.40 ± 0.50 µm at 1550 nm wavelength

h) Attenuation at the Water Peak: 0.32 to 0.34 dB/km at 1383 ± 3 nm wavelength

i) Cutoff Wavelength: 1260 nm.

j) Zero Dispersion Wavelength: 1300nm to 1322 nm

k) Zero Dispersion Slope: 0.090 ps / (nm^2 • km)

l) Polarization Mode Dispersion: 0.06 ps/ $\sqrt{}_{km}$

m) Maximum Polarization Mode Dispersion at 0.01% distribution (PMDq): 0.20 ps/$\sqrt{}_{km}$

n) Maximum Fiber Dispersion: 3.5 ps/(nm • km) for 1285 nm through 1330 nm and shall be < 18 ps/(nm • km) at 1550 nm.

o) Fiber Curl: ≥ 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.

(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.

-3-

REVISION OF SECTION 614
FIBER OPTIC CABLE (Single Mode)

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.

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)
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.

-5-

REVISION OF SECTION 614
FIBER OPTIC CABLE (Single Mode)

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.

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.

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.

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.

-7-

REVISION OF SECTION 614
FIBER OPTIC CABLE (Single Mode)

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

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	Pay Unit
Fiber Optic Cable (Single-Mode) (12 Strands)	**Linear Foot**
Fiber Optic Cable (Single-Mode) (96 Strands)	**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.

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 traffic signal cabinets, ramp metering cabinets and automated traffic recorder station cabinets for connection of optical devices from the termination panel to the optical device. Patch cables for these devices shall also be installed in the Colorado Transportation Management Center.

At the Ethernet Router locations, course wavelength division multiplexor (CWDM) shall be used and shall require bend intensive fiber optic pre-connectorized patch cables. Bend intensive (optimized) pre-connectorized patch cable shall also be required for CWDM optical connections at the Colorado Transportation Management Center. Ethernet Router location

MATERIALS

The pre-connectorized cables for traffic signal cabinets, ramp metering cabinets and automated traffic recorder stations shall be jacketed for extra protection and shall be provided with pre-connectorized connectors on both ends to match the optical connectors to which they connect. Connectors shall be pre-terminated by the manufacturer with a convex physical contact (PC) polish on the ferrule end to reduce reflection.

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 14º F to 140º F (-10ºC to +60ºC). The manufacturer shall have a program that periodically tests connectors to ensure than after 1000 re-matings, the attenuation will not change more than 0.2 dB.

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 pre-connectorized cables for CWDM optics modules shall be jacketed for extra protection and shall be provided with pre-connectorized connectors on both ends to match the optical connectors to which they connect. Connectors shall be pre-terminated by the manufacturer. Duplex patch cables shall be installed in all field cabinets for connection from the patch panel to the CWDM optic. In the Colorado Transportation Management Center Data Center, simplex patch cables shall be installed for connection from the 8-Channel Course Wavelength Division Multiplexing LGX Module port to the CISCO Ethernet Router optics. The bend intensive (optimized) cable shall be used to enable tight bend radii and routing to help alleviate data loss.

Single mode fiber optic cables for installation in field cabinets shall be made with bend insensitive fiber satisfying International Telecommunication Union (ITU) G.657 category A1 recommendations. The cable shall have a ‘tactical’ polyurethane jacket to resist bending.

-2-

REVISION OF SECTION 614
FIBER OPTIC PRE-CONNECTORIZED CABLE

The bend intensive (optimized) patch cable shall have the following requirements for simplex cables;

- Yellow PVC Jacket Material
- Nominal Dimension: 2.95 mm
- Weight: 16 Lbs./KM
- Pull Load (N): 1332 (Install) / 1066 (Operate)
- Bend Radius: 10mm (1 Turn)
- Core Size: 9/125
- Attenuation: 0.50 dB/Km at 1550nm (Maximun)
- Link Lengths at 1550nm: 10,000 Mtr (For 1GB/s) – 5,000 Mtr (For 10 GB/s)

The bend intensive (optimized) patch cable shall have the following requirements for duplex cables;

- Yellow PVC Jacket Material
- Noninal Dimension: 2.95 mm x 5.8 mm
- Weight: 32 Lbs./KM
- Pull Load (N): 2664 (Install) / 2132 (Operate)
- Bend Radius: 10mm (1 Turn)
- Core Size: 9/125
- Attenuation: 0.50 dB/Km at 1550nm (Maximun)
- Link Lengths at 1550nm: 10,000 Mtr (For 1GB/s) – 5,000 Mtr (For 10 GB/s)

The bend intensive (optimized) pre-connectorized patch cable shall meet the following specifications:

Patch Cable Connectors

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

Cable

Telcordia GR-409

All connectors shall have ceramic ferrules.

The cables shall contain the exact number of loose tube fibers and connectors to connect the optical equipment. If the optical equipment transmits and receives data on a single fiber, the pre-connectorized cable shall contain only a single fiber, (simplex). When the optical device transmits and received data on two or four fibers, a pre-

connectorized cable shall be provided with 2 (two) fibers per cable, (duplex), for each bulkhead pair, (transmit and receive).

-3-

REVISION OF SECTION 614
FIBER OPTIC PRE-CONNECTORIZED CABLE

Single mode fiber optic cables for installation in field cabinets shall be made with bend insensitive fiber satisfying International Telecommunication Union (ITU) G.657 category A1 recommendations. The cable shall have a 'tactical' polyurethane jacket to resist bending.

CONSTRUCTION REQUIREMENTS

Connectors shall be compatible with both the connectors on the optical devices and the termination patch panel bulkhead panels.

At the CTMC, the pre-connectorized cables shall be installed in the cable management hardware in the equipment racks. The Contractor shall provide patch cables of sufficient length to span from the fiber

patch panel to the optical network device. This length shall include a maximum of 4 feet of slack cable. Appropriate cable management shall be used while installing cables.

Prior to installation, all pre-connectorized cable bulkhead connectors shall be cleaned with lint-fee 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 the all residue is removed from the bulkhead surface.

Any manufacturer testing reports showing db loss for both Side A and Side B of the pre-connectorized cables shall be submitted as part of the as-built documentation. Installation location shall be noted on the test report for future reference.

At the CTMC cables shall have identification labels at each end indicating patch panel number, field device and field device location.

At all field device locations, each cable shall have individual labels indicating the devices, lateral fiber color 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……..	3 Feet – 0 Inch maximum
CTMC ……	Cable shall be of sufficient length to accommodate connection of each individual optical device to the equipment rack termination panel while allowing for appropriate slack.

-4-

REVISION OF SECTION 614
FIBER OPTIC PRE-CONNECTORIZED CABLE

METHOD OF MEASUREMENT

Fiber optic pre-connectorized cables and labeling will not be measured or paid for separately but will be considered subsidiary to the individual optical device item and shall include all labor, materials and equipment required to complete the work. Also included shall be all information labeling in the field device cabinet termination panels.

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.

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.

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.

1
REVISION OF SECTION 614
FIBER OPTIC TERMINATION PANEL

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. 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.

2
REVISION OF SECTION 614
FIBER OPTIC TERMINATION PANEL

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.

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

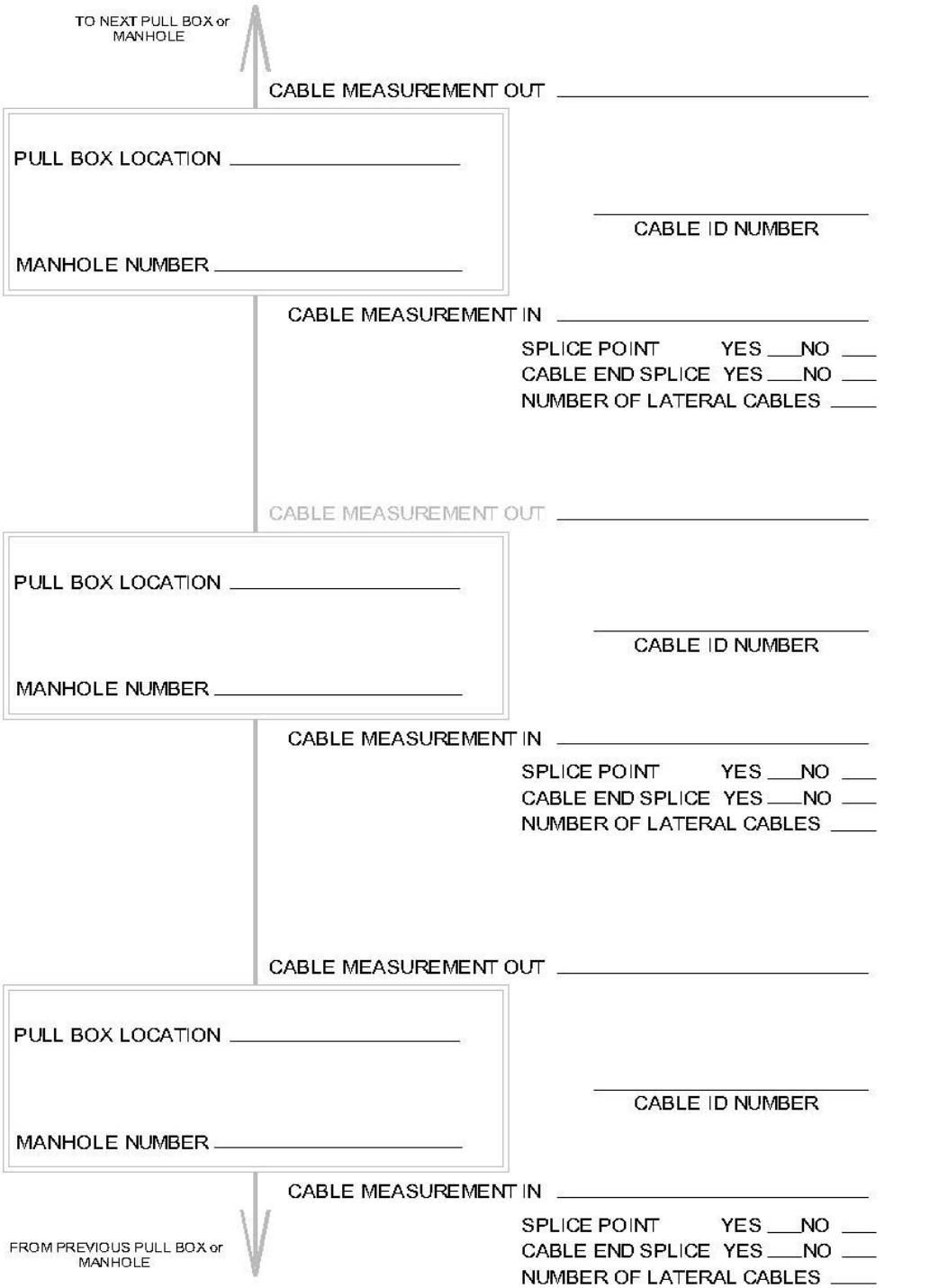
As part of the as-built documentation, any revised fiber optic splices shall also be provided as marked up copies of the original splice diagrams. If changes are made during the splicing procedures, those changes shall be documented by the Contractor and submitted to the Project Engineer as final as-built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

REVISION OF SECTION 614

FIBER OPTIC CABLE AS-INSTALLED DOCUMENTATION SHEET



FIBER OPTIC CABLE AS-BUILT DOCUMENTATION

REVISION OF SECTION 614
TEST FIBER OPTIC CABLE

Section 614 of the Standard specifications is hereby revised for this project as follows:

Subsection 614.01 shall include the following:

Test fiber optic cable shall include an OTDR on reel test and on all fiber optic cable strands install 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 regeneration node buildings.

Contractor shall use the Optical Spectrum Analyzer purchased as part of this project to test all course wavelength division multiplexing wavelengths (CWDM). Testing shall be conducted for all CWDM optics at the Colorado Transportation Management Center (CTMC) to individual field Ethernet field Routeres and from the field Routeres to the CTMC. This testing shall commence after all fiber optic cable is tested as stated in this specification.

Bidirectional wavelengths shall be tested at all optics to ensure the proper wavelength is being dropped at the Ethernet Routeres and in turn sent to the CTMC.

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

If required, CTMC personnel will aid in this testing.

Subsection 614.08 shall include the following:

(r) 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

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.

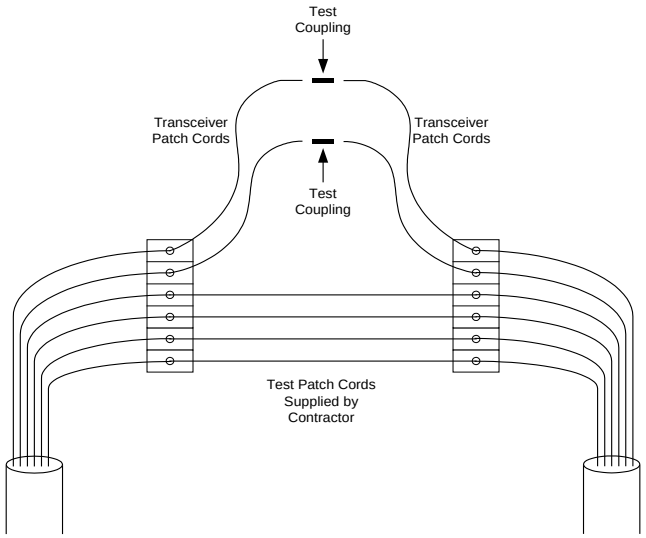
B) Optical Fiber Cable Testing with OTDR. The Contractor shall perform an OTDR test of all fibers in all tubes on the reel prior to installation of the fiber. The test results shall be supplied to the Engineer prior to installation of the cable.

If the fiber is specified as "Install Only", the Contractor shall test the fiber on the reel and provide the test results to the Engineer prior to accepting the cable. After installation, if there are unused portions of cable remaining on the reel, the Engineer may request the Contractor or other qualified technician to perform a reel test. The Contractor shall provide the Engineer the test results prior to delivering the cable to the 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.

-3-

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:

(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.

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:

Acceptable Link Attn.=Cable Attn.+Connection Attn.+Splice Attn.+CPR Adj.

62.5 μm Multi-mode Attenuation Coefficients:

Cable Attn.=Cable Length (km) x (3.40 dB/km@850 nm or 1.00 dB/km@1300 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.

-5-
REVISION OF SECTION 614
TEST FIBER OPTIC CABLE

CPR Adj.=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).

Multi-mode Light Source CPR Adjustment					
	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 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:

Acceptable Link Attn. = Cable Attn. + Connector Attn. + 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.

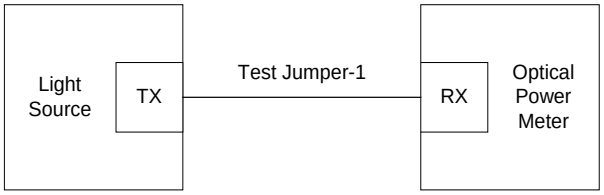
E) Test Procedures. All fiber testing shall be performed on all fibers in the completed end-to-end system.

(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.

REVISION OF SECTION 614
TEST FIBER OPTIC CABLE

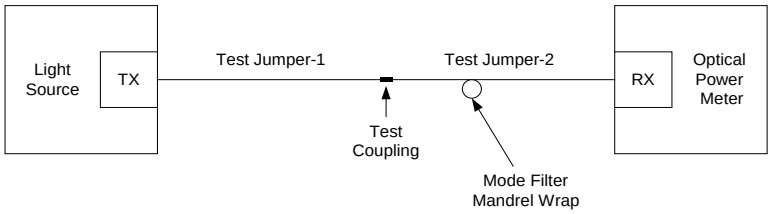
Connect Test Jumper-1 between the light source and the power meter. Avoid placing bends in the jumper that are less than 100 mm (4 inches) in diameter.



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.

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.



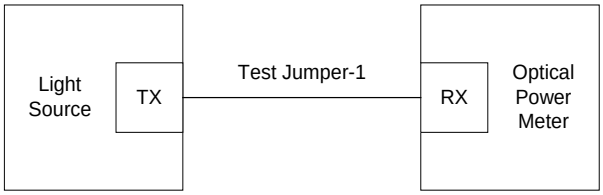
Record the Power Measurement (P_{sum}). If the power meter is in Relative Power Measurement Mode, the meter reading represents the CPR value. If the meter does not have a Relative Power Measurement Mode, perform the following calculation:

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 x $\log_{10}$ [O_{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.

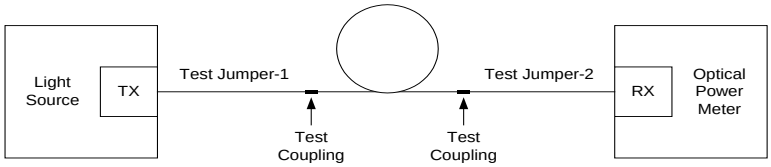
Connect Test Jumper-1 between the light source and the power meter. Avoid placing bends in the jumper that are less than 100 mm (4 inches) in diameter.



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.

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 x $\log_{10}$ [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.

REVISION OF SECTION 614
TEST FIBER OPTIC CABLE

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 four (4) hard copies of the OTDR trace for every fiber on the reel. After installation, the Contractor shall submit four (4) hard copies of the OTDR trace for every spliced fiber. 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 four (4) copies of all Optical Power Test results.

The Contractor shall submit four (4) copies of the complete contract Plans, 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

Subsection 614.13 shall include the following:

Test Fiber Optic Cable will be measured by on reel testing of all fiber strands complete end-to-end OTDR tests and power meter tests on the fiber, including labor, materials, document submission necessary to complete the work.

Subsection 614.14 shall include the following:

Test Fiber Optic Cable will not be paid for separately, but shall be included in the cost of Item 614 – Fiber Optic Cable (Single Mode).