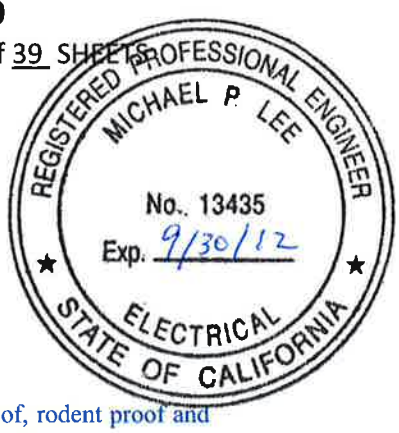
STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

CONTRACT CHANGE ORDER NO. 81 SUPPL. NO. 00

ROAD: 04-SF-80-13.2, 13.9 CONTRACT NO. 04-0120F4 SHEET 1 of 39 SHEETS



9/30/11

Section 10-3.09 PULL BOXES, SPLICE BOXES AND JUNCTION BOXES

Revise all under Subheading FIBER OPTIC SPLICE CLOSURE to read as follows:

Fiber optic cable field splices shall be enclosed in splice closures which shall be waterproof, rodent proof and re-enterable. The fiber optic splice closure shall be suitable for a temperature range of 0 °C to 50 °C.

The fiber optic splice closure shall consist of an outer closure, an inner closure and complete with splice organizer trays, brackets, plugs, clips, cable ties and sealants as needed and shall conform to the following special provisions.

The size of the closure shall allow all the fibers of the largest fiber optic trunk cable or buffer tube to be spliced to a second cable or buffer tube of the same size, plus fibers from fiber optic pigtail cable. The closure shall be not more than 914 mm in length and not more than 200 mm in diameter.

All materials in the closures shall be nonreactive and shall not support galvanic cell action. The outer-closure shall be compatible with the other closure components, the inner closure, splice trays, and cables.

The end plate shall consist of two sections and shall have capacity for two fiber optic trunk cables and fiber optic branch cables.

The outer-closure shall protect the splices from mechanical damage, shall provide strain relief for the cable, and shall be resistant to salt corrosion.

The outer-closure shall be waterproof, re-enterable and shall be sealed with a gasket. The outer-closure shall be flash-tested at 103 kPa.

The inner-closure shall be of metallic construction. The inner-closure shall be compatible with the outer closure and the splice trays and shall allow access to and removal of individual splice trays. The splice trays shall be compatible with the inner closure and shall be constructed of rigid plastic or metal.

Adequate splice trays shall be provided to splice all fibers of the largest communication cable or buffer tube plus FPC in the splice cabinet.

Vinyl markers shall be used to identify each spliced fiber in the trays as described under "Fiber Optic Cable Labeling" elsewhere in these special provisions.

Each splice shall be individually mounted and mechanically protected in the splice tray.

The Contractor shall install the fiber splice enclosure in the splice vault or cabinet as shown on the plans where splicing is required. The Contractor shall provide all mounting hardware required to securely mount the fiber optic splice enclosures to the splice vault or cabinet.

The fiber splice enclosure shall be mounted as shown on the plans in a manner that allows the cables to enter at the end of the enclosure. Not less than 9 meters of each cable (2 or 3) shall be coiled in the splice vault or cabinet to allow the fiber splice enclosure to be removed for future splicing.

The unprotected fibers exposed for splicing within the enclosure shall be protected from mechanical damage using the fiber support tube or tubes and shall be secured within the fiber splice enclosure.

Upon completion of the splices, the splice trays shall be secured to the inner closure.

The closure shall be sealed using a procedure recommended by the manufacturer that will provide a waterproof environment for the splices. Encapsulant shall be injected between the inner and outer closures.

Care shall be taken at the cable entry points to ensure a tight salt resistant and waterproof seal is made which will not leak upon aging. It is not acceptable to have multiple cables enter the fiber splice closure through one hole.

Sestion 10-3.10 CONDUCTORS, CABLES AND WIRING

Revise all under Section 10-3.10, Subheading FIBER OPTIC OUTSIDE PLANT CABLE to read as follows:

FIBER OPTIC GLOSSARY

Breakout.--The cable "breakout" is produced by (1) removing the jacket just beyond the last tie-wrap point, (2) exposing 900 mm to 1800 mm of the cable buffers, aramid strength yarn and central fiberglass strength member, and (3) cutting aramid yarn, central strength member and the buffer tubes to expose the individual glass fibers for splicing or connection to the appropriate device.

Connector.--A mechanical device used to align and join two fibers together to provide a means for attaching to and decoupling from a transmitter, receiver, or another fiber (i.e., patch panel).

Connectorized.--A term that describes the termination point of a fiber after connectors have been affixed.

Connector Module Housing (CMH).--A patch panel used in the FDU to terminate singlemode fibers with most common connector types. It may include a jumper storage shelf and a hinged door.

Couplers.--Couplers are devices which mate two fiber optic connectors to facilitate the transition of optical light signals from one connector into another. Couplers may also be referred to as: adapters, feed-throughs, and barrels. They are normally located within FDUs mounted in panels. They may also be used unmounted, to join two simplex fiber runs.

End-to-End Loss —The maximum permissible end-to-end system attenuation is the total loss in a given link. This loss could be the actual measured loss, or calculated using typical (or specified) values. A designer should use typical values to calculate the end-to-end loss for a proposed link. This number will determine the amount of optical power (in dB) needed to meet the System Performance Margin.

Fan Out Termination —Permits the branching of fibers contained in an optical cable into individual cables and can be done at field locations; thus, allowing the cables to be connectorized or terminated per system requirements. A kit provides pull-out protection for individual bare fibers to support termination. It provides three layers of protection consisting of a Teflon inner tube, a dielectric strength member, and an outer protective PVC jacket.

FBC.--Fiber Backbone Cable.

Fiber Distribution Unit (FDU).--A rack mountable enclosure containing both a Connector Module Housing (CMH) and a Splice Module Housing (SMH).

Fiber Storage Enclosure (FSE).--Designed for holding excess cable slack for protection. The FSE allows the user flexibility in equipment location and the ability to pull cable back for resplicing.

F/O.--Fiber optic.

FOIP.--Fiber optic inside plant cable.

FOOP.--Fiber optic outside plant cable.

FOTP.--Fiber optic test procedure(s) as defined by EIA/TIA standards.

FPC.--Fiber Pigtail Cable

FTC.--Fiber Trunkline Cable

Light Source.--A portable fiber optic test equipment that, inconjunction with a power meter, is used to perform end-to-end attenuation testing. It contains a stabilized light source operating at the designed wavelength of the system under test. It also couples light from the source into the fiber to be received at the far end by the receiver.

Link.--A passive section of the system, the ends of which are connectorized. A link may include splices and couplers. For example, a video data link may be from video F/O transmitter to video F/O receiver.

Link Loss Budget.--A calculation of the overall permissible attenuation from the fiber optic transmitter (source) to the fiber optic receiver (detector).

Loose Tube Cable.--Type of cable construction in which fibers are placed in buffer tubes to isolate them from outside forces (stress). A flooding compound or material is applied to the interstitial cable core to prevent water migration and penetration. This type of cable is primarily for outdoor applications.

Mid-span Access Method —Description of a procedure in which fibers from a single buffer tube are accessed and spliced to an adjoining cable without cutting the unused fibers in the buffer tube, or disturbing the remaining buffer tubes in the cable.

MMFO —Multimode Fiber Optic Cable.

Optical Time Domain Reflectometer (OTDR).--A fiber optic test equipment (similar in appearance to an oscilloscope) that is used to measure the total amount of power loss between two points and over the corresponding distance. It provides a visual and printed display of the relative location of system components such as fiber sections, splices and connectors as well as the losses that are attributed to each component and or defects in the fiber.

Patch cord.--A short jumper used to join two Connector Module Housing (CMH) couplers, and or a CMH and an active optical electronic device.

Pigtail.--Relatively short length of fiber optic cable that is connectorized on only one end. All pigtails shall be tight buffer cable.

Power Meter.--A portable fiber optic test equipment that, when coupled with a light source, is used to perform end-to-end attenuation testing. It contains a detector that is sensitive to light at the designed wavelength of the system under test. Its display indicates the amount of power injected by the light source that arrives at the receiving end of the link.

Segment.--A section of fiber optic cable that is not connected to any active device and may or may not have splices per the design.

SMFO.—Singlemode Fiber Optic Cable.

Splice.--The permanent joining of fiber ends to identical or similar fibers.

Splice Enclosure.--An environmentally sealed container used to organize and protect splice trays. The container allows splitting or routing of fiber cables from and to multiple locations.

Splice Module Housing (SMH).--Stores splice trays as well as pigtails and short cable lengths.

Splice Tray.--A container used to organize and protect spliced fibers.

Splice Vault.—An underground container used to house excess cable and splice enclosures.

System Performance Margin.—A calculation of the overall "End to End" permissible attenuation from the fiber optic transmitter (source) to the fiber optic receiver (detector). The system performance margin should be at least 6 dB. This includes the difference between the active component link loss budget, the passive cable attenuation (total fiber loss) and the total connector/splice loss.

Tight Buffer Cable.--Type of non-breakout cable construction where each glass fiber is tightly buffered (directly coated) with a protective thermoplastic coating to 900 µm with the exception of the protective thermoplastic coating. The tight buffer cable shall meet all the characteristics of the fiber in the fiber optic outside plant cable specified elsewhere in these specifications.

FIBER OPTIC CABLE

GENERAL.--Each fiber optic cable for this project shall be all dielectric, gel filled, duct type, with loose buffer tubes construction with a maximum outside diameter of 14 mm and shall conform to these special provisions. Cables shall contain singlemode (SM) dual-window (1310 nm and 1550 nm) fibers with the numbers described below and as shown on the plans:

Type A	Fiber trunkline cable (FTC)	72 SM fibers
Type B	Fiber pigtail cable (FPC)	12 SM fibers

The optical fibers shall be contained within loose buffer tubes. The loose buffer tubes shall be stranded around an all dielectric central member. Aramid yarn shall be used as a primary strength member, and a polyethylene outside jacket shall provide for overall protection.

All F/O cable of each specific type shall be from the same manufacturer, who is regularly engaged in the production of this material.

The cable shall be qualified as compliant with Chapter XV11, Title 7, Part 1755.900 of the Code of Federal Regulations, "REA Specification for Filled Fiber Optic Cables"

FIBER CHARACTERISTICS.--Each optical fiber shall be made of glass and consists of a doped silica core surrounded by concentric silica cladding. All fibers in the buffer tube shall be usable fibers, and shall be sufficiently free of surface imperfections and inclusions to meet the optical, mechanical, and environmental requirements of these specifications. The required fiber grade shall reflect the maximum individual fiber attenuation, to guarantee the required performance of each and every fiber in the cable.

The coating shall be a dual layered, UV cured acrylate and shall be mechanically strippable without damaging the fiber.

The cable shall comply with the optical and mechanical requirements over an operating temperature range of -40 °C to +70 °C. The cable shall be tested in accordance with EIA-455-3A (FOTP-3), "Procedure to Measure Temperature Cycling Effects on Optical Fiber, Optical Cable, and Other Passive Fiber Optic Components." The change in attenuation at extreme operational temperatures (-40 °C to +70 °C) for singlemode fiber shall not be greater than 0.20 dB/km, with 80 percent of the measured values no greater than 0.10 dB/km. The singlemode fiber measurement is made at 1550 nm.

For all fibers the attenuation specification shall be a maximum attenuation for each fiber over the entire operating temperature range of the cable.

Singlemode fibers within the finished cable shall meet the requirements in the following table:

Parameters	Characteristic
Type	Step Index
Core diameter	8.3 µm (nominal)
Cladding diameter	125 µm ±1.0 µm
Core to Cladding Offset	≤1.0 µm
Coating Diameter	250 µm ±15 µm
Cladding Non-circularity defined as: [1-(min. cladding dia ÷max. cladding dia.)]x100	≤2.0%
Proof/Tensile Test	345 MPa, min.
Attenuation: @1310 nm @1550 nm	 ≤0.4 dB/km ≤0.4 dB/km
Attenuation at the Water Peak	≤2.1 dB/km @ 1383 ±3 nm
Bandwidth: @ 850 nm @1310 nm (SM)	 N/A N/A
Chromatic Dispersion: Zero Dispersion Wavelength Zero Dispersion Slope	 1301.5 to 1321.5 nm ≤0.092 ps/(nm^2∗km)
Maximum Dispersion:	≤3.3 ps/(nm∗km) for 1285 - 1330 nm <18 ps/(nm∗km) for 1550 nm
Cut-Off Wavelength	<1250 nm
Mode Field Diameter (Petermann II)	9.3 ±0.5 µm at 1300 nm 10.5 ±1.0 µm at 1550 nm

COLOR CODING.--In buffer tubes containing multiple fibers, each fiber shall be distinguishable from others in the same tube by means of color coding according to the following:

1. Blue (BL)	7. Red (RD)
2. Orange (OR)	8. Black (BK)
3. Green (GR)	9. Yellow (YL)
4. Brown (BR)	10. Violet (VL)
5. Slate (SL)	11. Rose (RS)
6. White (WT)	12. Aqua (AQ)

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

1. Blue (BL)
2. Orange (OR)
3. Green (GR)
4. Brown (BR)
5. Slate (SL)

6. White (WT)

The colors shall be targeted in accordance with the Munsell color shades and shall meet EIA/TIA-598 "Color Coding of Fiber Optic Cables."

The color formulation shall be compatible with the fiber coating and the buffer tube filling compound, and be heat stable. It shall not fade or smear or be susceptible to migration and it shall not affect the transmission characteristics of the optical fibers and shall not cause fibers to stick together.

CABLE CONSTRUCTION.--The fiber optic cable shall consist of, but not be limited to, the following components:

1. Buffer tubes
2. Central member
3. Filler rods
4. Stranding
5. Core and cable flooding
6. Tensile strength member
7. Ripcord
8. Outer jacket

Buffer tubes.--Clearance shall be provided in the loose buffer tubes between the fibers and the inside of the tube to allow for expansion without constraining the fiber. The fibers shall be loose or suspended within the tubes. The fibers shall not adhere to the inside of the buffer tube. Each buffer tube shall contain up to 12 fibers.

The loose buffer tubes shall be extruded from a material having a coefficient of friction sufficiently low to allow free movement of the fibers. The material shall be tough and abrasion resistant to provide mechanical and environmental protection of the fibers, yet designed to permit safe intentional "scoring" and breakout, without damaging or degrading the internal fibers.

Buffer tube shall contain a water-swellable yarn or a homogeneous hydrocarbon-based gel with anti-oxidant additives for water migration resistance. The filling compound shall be non-toxic and dermatologically safe to exposed skin. It shall be chemically and mechanically compatible with all cable components, non-nutritive to fungus, non-hygroscopic and electrically non-conductive. The filling compound shall be free from dirt and foreign matter and shall be readily removable with conventional nontoxic solvents.

Buffer tubes shall be stranded around a central member by a method that will prevent stress on the fibers when the cable jacket is placed under strain, such as the reverse oscillation stranding process.

Central Member.--The central member which functions as an anti-buckling element shall be a glass reinforced plastic rod with similar expansion and contraction characteristics as the optical fibers and buffer tubes. A linear overcoat of Low Density Polyethylene shall be applied to the central member to achieve the optimum diameter to provide the proper spacing between buffer tubes during stranding.

Filler rods.--Filler rods may be included in the cable to maintain the symmetry of the cable cross-section. Filler rods shall be solid medium or high density polyethylene. The diameter of filler rods shall be the same as the outer diameter of the buffer tubes.

Stranding.--Completed buffer tubes shall be stranded around the overcoated central member using stranding methods, lay lengths and positioning such that the cable shall meet mechanical, environmental and performance specifications. A polyester binding shall be applied over the stranded buffer tubes to hold them in place. Binders shall be applied using tension sufficient 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.

Core and Cable Flooding.--The cable core interstices shall be filled with a polyolefin based compound to prevent water ingress and migration. The flooding compound shall be homogeneous, non-hygroscopic, electrically

non-conductive, and non-nutritive to fungus. The compound shall also be nontoxic, dermatologically safe and compatible with all other cable components.

Tensile Strength Member.--Tensile strength shall be provided by high tensile strength aramid yarns or fiberglass which shall be helically stranded evenly around the cable core and shall not adhere to other cable components.

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

Outer jacket.--The jacket shall be free of holes, splits, and blisters and shall be medium or high density polyethylene (PE), or medium density cross-linked polyethylene with minimum nominal jacket thickness of 1 mm ±76 µm. Jacketing material shall be applied directly over the tensile strength members and flooding compound and shall not adhere to the aramid strength material. The polyethylene shall contain carbon black to provide ultraviolet light protection and shall not promote the growth of fungus.

The jacket or sheath shall be marked with the manufacturer's name, the words "Optical Cable", the number of fibers, "SM", year of manufacture, and sequential measurement markings every meter. The actual length of the cable shall be within -0/+1 percent of the length marking. The marking shall be in a contrasting color to the cable jacket. The height of the marking shall be approximately 2.5 mm.

GENERAL CABLE PERFORMANCE SPECIFICATIONS.--The F/O cable shall withstand water penetration when tested with a 900 mm static head or equivalent continuous pressure applied at one end of a 900 mm length of filled cable for one hour. No water shall leak through the open cable end. Testing shall be done in accordance with EIA-455-82 (FOTP-82), "Fluid Penetration Test for Fluid-Blocked Fiber Optic Cable."

A representative sample of cable shall be tested in accordance with EIA-455-81A, "Compound Flow (Drip) Test for Filled Fiber Optic Cable." The test sample shall be prepared in accordance with Method A. The cable shall exhibit no flow (drip or leak) at 80 °C as defined in the test method.

Crush resistance of the finished F/O cables shall be 17.8 kg/m applied uniformly over the length of the cable without showing evidence of cracking or splitting when tested in accordance with EIA-455-41 (FOTP-41) "Compressive Loading Resistance of Fiber Optic Cables." The average increase in attenuation for the fibers shall be ≤0.10 dB at 1550 nm for a cable subjected to this load. The cable shall not exhibit any measurable increase in attenuation after removal of load. Testing shall be in accordance with EIA-455-41 (FOTP-41), except that the load shall be applied at the rate of 3 mm to 19 mm per minute and maintained for 10 minutes.

The cable shall withstand 25 cycles of mechanical flexing at a rate of 30 ±1 cycles/minute. The average increase in attenuation for the fibers shall be ≤0.20 dB at 1550 nm at the completion of the test. Outer cable jacket cracking or splitting observed under 5x magnification shall constitute failure. The test shall be conducted in accordance with EIA-455-104 (FOTP-104), "Fiber Optic Cable Cyclic Flexing Test," with the sheave diameter a maximum of 20 times the outside diameter of the cable. The cable shall be tested in accordance with Test Conditions I and II of (FOTP-104).

Impact testing shall be conducted in accordance with EIA-455-25 (FOTP-25) "Impact Testing of Fiber Optic Cables and Cable Assemblies." The cable shall withstand 20 impact cycles. The average increase in attenuation for the fibers shall be ≤0.20 dB at 1550 nm. The cable jacket shall not exhibit evidence of cracking or splitting.

The finished cable shall withstand a tensile load of 2669 N without exhibiting an average increase in attenuation of greater than 0.20 dB. The test shall be conducted in accordance with EIA-455-33 (FOTP-33), "Fiber Optic Cable Tensile Loading and Bending Test." The load shall be applied for one-half hour in Test Condition II of the EIA-455-33 (FOTP-33) procedure.

PACKAGING AND SHIPPING REQUIREMENTS.--Documentation of compliance to the required specifications shall be provided to the Engineer prior to ordering the material.

Attention is directed to "Fiber Optic Testing," elsewhere in these special provisions.

The completed cable shall be packaged for shipment on reels. The cable shall be wrapped in a weather and temperature resistant covering. Both ends of the cable shall be sealed to prevent the ingress of moisture.

Each end of the cable shall be securely fastened to the reel to prevent the cable from coming loose during transit. Two meters of cable length on each end of the cable shall be accessible for testing.

Each cable reel shall have a durable weatherproof label or tag showing the manufacturer's name, the cable type, the actual length of cable on the reel, the Contractor's name, the contract number, and the reel number. A shipping record shall be provided to the Engineer in a weatherproof envelope showing the above information and also include the date of manufacture, cable characteristics (size, attenuation, bandwidth, etc.), factory test results, cable identification number and any other pertinent information.

The minimum hub diameter of the reel shall be at least thirty times the diameter of the cable. The F/O cable shall be in one continuous length per reel with no factory splices in the fiber. Each reel shall be marked to indicate the direction the reel should be rolled to prevent loosening of the cable.

Installation procedures and technical support information shall be furnished at the time of delivery.

FIBER CABLE INSTALLATION

Fiber optic cable shall be installed in conduit system or cable tray system as show on the plans. Fiber optic conduit system shall consist of conduits, fiber optic pull boxes and fiber optic splice vaults or cabinets.

Installation procedures shall be in conformance with the procedures specified by the cable manufacturer for the specific cable being installed. The Contractor shall submit to the engineer the manufacturer's recommended procedures for pulling fiber optic cable at least 20 working days prior to installing cable. Mechanical aids may be used, provided that a tension measuring device is placed in tension to the end of the cable. The tension applied shall not exceed 2.2 kilonewtons or the manufacturers recommended pulling tension, whichever is less.

The F/O cable shall be installed using a cable pulling lubricant recommended by the cable manufacture and a non-abrasive pull tape conforming to the provisions described under "Conduit" elsewhere in these special provisions. Contractor's personnel shall be stationed at each pull box, vault and cabinet through which the cable is pulled to lubricate and prevent kinking or other damage.

During cable installation, the bend radius shall be maintained at not less than twenty times the outside diameter of the cable. .The cable grips for installing the fiber optic cable shall have a ball bearing swivel to prevent the cable from twisting during installation.

At the Contractor's option, the fiber cable may be installed using the air blown method. If integral innerduct is used, the duct splice points or any temporary splices of innerduct used for installation must withstand a static air pressure of 758 MPa.

The fiber installation equipment must incorporate a mechanical drive unit or pusher, which feeds cable into the pressurized innerduct to provide a sufficient push force on the cable, which is coupled with the drag force created by the high-speed airflow. The unit must be equipped with controls to regulate the flow rate of compressed air entering the duct and any hydraulic or pneumatic pressure applied to the cable. It must accommodate longitudinally ribbed or smooth wall ducts from nominal 16 mm to 51 mm inner diameter. Mid assist or cascading of equipment must be for the installation of long cable runs. The equipment must incorporate safety shutoff valves to disable the system in the event of sudden changes in pneumatic or hydraulic pressure.

The equipment must not require the use of a piston or any other air capturing device to impose a pulling force at the front end of the cable, which also significantly restricts the free flow of air through the inner duct. It must incorporate the use of a counting device to determine the speed of the cable during installation and the length of the cable installed.

The cable shall be installed without splices except where specifically allowed on the plans or described in these special provisions. Minimum slack of the cable as shown on the plans shall be provided at each cable access location without a cable splice. At fiber optic splice location, a minimum of 9 meters slack of each cable shall be stored in the splice location.

CONDUIT SEALING PLUGS

Except otherwise noted, all fiber optic conduits shall have their ends sealed with commercial preformed plugs which prevent the passage of gas, dust and water into these conduits.

Sealing plugs shall be removable and reusable. Plugs shall be the split type that permits installation or removal without removing cables. Sealing plugs shall seal the conduit simultaneously with one self contained assembly having an adjustable resilient filler of neoprene or silicone rubber clamped between backing ends and compressed with stainless steel hardware.

To provide suitable sealing between future varying size cables and the plugs, split neoprene or silicone adapting sleeves, used singularly or in multiples, shall be inserted within the body of the plugs. Sealing plugs used to seal the fiber optic conduit shall be capable of withstanding a pressure of 34 kPa. A sealing plug that seals an empty conduit shall have an eye or other type of capturing device (on the side of the plug that enters the conduit) to attach onto the pull rope, so that the pull rope will be easily accessible when the plug is removed.

WARNING TAPE

Warning tape must be furnished, installed and placed in the trench over new conduits to receive new fiber optic cable as shown on in the plans.

The warning tape must have:

Description	Parameters
Thickness	not be less than 0.1 mm thick
Width	100 mm
Material	Orange color polyolefin film
Tensile strength	Minimum of 711 newton force
Elongation	minimum of 700 percent elongation before breakage
Printed Text height	25 mm black color
Message background color	bright orange color background
Message statement	CAUTION: BURIED FIBER OPTIC CABLE - CALTRANS RADIO ROOM (510) 286-6359
Message spacing intervals	approximately every 1 meter

The printed warning must not be removed by the normal handling and burial of the tape and must be rated to last the service life of the tape.

The construction of the warning tape must be such that it will not delaminate when it is wet. It must be resistant to insects, acid, alkaline and other corrosive elements in the soil.

Full compensation for furnishing and installing the warning tape shall be considered as included in the contract lump sum price paid for traffic operations system and no additional compensation will be allowed therefore.

CABLE MARKER

Cable markers shall be provided at 15.2 meter spacing in places where fiber optic conduit is placed in non-paved areas. These markers shall conform to Standard Plan A73C, Class 1, Type F, flexible post delineators, except that the marker shall be non-reflective. The following text shall be written on each marker: "WARNING, FIBER OPTIC CABLE, call 72 hours before You Dig, 1-510-286-4444, COMMUNICATIONS". See details on the plans.

CABLE SPLICING

Field cable splices shall be done either in splice vaults or in cabinets as shown on the plans.

Unless otherwise allowed, the cable splices shall be fusion type. The mean splice loss shall not exceed 0.07 dB per splice. The mean splice loss shall be obtained by measuring the loss through the splice in both directions and then averaging the resultant values.

The mid-span access method shall be used to access the individual fibers in a cable for splicing to another cable as shown on the plans. Cable manufacturers recommended procedures and approved tools shall be used when performing a mid-span access. Only the fibers to be spliced may be cut. All measures shall be taken to avoid damaging buffer tubes and individual fibers including those not being used in the mid-span access.

The mid-span access method shall be used to access the individual fibers in the trunkline cable for splicing pigtail cable. Cable manufactures recommended procedures and approved tools shall be used when performing a mid-span access. All measures shall be taken to avoid damaging buffer tubes and individual fibers not being used in the mid-span access. The Contractor will be allowed to splice up to 5 fibers to repair any damage done during mid-span access splicing without penalty. For each additional splice the Contractor will be assessed $300.00. Any

single fiber may not have more than 3 unplanned splices. If the fiber needs to be spliced more than 3 times, the entire length of fiber optic cable must be replaced at the Contractor's expense.

The field splices shall connect the fibers of the two cable lengths together. These splices shall be placed in splice trays and these splice trays shall then be placed in the splice enclosure.

The termination splices shall connect the cable span ends with pigtails. The termination splices shall be placed in splice trays and the splice trays shall then be placed in the fiber distribution unit (FDU).

Splice trays must accommodate a minimum of 12 fusion splices. The individual fibers shall be looped at least one full turn within the splice tray to avoid micro bending. A 50 mm minimum bend radius shall be maintained during installation and after final assembly in the optical fiber splice tray. Each bare fiber shall be individually restrained in a splice tray. The optical fibers in buffer tubes and the placement of the bare optical fibers in the splice tray shall be such that there is no discernable tensile force on the optical fiber.

All splices shall be protected with a metal reinforced thermal shrink sleeve.

FIBER OPTIC CABLE TERMINATIONS

DISTRIBUTION BREAKOUT.--The jacketed cable shall be lashed with tie wraps to the rack prior to entering the FDU. The cable shall also be tie-wrapped to the inside of the FDU near the point of entry. The glass fibers shall not be damaged during cutting and removal of the buffer tubes.

The jacketed area and bare fibers shall be cleaned to remove the moisture blocking gel. The transition from the buffer tube to the bundle of jacketed fibers shall be treated by an accepted procedure for sleeve tubing, shrink tubing and silicone blocking of the transition to prevent future gel leak. A subsequent transition shall be made, with flexible tubing, to isolate the fiber bundles of each buffer tube to serve as a transition from the bundle to the separation point and to protect the individual coated fibers. The last transition point (bundle to single fiber) shall consist of inserting the individual fibers into No. 26 AWG clear teflon tubing, to protect the fiber as it is routed toward the splice tray and to allow clear color identification of fibers for proper distribution. The final transition from bundle to individual fiber tube shall be secured with an adhesive heat shrink sleeve. The individual fibers shall then be stripped and prepared for splicing.

All fibers inside a fiber optic cable entering a FDU shall be properly terminated, whether they are used or not

DISTRIBUTION INTERCONNECT PACKAGE.--Distribution involves connecting the fibers to the active electronic components. The distribution equipment consists of FDUs with connector panels, couplers, splice trays, fiber optic pigtails and cable assemblies with connectors. The distribution interconnect package shall be assembled and tested by a company who is regularly engaged in the assembly of these packages. Attention is directed to "Fiber Optic Testing" elsewhere in these special provisions. All distribution components shall be products of the same manufacturers, who are regularly engaged in the production of these components, and the respective manufacturers shall have quality assurance programs.

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FIBER OPTIC CABLE ASSEMBLIES AND PIGTAILS

General.--Cable assemblies and pigtails shall be products of the same manufacturer. The cable used for cable assemblies and pigtails shall be made of fiber meeting the performance requirements of these special provisions for the F/O cable being connected.

Pigtails.--Pigtails shall be of simplex (one fiber) construction, in 900 µm tight buffer form, surrounded by aramid for strength, with a PVC jacket with manufacturer identification information and a normal outer jacket with diameter of 3 mm. Singlemode cable jackets shall be yellow in color. All pigtails shall be factory terminated and tested and at least 900 mm in length.

Patch cords.—Patch cords may be of simplex or duplex design. Duplex jumpers shall be of duplex round cable construction, and shall not have zipcord (siamese) construction. The patch cord shall be terminated with ST compatible super physical contact singlemode connector at both ends. The fiber strands shall meet the specifications as those of the fiber cable and the connectors shall meet the specifications as specified elsewhere in these special provisions. All patch cords shall be at least 1.83 meters in length, sufficient to avoid stress and orderly routing.

The outer jacket of duplex patch cords shall be colored yellow. The two inner simplex jackets shall be color coded white and slate, respectively, to provide easy visual identification for polarity.

Connectors.--Connectors shall be of the ceramic ferrule ST "push-pull" type. Indoor ST connector housings shall be either nickel plated zinc or glass reinforced polymer construction. Outdoor connector body housing shall be glass reinforced polymer.

The associated coupler shall be same material as the connector housing.

All F/O connectors shall be 2.5 mm ST connector ferrule type with Zirconia Ceramic material with a physical contact pre-radiused tip.

The ST connector operating temperature range shall be from -40 °C to +70 °C. Insertion loss shall not exceed 0.4 dB and the return reflection loss on singlemode connectors shall be at least 40 dB. Connection durability shall be less than 0.2 dB change per 500 mating cycles per EIA-455-21A (FOTP-21). All terminations shall provide a minimum 220 newtons pull out strength. Factory test results shall be documented and submitted to the Engineer prior to installing any of the connectors. Singlemode connectors shall have a yellow color on the body or the boot.

Field terminations shall be limited to splicing of adjoining cable ends or cables to ST pigtails.

ST Couplers.-The ST couplers shall be made of nickel plated zinc or glass reinforced polymer that is consistent with the material forming the associated ST connector body. The design mechanism for mounting the coupler to FDU connector module panel may be flanged or threaded but shall coincide with FDU panel punch-outs.

All coupler sleeves shall be ceramic of the split clamshell or clover leaf design.

The temperature range for the couplers shall be the same as that specified for the ST connectors.

FIBER OPTIC DISTRIBUTION UNIT

Fiber distribution unit (FDU) shall be EIA-310 standard mount type as shown on the plans.

FDU shall consist of a connector module housing (CMH) and a splice module housing (SMH). The CMH shall have sufficient number of connection panels to handle the associated fiber terminations. The SMH shall have the capacity to secure and store the required splice trays and break out cables.

Connector module housing (CMH) shall have a Lexan front cover so as not expose fiber optic connections. Each connection panel shall have six coupler capacity and all panel positions shall be filled with couplers. All spare couplers shall have dust covers on both sides. Each connection panel shall be secured to the CMH frame with two plastic puch snap fastener on each side of the panel.

Splice module housing (SMH) shall have sufficient number of splice trays to handle the transition splices between the field cables and their respective breakouts. Cable accesses to the SMH shall have grommets. SMH shall have a rear metal cover of the same gauge and color as the remainder of the FDU rack

The front and back covers of the FDU shall be retractable or removable to facilitate internal installation.

FIBER OPTIC LABELING

GENERAL

The Contractor shall label all fiber optic and copper communications cabling in a permanent consistent manner. All tags shall be of a material designed for long term permanent labeling of fiber optic and copper communications cables and shall be marked with permanent ink on non-metal types, or embossed lettering on metal tags. Metal tags shall be constructed of stainless steel. Non-metal label materials shall be approved by the Engineer. Labels shall be affixed to the cable per the manufacturer's recommendations and shall not be affixed in a manner which will cause damage to the fiber. Handwritten labels shall not be allowed.

LABEL IDENTIFICATION

Labeling of Cables.--Labeling of the backbone, distribution and drop fiber optic cables shall conform to the following unique identification code elements:

Labeling schemes

Unique Identification Code Elements for Backbone, Distribution or Drop Cables

No.	Description	Code	Number of Characteristics
1	Cable Type	Fiber: S: Singlemode	1
2	Fiber Count	Number of fibers or conductor pairs (example: 72 fibers)	3
3	Begin Function	T: TMC; H: Hub; V: Video Node; D: Data Node; C: Cable Node; TV: CCTV Camera; CM: CMS; E: Traffic Signal; RM: Ramp Meter; TM: Traffic Monitoring/Count Station/Vehicle Count Station (VDS, TMS); SV: Splice Vault SC: Splice Cabinet	1 or 2
4	County	County Number; Example: 033 (for Alameda)	3
5	Route Number	Hwy, Rte (example: 005)	3
6	Post Mile	Example: xxxxx	5
7	End Function	T: TMC; H: Hub; V: Video Node; D: Data Node; C: Cable Node; TV: CCTV Camera; CM: CMS; E: Traffic Signal; RM: Ramp Meter; TM: Traffic Monitoring/Count Station/Vehicle Count Station (VDS, TMS); SV: Splice Vault SC: Splice Cabinet	1 or 2
8	County	County Number; Example: 034 (for Sacramento)	3
9	Route Number	Hwy, Rte (example: 005)	3
10	Post Mile	Example: xxxxx	5
11	Unique ID	Identifies when two or more fiber cables are involved (example: xx)	2

Caltrans District 4 county system numbers are as following:

County	County System Number
Alameda	33
Contra Costa	28
Marin	27
Napa	21
San Francisco	34
San Mateo	35
Santa Clara	37
Santa Cruz	36
Sonoma	20
Solano	23

Example: S 048 SV 033 080 00569 SV 033 080 00610 03.

The label in the example can be translated as a singlemode (S) 48 strand cable (048) that starts from a splice vault (SV) in Alameda County (033) on I-80 (080) post mile 5.69 (00569) ends at another splice vault (SV) in Alameda County (033) on I-80 (080) at postmile 6.10 (00610). This fiber optic cable is uniquely identified as 03. This means the cable is the 3rd of the fiber optic cables in the pull box or the vault.

Each cable shall display a unique identification, regardless of where the cable is viewed. The begin function and end function correspond to the end points of each cable. The order of the begin and end function follow a hierarchy as listed below, where the lowest number corresponding to the begin/end function is listed first.

1	TMC
2	HUB
3	Video Node (VN)
4	Data Node (DN)
5	Cable Node
6	CCTV Camera
7	CMS
8	Traffic Signal
9	Ramp Meter
10	Traffic Monitoring Count Station
11	HAR
12	EMS
13	Weather Station
14	Weight In Motion
15	Splice Vault or Cabinet

This scheme will work as follows:
A cable between the TMC and a HUB will always have the TMC listed as the start function and the HUB as the end function. Between a CMS and a Splice Vault, the start function will always be listed as the CMS, and so on. If a cable is connected between HUBs, for example HUB-01 and HUB-03, the lowest number, in this case HUB-01, will be listed as the start function and HUB-03 as the end function.

At each FDU or ITU the Contractor shall provide a listing of the cable or cables terminated and where each fiber appears on the connector panel, a list of all jumpers and the equipment that they are connected to, and a geographical layout of all the equipment installed by the Contractor. In field cabinets these shall be placed in a waterproof pouch mounted on the cabinet door.

LABEL PLACEMENT

Abbreviations:

TMC	TXXX.XX
HUB	HXXX.XX
VAULT	SVXXX.XX
PULL BOX	PBXXX.XX
CAMERA	TVXXX.XX
CMS	CMXXX.XX
TMS	TMXXX.XX
RAMP METER	RMXXX.XX

TRAFFIC SIGNAL	EXXX.XX
HAR	HRXXX.XX
EMS	FMXXX.XX
WEATHER STATION	WSXXX.XX
WEIGHT IN MOTION	WTXXX.XX

The X's denote the postmile of the above elements.

Cables.--All cables shall be clearly labeled with the unique identification code element method described elsewhere in these special provisions, at all terminations, even if no connections or splices are made, and at all splice vault entrance and exit points.

Cable to Cable Splices.--All cable jackets entering the splice enclosure shall be labeled in accordance with the identification method described elsewhere in these special provisions.

Cable to Fiber Distribution Units.--The cable jackets shall be clearly labeled at entry to the FDU in accordance with the unique identification code element method described elsewhere in these special provisions. In addition, each fiber and pigtail shall be labeled at the connector with the Fiber ID . The FDU shall be clearly labeled with the Cable ID on the face of the FDU. If multiple cables are connected to the FDU, each block of connectors relating to each individual cable shall be clearly identified by a single label with the Cable ID. Individual connections shall be clearly marked on the face of the FDU in the designated area with the Fiber ID.

Fiber.--Fibers labels shall be placed next to the connectors of the individual fibers.

Patch Panels.--The cable jackets shall be clearly labeled at entry to the Patch Panel in accordance with the unique identification code element method described elsewhere in these special provisions. In addition, each fiber and pigtail shall be labeled at the connector with the Fiber ID. . The Patch panel shall be clearly labeled with the Cable ID on the face of the Panel. If multiple cables are connected to the Patch Panel, each block of connectors relating to each individual cable shall be clearly identified by a single label with the Cable ID. Individual connections shall be clearly marked on the face of the Panel in the designated area with the Fiber ID.

Splice Trays.--A label shall be placed on each splice tray explaining the splices in each tray.

FIBER OPTIC DATA MODEM

The fiber optic data modem (FODM) shall be EIA-232 compatible fiber optic modem with dual optics for drop/insert capability which can be configured as master or local(slave) in either daisy chain or fault tolerant dual redundant (counter rotating) ring network architecture. These four modes of operations shall be selectable via an external Mode DIP-switch. All signals received via an optical port and retransmitted via fiber or via an expansion port shall be retimed to 0.01 percent pulse width accuracy by a crystal controlled timebase, eliminating pulse width distortion and eliminating virtually unlimited repeating. The FODMs shall have anti-streaming circuitry for both the optical fiber and the electrical (EIA-232) sides. On EIA-232 side, when enabled, the anti-streaming shall limit the amount of time an external device is allowed to transmit data onto the network for each Request to Send (poll). On the fiber side, the anti-streaming shall disable an optical receiver in the event that the receiver output stays high longer than maximum allowable time thus preventing the whole fiber network from being disabled by a continuous "on" failure by receiver or optical emitter. External (TIMEOUT) DIP-switch shall allow user to disable or select the timeouts for both the optical side anti-streaming feature and the EIA-232 side anti-streaming feature as well as to enable or disable the "Fiber Activity CTS Disable" feature. LED indicators to display power "on", anti-streaming "Fault" time-out and EIA-232 fiber optic activity (selectable via dual function switch).

The FODMs at the field element shall be stand-alone type and shall be securely fastened on a EIA-310 rack-mount shelf. At the hub location, the FODMs shall be rack-mount type installed in card cage assembly. The card cage assembly shall be EIA-310 rack mount type with at least 14 slots and with two power supplies for redundancy.

The FODM shall meet the following requirements:

Electrical Signaling:	EIA-232 with full handshake control signals
Electrical Power:	115 V(ac), 60 Hz
Operating Temperature	-40 to 70°C
Operating Mode:	1. Daisy chain Master mode 2. Daisy chain Local mode 3. Fault tolerant Master mode 4. Fault tolerant Local mode
Emitter type:	Laser
Wavelength	1310 nm
Minimum coupled transmit power into: 9/125µm at 25°C(75°C)	-11(-9.5) dBm
Output Variation	-0.015 dB/°C
Minimum receiver input power for 10^{-9} BER	-40 dBm
Maximum receiver input	-11 dBm
Optical port type	ST
EIA -232 connector type	DE9 female
Data Rates (auto)	1200 baud to 57.6 kbaud
Bit Error Rate:	10^{-9}
Link Budget(Range) via singlemode 1310 nm	31 dB for (56 km)

FODMs shall be tested as follows:

a. Each optical modem shall be functionally tested by looping back optical transmit connector to the optical receive connector using a variable optical attenuator with measured optical loss at 31 dB at 1310 nm. A test set shall be connected to the modem and set for EIA-232 communication testing. Fifteen minutes BER test burn-in test shall be error free.
b. After performing the 15 minutes BER test, at least two modems shall be tested for receiver dynamic range. The following procedure shall be followed: First, the optical attenuation shall be increased to the point at which the data test just begins to register bit errors. The optical receive power into the modem shall be measured and recorded. The optical atttenuation shall be then decreased until data test once again register errors. At no time shall the optical power into the receiver exceed the manufacturer's specified saturation level. The optical receive levels shall once again be measured and recorded. These minimum and maximum receiver power levels define modem receiver's dynamic range and shall meet or exceed the manufacturer's specifications.
c. One pair of modem shall be interconnected using optical patch cords and attenuators with a loss of 31 dB in each direction. The EIA-232 interface shall be looped back onto one modem and a test set connected to the EIA-232 interface of the other modem. A bit error rate of less than 10^{-9} shall be demonstrated.

HUB EQUIPMENT

Hub equipment shall conform to all rules and regulations of the Federal Communications Commission (FCC) in addition to the provisions in Section 86, "Signals, Lighting and Electrical Systems," of the Standard Specifications and these special provisions.

Prototype equipment is not acceptable. All equipment shall be current standard production units and shall have been in use for a minimum of 6 months. Rebuilt or reconditioned equipment will not be allowed. All rack mounted equipment and card cage assemblies shall have metal filler plates to cover any unused channel slots or card slots.

The communication equipment shall include associated power supplies and interconnect cables.

The communication equipment shall be designed for testing, monitoring, and adjustment without service interruption.

Front access shall be provided for all routine adjustments normally required to be performed by field personnel.

The Contractor shall install hub equipment with the following equipment, associated cable connectors and other necessary components for a functional and fully integrated system:

a. 4 - Switch ethernet hub.
b. 20 - Fiber optic data modems (FODM) with 3- Card cage assembly with power supply.
c. 20 - Video encoder units (VEU).
d. 2 - Fiber distribution units (FDU) - (described elsewhere in these special provisions).
e. 2 - Fiber storage enclosures (FSE) - (described elsewhere in these special provisions).
f. 20 – Fiber Optic Receivers (FORS) units with 3 - Card cage assemblies with power supplies.
g. 10 - Power strips.

The hub location is shown on the plans.

FIBER OPTIC TESTING

GENERAL

Testing shall include the tests on elements of the passive fiber optic components: (1) at the factory, (2) after delivery to the project site but prior to installation, (3) after installation but prior to connection to any other portion of the system, and (4) during final system testing. The active components shall be tested after installation. The Contractor shall provide all personnel, equipment, instrumentation and materials necessary to perform all testing. The Engineer shall be notified two working days prior to all field tests. The notification shall include the exact location or portion of the system to be tested.

2

Documentation of all test results shall be provided to the Engineer within 5 working days after the test involved. The Contractors attention is directed to "As-Built Plans" elsewhere in these special provisions, regarding the requirements for recording test results.

3

A minimum of 15 working days prior to arrival of the cable at the site, the Contractor shall provide detailed test procedures for all field testing for the Engineer's review and approval. The procedures shall include the tests involved and how the tests are to be conducted. Included in the test procedures shall be the model, manufacturer, configuration, date and operating procedures.

4

FACTORY TESTING

Documentation of compliance with the fiber specifications as listed in the Fiber Characteristics Table shall be supplied by the original manufacturer. Before shipment, but while on the shipping reel, 100 percent of all fibers shall be tested for attenuation. Copies of the results shall be (1) maintained on file by the manufacturer with a file identification number for a minimum of seven years, (2) attached to the cable reel in a waterproof pouch, and (3) submitted to the Contractor and to the Engineer.

5

ARRIVAL ON SITE

The cable and reel shall be physically inspected on delivery and 100 percent of the fibers shall be attenuation tested to confirm that the cable meets requirements. Attenuation tests shall be performed with an OTDR capable of recording and displaying anomalies of 0.02 dB as a minimum. Singlemode fibers (SM) shall be tested at 1310 nm and at 1550 nm. Test results shall be recorded, dated, compared and filed with the copy accompanying the shipping reel in a weather proof envelope. Attenuation deviations from the shipping records greater than 5 percent shall be brought to the attention of the Engineer. The cable shall not be installed until completion of this test sequence and the Engineer provides written approval. Copies of traces and test results shall be submitted to the Engineer. If the

test results are unsatisfactory, the reel of FO cable shall be considered unacceptable and all records corresponding to that reel of cable shall be marked accordingly. The unsatisfactory reels of cable shall be replaced with new reels of cable at the Contractor's expense. The new reels of cable shall then be tested to demonstrate acceptability. Copies of the test results shall be submitted to the Engineer.

6

AFTER CABLE INSTALLATION

After the fiber optic cable has been pulled but before breakout and termination, 100 percent of all the fibers shall be tested with an OTDR for attenuation. Test results shall be recorded, dated, compared and filed with the previous copies of these tests. Copies of traces and test results shall be submitted to the Engineer. If the OTDR test results are unsatisfactory, the fiber optic cable segment will be unacceptable. The unsatisfactory segment of cable shall be replaced with a new segment, without additional splices, at the Contractor's expense. The new segment of cable shall then be tested to demonstrate acceptability. Copies of the test results shall be submitted to the Engineer.

7

Attenuation tests shall be performed with an OTDR capable of recording and displaying anomalies of 0.02 dB as a minimum. Singlemode fibers (SM) shall be tested at 1310 nm and at 1550 nm. Attenuation readings shall be recorded on a cable data sheet showing factory and after installation results.

8

The OTDR shall have a printer capable of producing a verifying test trace with fiber identification as shown in Appendix A "Link Loss Budget Work Sheet," numerical loss values, the date and the operator's name. It shall also have a DOS based 3.5" disk recording capability that has associated software to do comparisons and reproductions on 8.5" x 11" paper, via a personal computer.

9

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FIBER OPTIC SYSTEM GAIN MARGIN

The installed system gain margin shall be at least 6 dB for each and every link. If the design system gain margin is less than 6 dB, the Engineer shall be notified and informed of the Contractor's plan to meet that requirement. Test results shall be recorded and submitted to the Engineer for approval.

10

INTERCONNECTING PARTS TESTING AND DOCUMENTATION

All the components of the passive interconnecting parts (FDUs, pigtails, couplers and splice trays) shall be from a manufacturer who is regularly engaged in the production of the fiber optic components described.

11

Each ST termination shall be tested for insertion attenuation loss with the use of an optical power meter and source. In addition, all singlemode terminations shall be tested for return reflection loss. These values shall meet the loss requirements specified earlier and shall be recorded on a tag attached to the pigtail or jumper.

12

Once interconnecting assembly is complete, the contractor shall visually verify that all tagging, including loss values, is complete. Then as a final quality control measure, the contractor shall do an "end to end" optical power meter/light source test from pigtail end to jumper lead end to assure continuity and overall attenuation loss values.

13

The final test results shall be recorded, along with previous individual component values, on a special form assigned to each FDU. The completed form shall be dated and signed by the contractor's supervisor. One copy of this form will be attached in a plastic envelope to the assembled FDU unit. Copies will be provided separately to the Contractor and to the Engineer.

14

ACTIVE COMPONENT TESTING

The transmitters and receivers shall be tested with a power meter and light source, to record the transmitter average output power in (dBm) and receiver sensitivity in (dBm). These values shall be recorded in the "Link Loss Budget Work Sheet" shown in Appendix A.

15
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SYSTEM VERIFICATION AT COMPLETION

Once the passive cabling system has been installed and is ready for activation, 100 percent of the fiber links shall be tested with the OTDR for attenuation at both wavelengths. Test results shall be recorded, dated, compared and filed with previous copies. A hard copy printout and a electronic copy of the traces and test results along with a licensed copy of the associated software on a minimun 4 GB USB version 2.0 flash drive or a Secure Digital card shall be submitted to the Engineer. If the OTDR test results are unsatisfactory the link shall be replaced at the Contractor's expense. The new link shall then be tested to demonstrate acceptability. Copies of the test results shall be submitted to the Engineer.

16

The "Link Loss Budget Work Sheet" shown in Appendix A shall be completed for each link in the fiber optic system, using the data gathered throughout the installation process. The completed work sheets shall be included as part of the system documentation in the As-Built Plans.

17

The "Total System Gain" shall be calculated by subtracting the measured "Optical Receiver Sensitivity" (line 1B on the "Link Loss Budget Work Sheet") from the measured "Optical Transmitter Average Power" (line 1A), which were obtained using a power meter and source. The resulting difference shall be the maximum allowable loss between the transmitter and the receiver, within 0 percent to +10 percent of the manufacturers specified loss budget for the transmitter/receiver pair. The "Total System Gain" shall be recorded on line 1C.

18

The "Fiber Losses" for a link shall be calculated by multiplying the length of the fiber link (line 2A) by the normalized cable attenuation (dB/km, line 2B) at the operating wavelength. The normalized attenuation for this calculation shall be the maximum value throughout the operating temperature range of the cable. The product shall be recorded on line 2C.

19

The total connector losses shall be calculated by summing the individual attenuation values for each connector pair in the link, excluding the transmitter and receiver connectors. The sum shall be recorded on line 2D.

20

The total splice losses shall be calculated by summing the individual attenuation values for each splice in the link. The sum shall be recorded on line 2E.

21

The total of other losses shall be calculated by summing the individual attenuation values for each component in the link not previously addressed. The sum shall be recorded on line 2F. These items may include, but are not limited to, couplers, splitters, routers and switches.

22

The "Total System Loss" shall be recorded on line 2G of the "Link Loss Budget Work Sheet."

23

The "Design System Gain Margin" shall be calculated by subtracting the Total System Loss (line 2G) from the Total System Gain (line 1C). The resulting difference shall be recorded on line 3A. The Contractor's attention is directed to "F/O System Gain Margin," elsewhere in these special provisions.

24

At the conclusion of the final OTDR testing, 100 percent of all fiber links shall be tested end to end with a power meter and light source, in accordance with EIA Optical Test Procedure 171 and in the same wavelengths specified for the OTDR tests. These tests shall be conducted in both directions. Test results shall be recorded, compared and proven to be within the design link loss budgets, and filed with the other recordings of the same links. Test results shall be submitted to the Engineer.

25

If during any of these system verification tests, the results prove to be unsatisfactory, the F/O cable will not be accepted. The unsatisfactory segments of cable shall be replaced with a new segment of cable at the Contractor's expense. The new segment of cable shall undergo the same testing procedure to determine acceptability. Copies of

the test results shall be submitted to the Engineer. The removal and replacement of a segment of cable shall be interpreted as the removal and replacement of a single contiguous length of cable connecting two splices, two connectors, or a splice and a connector. The removal of only the small section containing the failure and therefor introducing new unplanned splices, will not be allowed.

APPENDIX A

Link Loss Budget Worksheet
Contract No. _____

Contractor: _____

Approved by Caltrans: _____

Date: _____ Operator:_____

Link Number: _____ Fiber Color: _____

Buffer Color: _____ Cable #: _____

Test Wavelength (Circle one): 1310 nm 1550 nm

Section 1: Total System Gain			
Measured Optical Transmitter Average Power:	_____ dBm		1 A
Measured Optical Receiver Sensitivity (this should be a negative value):	_____ dBm		1 B
Subtract line 1B from 1A to obtain Total System Gain:	_____ dB		1 C
Section 2: Total System Loss			
Measured length of the link:	_____ km		2 A
Measured loss per km of the fiber:	_____ dB/km		2 B
Multiply line 2A by 2B to obtain the Total Fiber Loss:	_____ dB		2 C
Sum of all Connector Losses in the link:	_____ dB		2 D
Sum of all Splice Losses in the link:	_____ dB		
Sum of all Other Losses from other components (couplers, splitters, routers, switches, etc.)	_____ dB		2 E
Add lines 2C, 2D, 2E and 2F to obtain Total System Loss:	_____ dB		2 F 2 G
Section 3: Design System Gain Margin			
Subtract line 2G from line 1C (This number must be at least 6 dB):	_____ dB		3 A

Revise the entirety of Section 10-3.13 TRAFFIC OPERATION SYSTEM to read as follows

CAMERA STATION

GENERAL

The Contractor shall furnish and install the following closed circuit television (CCTV) equipment at each camera station as described in these special provisions and as shown on the plans:

1. One integrated camera unit.
2. One CCTV pole and camera mounting adapter if required.
3. One camera control unit (CCU).
4. One video encoder unit (VEU).
5. Power strip.
6. Hybrid camera cable (HCC), connectors and fittings as required.
7. Interface cable and conductors as required.
8. Equipment shelf with brackets as required.

INSTALLATION OF CAMERA STATION

The Contractor shall install CCTV pole with foundation, conduits and pull boxes as required and as shown on the plans. The type of CCTV pole is shown on the plan and shall meet the specifications describe elsewhere in these special provisions. The Contractor shall install and terminate the HCC with connectors as shown on the plans. The HCC shall connect to camera pigtail cable and secure to the pole as shown on the plans for strain-relief.

The integrated camera unit shall be installed on camera mounting plate as shown on the plans. The integrated camera unit shall be secured to the mounting plate using the stainless steel bolts provided with the integrated camera unit. Before each bolt is fastened, a locking type coating shall be applied to the threads. The coating shall lock the bolt and nut in place, making it impossible to turn the bolt or nut without tools. This coating shall last through and be effective through at least ten insertions and withdrawals of the bolt or nut.

The Contractor shall install CCU, VEU, router, power strip, 8-position connecting block, equipment shelves and all the interface cables in the controller cabinet as shown on the plans. The power strip shall be mounted on the rear mounting rack of the controller cabinet.

The Contractor shall furnish all materials necessary to provide a complete and functional camera station in accordance with these special provisions. Miscellaneous equipment and materials not mentioned but necessary to provide a complete and fully operational camera station shall be furnished by the Contractor as incidental to the work for which no additional compensation will be allowed therefore.

All items furnished under this contract shall be new and shall be the latest version.

CAMERA STATION TESTING

Upon completion of work, each camera station shall be subjected to post-installation tests as outlined herein. All software shall be provided and loaded before the start of testing The District Electrical Systems Branch personnel, arranged by the Engineer and in the presence of the Contractor, shall perform all tests. The Contractor shall notify the Engineer in writing 15 days prior to the scheduled testing. Upon receipt of the notification, the Engineer shall contact Office of Electrical Systems at (510) 286-6142. The Contractor shall provide all necessary equipment required to access the CCTV equipment for testing.

The testing shall consist of five consecutive days of continuous satisfactory operation of each camera station. If any material and equipment furnished and installed by the Contractor in this project is found defective or otherwise unsuitable, or the workmanship does not conform to the accepted standards, the Contractor shall replace such defective material and equipment at no cost to the State.

The Contractor may offer rejected material or equipment for consideration provided all non-compliance has been corrected and pretested by the Contractor. After all defects have been corrected, the camera station shall be re-tested until five consecutive days of continuous satisfactory operation is obtained.

The post-installation tests shall consist of, but not be limited to, inspection and functional testing in accordance

with these special provisions.

Inspection shall consist of, but not be limited to, verification of correct wiring terminations, correct cable interconnections, good workmanship and compliance with these special provisions.

Functional testing shall include, but not be limited to, the following:

a. Verify all local mode CCTV operations using the CCU front panel controls.
b. Verify video signal output from CCU with a National Television Systems Committee (NTSC) monitor.
c. Verify the correct operation of the auto/manual iris and focus, and manual zoom functions.
d. Verify the correct operation of the pan/tilt function. The pan/tilt function shall be tested over 355 degrees in the horizontal plane and +20 to -90 degrees in the vertical plane
e. Verify the correct operation of the preset positions.

INTEGRATED CAMERA UNIT

GENERAL

Each integrated camera unit shall consist of a camera, lens, receiver/driver, pan/tilt assembly, environmental housing, sunshield and pigtail cable with connector. The integrated camera unit shall automatically switch to monochrome mode when ambient light level is at 200 lux and switch back to color at 1,800 lux.

Each integrated camera unit shall be assembled, inspected and tested in accordance with these special provisions prior to delivery to the job site. Installation, operations and maintenance manuals shall also be submitted at the time of delivery. The Contractor shall submit the applicable documents of the U.S. Military Specification (MIL-SPEC), Underwriters Laboratories Inc. (UL), Electronics Industries Association (EIA) Standards and other Standards from parts of the specification to the extent specified in these standards. In the event of a conflict between the content of this section and the content of the specification, the standards defined in this section shall supersede.

Military Specification Documents	
MIL-I-45208A	Inspection System Requirements, Dec. 16, 1963
MIL-C-45662	Calibration System Requirements, June 10, 1980
MIL-STD-416A	Electromagnetic Interface Characteristics Requirements for Equipment, Subsystems & Systems, Aug. 1, 1968
MIL-E-5400T	Electronic Equipment, Airborne General Specification
MIL-STD-810	Environmental Test Methods, 19 July 1983
MIL-C-5541	Chemical Conversion Coatings on Aluminum Alloys, June 3, 1970

Underwriters' Laboratory, Inc. and other documents	
UL-796	Printed Circuit Boards
EIA-170A	Electrical Performance Standards Color Television Studio Facilities
EIA RS-330	Electrical Performance Standards for Closed Circuit Television (CCTV) Camera 525/60 Interlaced

CAMERA

Each camera shall meet the following specifications at a minimum:

Imager	Interline transfer Progressive Scan CCD with mosaic-type color compensating filter
Image Area	6.4 mm Format, 3.6 mm (H) x 2.7 mm (V)
Resolution	540 horizontal; 350 vertical
Picture Elements	811 (H) x 508 (V), Total 411,988
Video Output	NTSC, 1 V p-p @ 75 ohms, unbalanced
Lens	Aperture: f/1.4 (wide angle) to f/4.2 (telephoto)
Optical Zoom Range	35X, 3.4 mm to 119 mm
Digital Zoom Range	1X (Off) through 210X, Smooth transition from Optical to Digital Zoom

Horizontal Angle of View	Optical: 55.8° to 1.7°; At 10X Digital: 55.8° to 0.17°.
Focus Distance.	1016 mm telephoto, 10.2 mm wide angle
Digital Compass	8 or 16 direction point compass annotation with primary direction spelled out and intermediate directions abbreviated with two letters
Auto Focus	Selectable Auto/Manual
Manual Focus Speed	Approximately 2.0 seconds to full range
Minimum Scene Illumination	For Reliable Auto Focus, 30 percent video
Zoom & Focus Presets	64 preset positions with auto focus and ID
Flash Memory	Update firmware and new features via serial communication
Shutter speeds	1/60; 1/120; 1/180; 1/250; 1/500; 1/1,000; 1/2,000; 1/4,000; 1/10,000; 1/30,000 second
Auto Iris	Automatically adjusts to compensate for changes in scene illumination to maintain constant video level output within sensitivity specifications
Manual Iris	Changing the video level to give the effect of open iris/close iris
Gamma	0.45
AGC	0 to 28 dB
Color Balance	Auto Tracking Color Balance/Manual with adjustable Red and Blue Levels
Signal to Noise Ratio	>50 dB
Synchronization	Crystal or Phase-Adjust Line Lock on 60 Hz
Sensitivity	@F1.4, Wide Angle 35 IRE 0.5-Lux @ 1/60 s, F1.4, Shutter, Color I.R. Cut On 0.05-Lux @ 1/2 s, F1.4, Shutter, Color I.R.Cut On 0.2-Lux@ 1/60 s, F1.4, Shutter, monochrome mode I.R. Cut Off 0.01-Lux@ 1/4 s, F1.4, Shutter, monochrome mode I.R. Cut Off

Pan & tilt function specifications:

1	Continuous rotation capability in either direction
2	110° of tilt movement, +20° to –90° unobstructed
3	Pan Speed (Operator Control): Variable from 0.1°/s to 80 °/s
4	Pan Speed (Preset Control): >140°/s
5	Tilt Speed (Operator Control): Variable from 0.1°/s to 40 °/s
6	Tilt Speed (Preset Control): 140°/s
7	64 Pan & Tilt preset positions with repeatability within ±0.5°
8	The positioning system shall be invertible if inverse mounting is required

The integrated camera unit shall have eight programmable camera movement sequences. Each sequence is programmed by selecting the preset position by number, and then selecting a dwell time. The presets can be used in any order, and the same preset may be used more than once as long as the total number of preset positions used does not exceed 32. The dwell time defines the length of time paused at each preset position. It can be from 1 second to 60 seconds. The dwell time can be changed individually for all stops on the sequence. If the appropriate preset ID is programmed, it shall be displayed for each preset position used on the sequence. The sequence shall stop upon receipt of a pan command. All programmable functions shall be stored in non-volatile memory.

The camera housing shall be a corrosion resistant and tamper proof sealed and pressurized housing with 9 kg dry nitrogen with Schrader purge fitting and 138 kPa relief valve for each camera. The size of the housing shall be 88.9 mm diameter or smaller. The housing exterior shall be finished by pre-treatment with conversion coating and baked enamel paint. The camera enclosure shall be designed to withstand the effects of sand, dust and hose-directed water.

The internal humidity of the housing shall be less than 10 percent, when sealed and pressurized. Desiccant packs shall be securely placed inside the housing to absorb any residual moisture and maintain internal humidity at 10 percent or less. The housing shall include a thermostatically controlled heating pad rated at 115 V(ac) 100 W maximum.

A sun shield or visor shall be provided to shield the lens from direct sunlight.

The integrated camera unit shall include a character generator. The text characters shall be uppercase white with black border impose on the video stream. A maximum of six lines of user programmable alphanumeric text shall be displayed through serial communications. Messages can be positioned at either the top or the bottom of display. The Right side positioning is accomplished by padding left side of message with spaces. Blank lines shall not be displayed. Any programmed line being displayed shall fill in toward the top if top positioning is selected, or toward the bottom if bottom position is selected.

Camera ID shall be used for upper 2 lines with each up to 24 characters long. If both lines are programmed, line 1 of Camera ID shall always appear above line 2 of Camera ID regardless of top or bottom selection.

Preset ID shall be 1 line, up to 24 characters long, user programmable for each of the 64 preset positions. When a preset position is recalled the corresponding preset ID shall be displayed. The preset ID shall remain displayed until a pan, tilt, zoom, manual focus, auto focus select, or another preset command is received.

An 8-point or 16-point compass annotation shall be settable for a true north position. Display shall include North, NE, East, SE, South, SW, West and NW. Position shall be able to be grouped with the site location or separated from site location. Azimuth and elevation position shall be displayed in 0 - 359 degrees and +95 to –95, respectively. All display shall be user selectable for enable/disable, 3-second time out or permanent display. Sector Message of up to 16 sectors in 360° shall be defined with up to 24 characters long.

Low-pressure indicator shall use 1 line with messages displayed in "blinking" or "non-blinking" mode when activated by low internal pressure. Adjustable set points by altitude shall be provided via the serial port to activate low-pressure. Message shall be enabled or disabled. In maintenance mode readings of the internal pressure of the camera housing shall be displayed from 34474 Pa down to 6895 Pa, in 689 Pa increments.

PHYSICAL AND MECHANICAL REQUIREMENTS

Each integrated camera unit shall not weight more than 9 kg. Its dimensions shall not exceed 356 mm length, 178 mm width and 305 mm height (Including mounting base.) The integrated camera unit shall be pole mount version. There shall be four equal spaced mounting holes on the mounting base. Each integrated camera unit shall be provided with four stainless steel hex head bolts to secure the integrated camera unit to the camera mounting plate. All fasteners and nuts used in attaching the integrated camera unit to the mounting plate shall be of grade 18-8 stainless steel. A camera-mounting adapter shall be provided if the bolt hole pattern of the camera base is not match the camera mounting plate as shown on the plans.

POWER REQUIREMENTS

The integrated camera unit shall operate between voltage 89 V(ac) to 135 V(ac), 120 V(ac) nominal voltage and 50 or 60 Hz. (±3.0 Hz). The integrated camera unit shall conform to National Electrical Manufacturers Association (NEMA) standard TS-2 (1998) for traffic control system 2.1.2. The integrated camera unit shall meet the requirements of Section 2.1.6 "transients, power service" of the NEMA standard TS-2 (1998). The line variation and surge performance shall be tested to meet these specifications by an outside agency, other than the camera manufacturer. The tests shall be provided upon request. The power consumption shall not exceed a total of 200 watts, in which 100 watts for camera, receiver, pan/tilt driver and 100 watts for heater on.

ENVIRONMENTAL REQUIREMENTS

The integrated camera unit shall operate in ambient temperature range from -34°C to +74°C, in relative humidity up to 100 percent. The unit shall operate when exposure to sand, dust, fungus and salt atmosphere per MIL-E-5400T, paragraph 3.2.24.7, 3.2.24.8, 3.2.24.9 and with shock for up to 10 Gs, 11 ms, in any axis under non-operating conditions, per MIL-E-5400T, para 3.2.24.6. The unit shall not be damaged with sine vibration from 5 to 30 Hz, 1/2 G, 3 axis in one hour.

CAMERA PIGTAIL AND CONNECTOR

The camera pigtail cable shall conform to the provisions in "Hybrid Camera Cable," of these special provisions. The length of the camera pigtail cable shall not be less than 813 mm. The terminating connector shall be equivalent to an Am phenol 206036-3 with back shell 206070-1.

The contact pin assignment of the connector shall be:

Position	Function	Position	Function
1	Video, 75 ohm	9	Not Used
2	Video Ground	10	Not Used
3	Data Ground	11	Not Used
4	Tx-	12	115 V(ac) Line, Hot
5	Tx+	13	115 V(ac), Neutral
6	Rx+	14	Not Used
7	Rx-	15	115 V(ac), Ground
8	Not Used	16	Not Used

The Contractor shall furnish a mating connector, Am phenol 206037-1 with back shell 206070-1 and sixteen contact crimping sockets for each integrated camera unit supplied in the contract.

HYBRID CAMERA CABLE AND CONNECTORS

The Hybrid camera cable (HCC) shall consist of one RG-59/U type analog video coaxial cable, one 6-No. 22 AWG conductor group, one 8-No. 26 AWG conductor group and a two twist pair 4-No. 26 AWG conductor group in a common outer jacket. The hybrid camera cable cross section is shown on the plans.

The Coaxial cable shall conform to:

Electrical	Coax
Capacitance (picofarads/m nominal)	5.2
Impedance (ohms-nominal)	75
Velocity of propagation (nominal)	78 percent
Nominal Diameter (mm)	6.2
Insulation Rating	300 V

The cable attenuation at 20 C shall measure at maximum as:

Frequency (MHz)	Nominal dB/30.5 m
1	0.30
10	0.90
50	2.10

The coaxial cable physical measurements:

Component	Nominal O.D. (mm)
Copper center conductor	1.0
Foam polyethylene dielectric	4.6
Sealed APA tape with 1.5 mm overlap	5.5
Woven aluminum braid	6.1
PVC outer jacket	7.5

(APA = Aluminum polyolefin and aluminum with adhesive)

The 6-No. 22 AWG shall be stranded 7 x 30, tinned copper insulated with 0.29 mm nominal wall of S-R PVC and a nominal O.D. of 1.2 mm. The 6 conductors shall be color coded as follows:

1. Black
2. Red
3. Green
4. White
5. Blue
6. Yellow

The 8-No. 26 AWG shall be stranded 7 x 34, tinned copper insulated with 0.29 mm nominal wall of S-R PVC and a nominal O.D. of 9.4 mm. The 8 conductors shall be color coded as follows:

1. Brown
2. Blue
3. Orange
4. Yellow
5. Purple
6. Gray
7. White with Black Stripe
8. Red with Green Stripe

The 4-No. 26 AWG in 2 twisted pairs shall be stranded 7 x 34, tinned copper insulated with 0.29 mm nominal wall of S-R PVC and a nominal O.D. of 9.4 mm. The 4 conductors shall be color coded as follows:

Pair 1

1. Black
2. White

Pair 2

3. Red
4. Green

The HCC shall also have a 36 AWG tinned copper braid with 90 percent coverage, an O/A binder of 0.0255 mm polyester 25 percent overlap, and an outer jacket conforming to: color to match Fed-Std-595 color No. 24091, material 0.81 mm dark gray UV resistant PVC to 10.8 mm O. D. and must pass the VW-1 vertical flame test. Fillers shall be used as required to form a uniform round cable. The insulation rating of the overall cable jacket shall be 300 V.

The manufacture identification shall be surface printed in white ink every 305 mm along the length of the cable.

The HCC shall be continuous from the integrated camera unit to CCU in the controller cabinet without splicing, unless shown on the plan or approved by the Engineer. The maximum length of HCC is 230 m.

The HCC shall be terminated with cable connectors on both ends. Connector AMP 206036-3 with a full set crimp contact pins and strain relief back shell, AMP 206070-1 shall be installed on the cable end toward CCU. Connector AMP 206037-1 with a full set crimp contact sockets and strain relief back shell, AMP 206070-1 shall be installed on the cable end toward the integrated camera unit. All connector contact shall be constructed with brass contact body material and with stainless steel spring that are sub-plated with 0.00127 mm nickel and plated with 0.00076 mm gold. Contact size shall be 16. AMP No. 305183 contact extraction tool shall be used to replace contact. AMP hand tool assembly 58495-1 with die assembly 58495-2 shall be used to place contacts on to each conductor. No other tool, unless approved by the Engineer shall be used for this work.

INSPECTION AND TESTING

Testing of HCC and connectors shall be performed in accordance with provisions in Section 86-2.14B, "Field Testing" of the Standard Specifications and these special provisions. Any cable lengths found to have faults shall be

replaced and retested. The Contractor shall dispose of the removed faulty cable. The cable termination shall be randomly inspected for contact crimping quality control. Any contact found not crimped with the correct crimping tool and is defect shall be rejected. The Contractor shall redo the termination until all defects are corrected.

Prior to the beginning of work, the coaxial cable length of HCC shall be tested for attenuation and faults to ensure compliance with specifications contained herein using a time domain reflectometer (TDR). For the purpose of these special provisions, one or more of the following defines a fault in a long length of cable:

a. Return loss measurements indicating that attenuation exceeds 3 dB at 5 MHz to 30 MHz in a portion of cable less than 3 m long.
b. A return loss measurement indicating that there is a short in the cable.
c. A return loss measurement indicating a cut or open circuit in the cable.
d. A visual inspection that reveals exposure of or damage to the cable shielding.

INTERFACE CABLES

GENERAL

All interface cables when required to interface with other equipment as shown on the plan shall be minimum of 1.8 m in length. All interface cables shall be commercially made high quality type with appropriate connectors on the cable ends as shown on the plans.

NETWORK STRAIGHT THROUGH DATA CABLE

The network straight through data cable shall be made of Ethernet twisted pair cable (ETPC) and terminated with an 8-conductor, RJ-45 modular plug on both ends. ETPC shall consist of 4 unshielded twisted pair (UTP) No. 24 AWG stranded copper conductors insulated with high-density polyethylene (PE). The insulated conductors shall be tightly twisted into individual pairs and jacketed with PE or PVC. Each Ethernet cable shall be compliant with EIA/TIA-568B Category 5E standards. The maximum DC resistance shall be 0.008 Ω/m at 20 °C. The mutual capacitance shall be 4.07 pF/m nominal. The characteristics impedance shall be 100 Ω ±15 percent from 1 MHz to 100 MHz.

The data cable shall be color coded as follows:

PAIR	COLOR CODE (TIP//RING)	8-position RJ-45 Modular Plug's No. (TIP//RING)
1	White/Blue Stripe // Blue	5//4
2	White/Orange Stripe // Orange	3//6
3	White/Green Stripe // Green	1//2
4	White/Brown Stripe // Brown	7//8

VIDEO PATCH CABLE

The video patch cable shall be RG-59/U coaxial cable terminated at both end with BNC connectors. The coaxial cable shall conform to:

Electrical	Coax
Capacitance (picofarads/m nominal)	5.2
Impedance (ohms-nominal)	75
Velocity of propagation (nominal)	78 percent
Nominal Diameter (mm)	6.2

The cable attenuation at 20 °C shall measure at maximum as:

Frequency (MHz)	Nominal dB/ 30.5 m
1	0.30
10	0.90
50	2.1

The coaxial cable physical measurements:

Component	Nominal O.D. (mm)
Copper center conductor	1.0
Foam polyethylene dielectric	3.7
Sealed APA tape with 1.5 mm overlap	5.5
Bare copper braid	6.1
PVC outer jacket	7.5

(APA = Aluminum polyolefin and aluminum with adhesive)

EIA-232 DATA PATCH CABLE

The EIA-232 data patch cable shall meet EIA-232 standard. The data cable shall have multiple No. 20 AWG conductors with (UL) Type CM shielded or AWM 2464 80C 300 Volts – C (UL). One end of data cable shall be terminated with a DB9 female connector. All contact socket pins shall be gold plated. The contact pin assignment is shown on the plans. The other end of the data cable shall be either terminated with an 8-conductor, RJ-45 modular plug or not terminated. When there is no connector required on the other end of cable, each conductor's insulation shall be stripped 6.4 mm long from the end of cable and the bare conductor shall be tinned with solder.

FIBER PATCH CABLE

The fiber patch cable shall be single mode tight buffer tube indoor rated cable with ST connectors terminated on both ends. The fiber patch cable shall have yellow color in its outside jacket.

RACK-MOUNT POWER STRIP

ELECTRICAL

Each rack-mount power strip shall meet the following requirements:

1. A maximum rating of 15 A, 120 V(ac), 60 Hz.
2. A surge protection with UL 1449 Clamping Level of 400 V, an IEEE Let-Through Voltage rating of less than 336 V, a single-pulse energy rating of 210 J and EMI/RFI noise protection rating of 40 dB.
3. One 15 A circuit breaker.
4. One internally illuminated switch to cut off power to all outlets.
5. Six NEMA 5-15R outlets.

MECHANICAL

Each rack-mount power strip shall meet the following requirements:

1. Dimensions of 51 mm (H) x 483 mm (W) x 71 mm (D) maximum and shall not weigh more than 2.0 kg .
2. The front plate of the power strip shall have two cut-off EIA mounting screw holes on each end.
3. Each outlet shall have 38 mm minimum spacing center-to-center to its adjacent outlet.
4. The power cord shall enter from the rear with a length of 2.1 m minimum.
5. The clearance between the power cord entrance and the nearest outlet shall be 86 mm minimum.
6. Both the circuit breaker and the switch shall be front-mounted.
7. Each outlet shall be rear-mounted.

The power strip shall be plugged into the non-GFCI duplex outlet normally labeled with "Controller Unit Receptacle" in the back of the Power Distribution Assembly (PDA). The power strip shall be mounted on the rear of the standard EIA-310 rack cage and across the two vertical back rails with four stainless steel EIA mounting screws, two on each side. The power strip shall not hinder the accessibility to the back of all existing electrical equipment. All power cords for permanently field installed electrical equipment shall be plugged into the power strip.

CAMERA CONTROL UNIT

GENERAL

The Contractor shall furnish and install Camera Control Units (CCU) at each field CCTV assembly location. The camera control units shall consist of a rack-mounted field unit. The camera control unit shall have the same manufacturer as the integrated camera unit. The camera control unit shall be designed to provide on-site camera control functions. The control functions shall include pan/tilt positioning, zoom in/out control, auto/manual focus, and auto/manual iris.

CCU shall include a local/remote switch that transfers control from the remote system to local. This shall allow the remote control system and the CCU to remain connected while transfer the control function without disconnection of the camera site equipment. The local function shall time-out and return to remote mode in 10 minutes.

LED indicators on the CCU shall provide positive feedback of the automatic and manual mode status of the camera focus and iris functions, and the manual mode status of the pan/tilt function.

PHYSICAL AND MECHANICAL REQUIREMENTS

Each CCU shall mount in 51 mm (1 rack unit) of EIA-310 rack space with a maximum depth of 356 mm. The front panel shall be black gloss color Number 17986 as per Federal Standard Color Chart 595B. The front and rear panel lettering shall be white color Number 17886 as per Federal Standard Color Chart 595B.

A high-impedance front and rear panel jack bayonet nut connector (BNC) shall be installed on the front and rear panel as shown on the plans. These connectors shall provide video input to a test monitor without affecting the remainder of the CCTV system. These connectors shall be directly monitoring the video input from the camera. The connectors shall be of copper material with bright nickel (tarnish resistant) finish for the body and silver finish for the contact.

A automobile glass (AG), size 6.4 mm x 31.8 mm, slow blow fuse shall be installed and replaceable from the outside of the unit.

Switches shall protrude no more than 12.7 mm from the front panel and shall be mounted as shown on the plans. Each switch shall be labeled as to their functions.

The rear panel connectors shall be mounted as shown on the plans and shall meet the following requirements:

1. Camera Connector shall be of the following type or equivalent: AMP 206037-1, Square Flange type. The socket contacts for camera connector shall be constructed with brass contact body material and with stainless steel spring that are sub-plated with 0.00127 mm nickel and plated with 0.00076 mm gold. Contact size shall be 16. AMP No. 305183 contact extraction tool shall be used to replace contact.
2. The EIA-232 connectors shall be a DE9 pin connector and EIA-422 connector shall be a DE9 socket connector.
3. One mating connector, AMP 206036-3 with a full set crimp contact pins and strain relief back shell, AMP 206070-1 shall be supplied with each CCU supplied in the contract.

The Contractor shall provide all necessary interface cables for CCU to connect to all other camera equipment.

Each LED shall be equal to Hewlett Packard High Intensity Untinted, Non-diffused LED. Each LED shall be mounted as shown on the plans.

An on/off switch to turn the CCU on/off shall be provided. An LED to indicate the AC power is on shall be provided.

Each CCU shall not weight more than 2.3 kg.

ELECTRICAL REQUIREMENTS

Camera Control Functions

Each CCU shall have circuitry to detect the absence and presence of video sync on its video input. Each CCU shall have auto-iris override. Each CCU shall have a transfer switch between local and remote mode. The local function shall time-out and return to the remote mode within 5 minutes. A system-reset switch with momentary-pushbutton type shall be mounted on the front panel to function as external reset input to the microprocessor. The system-reset shall exercise the pan and tilt movements through their ranges and return the camera to the prior position. The system-reset function shall allow remote execution.

The CCU shall have, as a minimum, control and drive circuits for the following camera control functions:

Control Function	Switch Position
Pan momentary toggle switch	Left-Stop-Right
Tilt momentary toggle switch	Up-Stop-Down
Zoom In/Out momentary toggle switch	Telephoto-Stop-Wide Angle
Focus Automatic/Manual momentary toggle Switch	Auto Focus -Manual
Manual Focus toggle Switch	Near-Stop-Far
Iris Automatic/Manual toggle Switch	Auto Iris -Manual Override
Manual Iris toggle Switch	Open-Stop-Close
Remote/Local momentary toggle Switch (Local function shall time-out and return to remote mode in 10 Minutes)	Remote-Local
Reset momentary push button switch	Reset

Camera Connector Contact Assignment:

Position	Function	Position	Function
1	Video, 75 ohm	9	Not Used
2	Video Ground	10	Not Used
3	Data Ground	11	Not Used
4	Rx-	12	115 V(ac), Hot
5	Rx+	13	115 V(ac), Neutral
6	Tx+	14	Not Used
7	Tx-	15	115 V(ac), Ground
8	Not Used	16	Not Used

EIA-232 Connector Contact Assignment (DE9 Pins):

Position	Function	Position	Function
1	Not Used	6	Not Used
2	Receive Data, Rx	7	RTS
3	Transmit Data, Tx	8	CTS
4	Not Used	9	Not Used
5	Signal Ground		

EIA-422 Connector Contact Assignment (DE9 Sockets):

Position	Function	Position	Function
1	Tx+	6	Signal Ground
2	Tx-	7	Not Used
3	Signal Ground	8	Not Used

4	Rx+	9	Not Used
5	Rx-		

Communication and Camera Addressing Protocol

The execution of CCU functions, other than the hardware controls on the front panel, shall be done through either EIA-232 or EIA-422 optically isolated serial communication ports on the back panel. A minimum 9,600-baud data rate shall be used. The CCU shall have a front panel EIA-232 port for connection to a local laptop computer. The (NTCIP) 1205 MIB communications protocol shall be included.

The communications between CCU and the integrated camera unit shall be conducted through an EIA EIA-422 circuit with full handshake support. A minimum 9,600-baud data rate shall be used. The CCU shall be 100 percent compatible with the protocol and data backbone architecture.

Power Consumption

The maximum power consumption for the CCU shall not exceed 45 W. Power consumption of equipment attached to CCU shall not exceed 250 W.

CCU to Laptop PC Cable

The Contractor shall furnish and install a universal serial bus (USB) to EIA-232 serial adapter at each camera location. The adapter shall have a DE9 socket connector for EIA-232 and Type A plug connector for USB. The Contractor shall also supply a 1.8 m straight through USB extension cable. The USB function shall conform to version 2.0. The Contractor shall submit the adapter software in 1 GB Secure Digital (SD) card format.

ENVIRONMENTAL REQUIREMENTS

Each CCU shall operate in an ambient temperature environment of –34 °C to +74 °C and up to 90 percent relative humidity. Each CCU shall pass 5 Gs, 11 ms, in any axis under non-operating conditions, MIL-E-5400T, para 3.2.24.6 shock test. Each CCU shall pass vibration tests**:**

1. Sine vibration from 5 to 60 Hz with 2.1 mm total excursion without damage.
2. Random vibration from 60 to 1,000 Hz, 5 Gs RMS (0.027-G2/Hz) without damage.

VIDEO ENCODER UNIT

GENERAL

A prototype of the video encoder unit (VEU) is not acceptable. All equipment shall be off-the-shelf production units. All equipment shall be new and not previously used. The Contractor shall provide a Service and Operation manual describing the operation, maintenance of the VEU for each unit provided in the contract. The Contractor shall provide all necessary interface cables to connect communication equipment and the camera control unit (CCU) for a complete and successful installation and operation of the VEU, and as shown on the plans.

ABBREVIATIONS

LED	Light Emitting Diode
AC	Alternating Current
SNMP	Simple Network Management Protocol
TELNET	TELecommunication NETwork
CLI	Command Line Interface
NTSC	National Television System Committee
SIF	Source Input Format
QSIF	Quarter Source Input Format
CIF	Common Intermediate Format
QCIF	Quarter Common Intermediate Format

BNC	Bayonet Nut Connector
RJ	Registered Jack
IP	Internet Protocol
DHCP	Dynamic Host Configuration Protocol
bps	Bits Per Second
fps	Frame Per Second
MPEG	Motion Picture Experts Group
ISO	International Organization for Standardization
IEC	International Electrotechnical Commission
DiffServ (QoS)	DIFFerentiated SERVices (Quality Of Service)
UDP	User Datagram Protocol
RTP	Real-time Transport Protocol
RTSP	Real Time Streaming Protocol
RTCP	Real-time Transport Control Protocol
HTTP	HyperText Transfer Protocol
MIL	MILitary
NEMA	National Electrical Manufacturers Association

PHYSICAL AND MECHANICAL REQUIREMENTS

The VEU shall be mountable in a standard EIA-310 equipment rack or can be a stand-alone unit which shall be mounted to a standard EIA-310 equipment shelve. The VEU and shelve if any shall fit in 133.4 mm of a standard EIA-310 equipment rack space. Each VEU shall have all the cable connections on the rear of the unit. A main power switch to turn the unit on/off shall be provided. An LED to indicate the AC power on shall be provided.

ELECTRICAL REQUIREMENTS

The VEU shall be able to be remotely managed, configured and maintained without the use of any third party software with the management and performed using SNMP, TELNET and CLI. The VEU shall operate with both color and black/white video input signal without modification to the hardware.

The input video resolution of the VEU shall be the following:

Video Resolution	NTSC
SIF	352 x 240
QSIF	176 x 128
CIF	N/A
QCIF	N/A
Custom	64 x 48
Custom	128 x 96
Custom	192 x 144
Custom	256 x 192
Custom	352 x 240

The input video formats of the VEU shall be composite NTSC with 525 lines at 60 Hz. The VEU shall have a minimum of one composite video input. The input video connector shall be compatible with EIA-170 at 75 ohms impedance with Bayonet Nut Connector (BNC) type.

The network communication interface of the VEU shall be Ethernet 10/100 Mbps through RJ-45 connector port, either in static IP or assigned through DHCP.

The camera control data interface shall include a Maintenance Serial Port for local maintenance and a Control Serial Port for Data transport. The port shall be EIA-232 at a user selectable data rate from 1,200 to 56,000 bps, asynchronous. The connector type for the port shall be a DB9 pin type.

The VEU shall provide bandwidth for camera control within the bandwidth allocated for video only when bandwidth is needed for camera control/status data transmission.

The video compression of the VEU shall meet MPEG 4-ISO/IEC 14496-2 (1999) standard. The MPEG-4 compliant levels are:

1. Level 1 – up to 64 Kbps
2. Level 2 – up to 128 Kbps
3. Level 3 – up to 384 Kbps

The video rates of the VEU shall be scaleable from 1 fps to 30 fps and from 8 Kbps to 2 Mbps. User selectable options are:

1. Constant Bit rate at Constant Frame rate
2. Variable Bit rate at Constant Frame rate
3. Constant Bit rate at Variable Frame rate

The video delivery options of the VEU are either unicast or multicast with protocols DiffServ (QoS), UDP, IP, RTP, RTSP, RTCP, HTTP, SNMP, TELNET and CLI.

POWER REQUIREMENTS

The VEU shall operate between voltage 89 V(ac) to 135 V(ac), 120 V(ac) nominal voltage and 50 or 60 Hz (±3.0 Hz). The VEU shall conform to NEMA standard TS-2 (1998) for traffic control system 2.1.2. The VEU shall meet the requirements of Section 2.1.6 "transients, power service" of the NEMA standard TS-2 (1998). The line variation and surge performance shall be tested to meet these specifications by an outside agency, other than the VEU manufacturer. The test results shall be provided upon request. The power consumption shall not exceed a total 25 watts.

ENVIRONMENTAL REQUIREMENTS

Each VEU shall operate in an ambient temperature environment of –20 °C to +70 °C and up to 90 percent relative humidity. Each VEU shall pass 5 Gs, 11ms, in any axis under non-operating conditions, MIL-E-5400T, para 3.2.24.6 shock test. Each VEU shall pass vibration tests**:**

1. Sine vibration from 5 to 60 Hz with 2.1 mm total excursion without damage.
2. Random vibration from 60 to 1,000 Hz, 5 G's RMS (0.027-G2/Hz) without damage.

EQUIPMENT SHELF WITH BRACKETS

The Contractor shall furnish and install each equipment shelf as shown on the plans.

Each shelf shall be furnished with 2 mounting brackets.

Each mounting bracket shall extend from the front to back mounting rails of the controller cabinet rack cage. Each bracket shall be designed to support a minimum of 22.7 kg. The horizontal side of each bracket shall be a minimum of 76.2 mm. Each bracket shall be attached to front and rear of the rack cage with four (4) 10-32 stainless steel Phillips round head bolts.

Each shelf shall be fabricated of 3.2 mm cold rolled sheet or 3.2 mm aluminum sheet. Each shelf shall be the width of the control cabinet rack cage and 457 mm deep. Each shelf shall have equally distributed holes or slots throughout the shelf that shall provide 40 percent minimum open area for vertical flow-through ventilation. Each hole or slot shall not exceed 484 square millimeters in area. Each shelf shall be cadmium-plated or zinc-plated after cutting and drilling.

Each shelf shall be attached to the top of its pair of brackets in all four corners with stainless steel hardware, with the front of the shelf abutting against the front rail of the control cabinet rack cage.

FIBER OPTIC TRANSMITTERS AND RECEIVERS

GENERAL

When fiber optic transmitters (FOTS) are connected to fiber optic receivers (FORS) via a fiber optic link, they shall support a minimum optical loss budget of 14 dB including system margin over a single mode fiber. The data channels shall be multiplexed and transmitted digitally with the video channel. The data channels shall support EIA-232 full duplex with data rate capability up to 9.6 kbps. The units shall use PFM, FM, FDM, FSK and digital techniques. The result shall be high quality, crosstalk free, adjustment free operation over a wide dynamic range. There shall be no variations in the video output level due to fiber attenuation, variation because of LED aging, optical "slip rings", dynamic cable layout, or environmental factors. The units shall be optimized for single-mode 8.3/125 µm fiber operating in the 1300 nm optical window. The optical connectors shall be of the ST-compatible type.

Each transmitter and receiver shall have sync and loop back indicators in its front face panel for visual verification of bi-directional operation.

PERFORMANCE REQUIREMENTS

The baseband video signal output from the video/data receivers when it is receiving an optical signal from the video/data transmitters at an average power level equal to the video/data receiver sensitivity shall meet the following performance specifications defined and measured in accordance with EIA-250 for Short Haul Transmission System for End-to-End modified performance.

Output Signal Level	as per EIA- 250
Amplitude Vs Frequency Characteristics	as per EIA- 250
Chrominance to Luminance Gain Inequality	as per EIA- 250
Chrominance to Luminance Delay Inequality	as per EIA- 250
Field Time Waveform Distortion	as per EIA- 250
Line Time Waveform Distortion	as per EIA- 250
Insertion Gain Variation	as per EIA- 250
Differential Gain	as per EIA- 250
Differential Phase	±2 degrees
Signal-to-noise ratio	50 dB weighted
Signal-to-low frequency noise ratio	as per EIA- 250

PHYSICAL AND MECHANICAL REQUIREMENTS

Each FOTS shall have the capability of transmitting one simplex composite NTSC baseband video channel, three full duplex data channels and one bi-directional audio channel over a single-mode optical fiber. Each FOTS shall accept a composite NTSC video input as well as provide input/output for full duplex data and audio. The FOTS shall utilize cooled 1300 nm laser diodes with at least -14 dBm and the spectral line width of less than or equal to 5 nm.

Each FOTS shall have the following interfaces/provisions:

1. Video interface that shall be via a BNC connector.
2. Data channel interface that shall be via an 8-position, 8-connector modular jack (RJ45).
3. An audio interface port compatible with unbalanced and balanced 0 dBm, 600 Ω, 4 wire line. The audio interface shall be via an 8-position , 8-connection modular jack (RJ45).
4. A handset port compatible with standard telephone set equipped with carbon microphone. The handset port shall consist of a 4-position, 4-connection modular jack.

Each FORS shall have the capability of receiving one simplex composite NTSC baseband video channel, three full duplex data channels and one bi-directional audio channel from a single-mode optical fiber. Each FORS shall provide a composite NTSC video output as well as provide input/output for full duplex data and audio.

Each FORS shall have the following interfaces/provisions:

1. Video interface that shall be via a BNC connector.
2. Data interface that shall be via an 8-position, 8-connector modular jack (RJ45).
3, A harness with the modular jacks and screw terminal connectors for the audio and data signals The harness shall be fully compatible with the FDU and FORS as specified in these special provisions.

The I/O for each FORS shall correspond to the following configuration on the RJ45 jack of the harness. Single ended or differential transmission shall be selected by DIP-switches on the FORS.

RJ45 CONTACTS	EIA-232	EIA-422
1	NC	NC
2	CTRL OUT	NC
3	TxD	TxD-
4	RxD	RxD-
5	GND	RxD+
6	GND	TxD+
7	CTRL IN	NC
8	NC	NC

3. Each FORS shall provide an audio interface port compatible with unbalanced and balanced 0 dBm, 600 Ω, 4 wire line. The audio interface shall be via an 8-position , 8-connection modular jack (RJ45).
4. Each FORS shall provide a handset port compatible with standard telephone set equipped with carbon microphone. The handset port shall consist of a 4-position, 4-connection modular jack and shall be located on the front panel of each FORS.

Each FOTS and FORS shall be housed in a compact stand-alone enclosure with side flanges and shall be shelf mountable.

Each FORS shall be a chassis mount card unit which plug in to EIA-310 rack space card cage. The unit shall permit the installation or removal of cards with the power applied without affecting other cards in the card cage.

Each FOTS shall be powered by regulated +12 V(dc) at 370 to 480 mA. An AC to DC wall mount adapter may be used for powering from 120 V(ac), 60 Hz.

The card cage for the FORS shall be powered by dual regulated 120 V(ac), 60 Hz AC to +12 V(dc). power supplies.

ENVIRONMENTAL REQUIREMENTS

Each FOTS and FORS shall be fully operational over a temperature range of -30°C. to +70°C. and shall withstand a humidity range from 0 to 95 percent without condensation.

SERVICE MANUAL REQUIREMENTS

The Contractor shall provide to the Engineer a minimum of 5 copies of service manuals for the integrated camera unit, camera control unit (CCU), video encoder unit (VEU) and video decoder unit (VDU) under this special provisions. Each manual shall contain the following sections and sub-sections.

General information section

a. A list of applicable subassemblies that comprise the specified equipment.
b. Overall description of the equipment design features (including all enhance features if applicable), performance, and applications.
c. Equipment specifications summary.
d. Equipment installation instructions.

Theory of operations section

a. Theory of operation of the standard equipment, with unique or unusual circuitry described in detail.
b. Theory of operation reflecting any modifications to the standard equipment.

Maintenance section

a. Recommended test equipment and fixtures, or minimum operational and performance requirements for appropriate test equipment.
b. Trouble shooting information and charts.
c. Removal and installation procedures for replacing assemblies and subassemblies, if not obvious or if improper sequencing of steps may result in component damage.

Replacement parts section

a. Each manual shall contain an equipment replacement parts list including electrical parts, mechanical parts and assemblies.
b. All semiconductors shall be identified by the supplier's numbers and by Joint Electron Device Council (JEDEC) numbers if applicable.

Diagram section

a. Schematic diagram(s) identifying all circuit components and showing normal test voltages and levels.
b. An overall functional block diagram.
c. Detailed interconnecting diagram(s) showing wiring between modules, circuit boards and major components.
d. Pictorial circuit board layout diagram(s) showing both component placement and printed wiring detail.
e. Diagram(s) showing location of circuit boards and other subassemblies.
f. Exploded view diagram(s) of complex mechanical assemblies.

Physical requirements

a. All pages, including latest revisions, shall be securely fastened together between protective covers (loose-leaf ring binding is acceptable).
b. No page shall be subject to fading from exposure to any normal source of ambient lighting (ozalid reproduced pages are not acceptable).

MICROWAVE VEHICLE DETECTION SENSOR SYSTEM

The Contractor shall install the following microwave vehicle detection sensor (MVDS) equipment at each location as described in these special provisions and as shown on the plans:

A. Microwave detector units, connectors, cables, conduit, pull box, mounting equipment, software, firmware, power supply units and all other support equipment.
B. One State-furnished Model 334 controller cabinet (described elsewhere in these special provisions).
C. One fiber optic data modem (described elsewhere in these special provisions).

Functional Requirements

The MVDS signal shall emulate the response of an inductive loop detector. The MVDS units shall be tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC rules. Each MVDS unit shall operate independently and not interfere with other MVDS units.

The microwave sensor unit shall operate in the frequency band of 10.525 GHz ± 25 MHz. The transmitter power shall be a maximum of 10 mW.

The MVDS field of view shall be covered by a maximum detection range defined as follows:

Elevation beam-width	45 degrees
Azimuth beam-width	15 degrees
Range	3 to 60 meters

Each MVDS unit shall have the capability of providing a minimum of 8 detection zones within each beam footprint. The size of each zone shall be user definable with a maximum range resolution of 2 meters. The minimum footprint shall be greater than or equal to 1.8 meters.

The time of events shall be measured in a maximum of 10 ms resolution.

Measurement accuracy shall be better than 95 percent certainty for vehicle presence.

Each MVDS unit shall be supplied with a connectorized MVDS cable harness with appropriate cable length for each installation. The MVDS cable shall consist of 15 unshielded twisted pairs of No. 20 conductors with an overall shield. Each conductor shall have a minimum of 19 tinned copper strands with a minimum of 1.60 mm PVC insulation rated for 300 V at 105˚C. The outer jacket shall be chrome PVC with minimum thickness of 1.60 mm. The outside diameter of the cable shall not exceed 19.2 mm. A minimum of 4 meter slack of MVDS cable is required in each controller cabinet.

The connector shall be in conformance with Military Part Numbering System Designation: MS3476W18-32S or equivalent. This connector shall include contacts for powering the sensor unit, RS-232 serial data communications and contact pairs for each detection zone. The connector pinout is as follows:

No.	Pin No.	Designation	Signal	Remark
1	A	Contact Closure	Opto 1	
2	B	Contact Closure	Opto 1 Return	
3	C	Contact Closure	Opto 2	
4	D	Contact Closure	Opto 2 Return	
5	E	Contact Closure	Opto 3	
6	F	Contact Closure	Opto 3 Return	
7	G	Contact Closure	Opto 4	
8	H	Contact Closure	Opto 4 Return	
9	J	Contact Closure	Opto 5	
10	K	Contact Closure	Opto 5 Return	
11	L	Contact Closure	Opto 6	
12	M	Contact Closure	Opto 6 Return	
13	N	Contact Closure	Opto 7	
14	P	Contact Closure	Opto 7 Return	
15	R	Contact Closure	Opto 8	
16	S	Contact Closure	Opto 8 Return	
17	d	Contact Closure	Opto 9	
18	e	Contact Closure	Opto 9 Return	
19	f	DC Power	12-24 VDC +	
20	g	DC Power	12-24 VDC -	
21	h	AC Power	115 VAC +	Not Used
22	j	AC Power	115 VAC -	Not Used
23	V	RS-232 p2	Tx	
24	T	RS-232 p3	Rx	
25	U, W	RS-232 p5	Signal Ground	
26	b	Auxiliary	+5VDC Out	Not Used
27	c	Auxiliary	+5VDC Out Return	Not Used
28-32				Spares

The Contractor shall wire the MVDS cable harness and power conductors to the 10-position Type DIN rail mounted terminal blocks in the controller cabinet as directed by the Engineer. The RS-232 serial data communication output conductors shall be terminated at the service panel terminal block, TB-0. The contact pair output conductors shall be terminated at the input panel terminal block, TB-2. The ends of all unused and spare conductors shall be taped to prevent accidental contact to other circuits.

All software for testing and set-up procedures shall be supplied with the MVDS unit. The software shall test the MVDS unit performance and provide diagnostic information.

Operational Requirements

The Contractor shall provide a certification from the manufacturer that the MVDS unit will interface and operate with a Model 170 controller. In addition, the MVDS unit shall meet the following requirements:

A. Electrical

The unit shall operate with 12-24 VDC at 0.5 A power source. The unit shall have a feature of automatic recovery after a power failure.

B. Physical

The unit shall be encased in a weatherproof NEMA-3R enclosure. The unit shall not exceed 160 mm x 240 mm x 250 mm in size and shall not weigh more than 4.5 kg. The unit shall operate over a temperature range from -37˚C to +74˚C, up to 95 percent relative humidity.

C. Pull Box

A pull box shall be installed with conduit connections as shown on the plans.

D. Installation and Testing

Prior to installing any MVDS units, the Contractor shall perform functional tests to verify that all MVDS units comply with these specifications. The MVDS units shall be installed as shown on the plans and in accordance with the manufacturer's recommended installation procedures. The Contractor shall confirm equipment placement with the Engineer before installing any equipment. The Contractor shall test the MVDS units for the following functions:

1. Speed, volume and occupancy for all roadway monitoring locations.
2. Correct speed and count readings of roadway traffic with a portable detection equipment.

STATE-FURNISHED CONTROLLER ASSEMBLIES

The Model 170 controller assemblies, including controller unit and completely wired controller cabinet will be State-furnished as provided under "Materials" of these special provisions.

The Contractor shall install the controller cabinet on each service platform, including furnishing and installing anchor bolts, and shall make field wiring connections to the terminal blocks in the controller cabinet.

A listing of field conductor terminations, in each State-furnished controller cabinet, will be furnished free of charge to the Contractor at the site of the work.

State forces will maintain controller assemblies. The Contractor's responsibility for controller assemblies shall be limited to conforming to the provisions in Section 6-1.02, "State-Furnished Materials," of the Standard Specifications.

Controller Assemblies Power Strip (Contractor-furnished)

The Contractor shall furnish and install one rack-mount surge power strip with a switch in each State-furnished Model 334 controller cabinet. The power strip shall be plugged into the non-GFCI duplex outlet normally labeled with "Controller Unit Recp." in the back of the power distribution assembly (PDA) unit. The power strip shall be mounted at the top of the standard EIA-310 rack cage and across the two vertical back rails with four stainless steel EIA mounting screws, two on each side. The power strip shall not hinder the accessibility to the back of all existing electrical equipment. All power cords for permanently field installed electrical equipment shall be plugged into the power strip.

The power strip, at a minimum, shall meet the following requirements:

A. Maximum rating of 15 A, 120 V(ac), 60 Hz.
B. The power strip shall have a surge protection with UL 1449 Clamping Level of 400 V, an IEEE Let-Through Voltage rating of less than 336 V, a single-pulse energy rating of 210 J and EMI/RFI noise protection rating of 40 dB.
C. The power strip shall be 46 mm (H) x 483 mm (W) x 70 mm (D) maximum and shall not weigh more than 2.0 kg.
D. The front plate of the power strip shall have four cut-off EIA mounting screw holes, two on each side.
E. The power strip shall have six rear outlets with 38 mm minimum apart center to center. The power cord shall enter from the rear with a length of 2 meters minimum. The clearance between the power cord entrance and the nearest outlet shall be 90-mm minimum.
F. It shall have a 15 A circuit breaker and an internally illuminated switch to cut off power to all outlets. Both the circuit breaker and the switch shall be front mounted.