

**TABLE OF CONTENTS**  
**PART II – CONSTRUCTION MATERIALS AND METHODS**  
**Section 50**

**TRAFFIC**

<b><u>SECTION</u></b>	<b><u>TITLE</u></b>	<b><u>PAGE</u></b>
<b>50.1</b>	<b>TRAFFIC CONTROL PLANS</b>	<b>50.1</b>
	50.1.1 General	50.1
	50.1.2 Traffic Control Devices	50.2
	50.1.3 Roadway Closures and Partial Closures	50.2
	50.1.4 Typical Construction Zone Drawings	50.5
<b>50.2</b>	<b>TRAFFIC CONTROL MATERIALS</b>	<b>50.5</b>
	50.2.1 Signal Heads	50.5
	50.2.2 Back Plates	50.7
	50.2.3 Traffic Signal Lamps	50.6
	50.2.4 Electrical Cable	50.7
	50.2.5 Detectors	50.7
	50.2.6 Pedestrian Push-Button	50.10
	50.2.7 Traffic Signal Poles, Pedestals and Mastarms	50.10
	50.2.8 Controller Cabinet	50.11
	50.2.9 Controllers	50.14
	50.2.10 Uninterrupted Power Supply (UPS)	50.16
	50.2.11 Aluminum Pedestal Mounts	50.19
	50.2.12 Mast Arm Cabinets	50.19
	50.2.13 Instructions and Wiring Diagrams	50.20
	50.2.14 Guarantee	50.20
<b>50.3</b>	<b>SYSTEM COMMUNICATIONS</b>	<b>50.20</b>
	50.3.1 Ethernet Managed Switch	50.20
	50.3.2 Radio/Wireless Communications	50.20
	50.3.3 Traffic Signal Interconnect Cable – Fiber Optic	50.21
	50.3.4 Fiber Optic Splicing and Terminations	50.26
	50.3.5 Testing, Identification and Administration of Fiber Optic Infrastructure	50.28
	50.3.6 Hardwire Interconnect	50.42
<b>50.4</b>	<b>TRAFFIC CONTROL CONSTRUCTION STANDARDS</b>	<b>50.43</b>
	50.4.1 Traffic Signals	50.43
	50.4.2 Regulation and Code	50.44
	50.4.3 Equipment List and Drawings	50.45
	50.4.4 Excavating and Backfilling	50.45
	50.4.5 Removing and Replacing Improvements	50.45
	50.4.6 Underground Facilities	50.46
	50.4.7 Traffic Signing and Pavement Markings	50.52

**PART II - CONSTRUCTION MATERIALS AND METHODS**  
**SECTION 50**

**TRAFFIC**

**50.1 TRAFFIC CONTROL PLANS**

50.1.1 General

Where the Contractor's work requires either partial or complete closure of any public street, road, highway, alley or sidewalk, the Contractor shall submit a Traffic Control Plan to the Engineering Division for approval at least 48 hours in advance of the actual closure. If the Engineering Division approves the complete closure of an arterial or collector street, the Traffic Control Plan shall be submitted 14 days in advance of the actual closure, so that there will be sufficient time for public notification. The Contractor shall notify the City Police Dispatcher and Arvada Fire Protection District at the time the closure is done and again when the street is reopened. These Specifications shall apply to all new construction within the City of Arvada.

Where the control and maintenance of traffic has not been performed as specified in the Special Conditions and/or the Contractor does not conform to the Engineering Code of Standard and Specifications for the Design and Construction of Public Improvements established by the City of Arvada, the Project Engineer shall act to provide for the control and maintenance of traffic as directed by the City Engineer or designee. All costs incurred by the City shall be borne by the Contractor.

The Traffic Control Plan will be prepared by the Contractor for review by the Engineering Division. No work shall commence without an accepted TCP. Any changes to the TCP must be approved by the City Engineer or designee prior to implementation. The TCP will be reviewed with the Contractor or job superintendent. The Traffic Control Plan shall include:

- A. Identification of construction zone (work area)
- B. Scheduling (start/completion date)
- C. Signs (the size and type to be used and their location relative to the work area)
- D. The method and materials to be used for delineation and channelization of traffic movements
- E. Placement and maintenance of traffic control devices
- F. Removal and/or application of pavement markings
- G. Location of flagging persons, where required
- H. Detour routes where the use of detours is approved by the Engineering Division.
- I. All elements of the TCP will be dimensioned, and these dimensions will be followed as closely as possible in setting up the work zone and the associated signing.

Once the TCP is reviewed and accepted by Engineering, the Contractor is solely responsible for the installation, maintenance, and inspection of the construction zone. All traffic control signs that are not applicable to the given circumstance shall be removed, covered, or turned around so that they do not face traffic and pose a hazard. The Contractor shall correct any deficiencies noted by the City immediately. If the Contractor does not comply within forty eight (48) hours notice, is not available, or cannot be found, the City may make such corrections and the Contractor shall pay the actual cost plus a penalty of fifty (50%) percent of the amount thereof. The Contractor must remove all traffic control within forty-eight (48) hours after job completion. Any traffic control not removed by the Contractor shall be removed by the City, with such work being billed to the Contractor at overtime rates. The Contractor shall pay all charges within thirty (30) days of the statement date. The charges shall be held out of the amount due the Contractor on City projects.

The work area shall be understood to include all open trenches, other excavations, material piles, equipment, obstructions, detours and other temporary roadways, and other similar hazards within or related to the project.

#### 50.1.2 Traffic Control Devices

On or adjacent to all streets, roads, highways and other public thoroughfares which require closure, either partial or complete, under the authority of a proper permit, the work area and the traveling public, either vehicular or pedestrian, shall be protected by means of approved traffic control devices as provided in the City of Arvada Engineering Code of Standard and Specifications for the Design and Construction of Public Improvements. When specifications, standards and guidelines for the application, installation and maintenance of traffic control devices are not provided for in the City of Arvada Engineering Code of Standard and Specifications for the Design and Construction of Public Improvements, all traffic control devices used shall be in accordance with the most recent Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD), Work Zone Traffic Control. A copy of this manual is available for inspection at the City of Arvada's Engineering Division. Engineering also has a set of typical construction zone drawings that can be used as a guideline for street closures.

#### 50.1.3 Roadway Closures and Partial Closures

- A. Barricades shall be painted, kept clean, weighted, and the face material shall be retro-reflective.
- B. All signs (warning, regulatory, etc.) shall be kept clean and shall be replaced when the face is damaged. These sign faces shall be retro-reflective. All signs shall be removed or turned away from the roadway immediately after they are no longer applicable, especially when left at the job site over night.
- C. Traffic cones are for daytime use only. Barricading devices with lights shall be used for all work that is left overnight.
- D. When lights are used, steady burn lights shall be used for delineation and channelization. Flashing lights shall be used to denote a specific hazard.

- E. Under certain conditions the use of pavement markings shall be required in addition to the devices used for delineation. This shall be shown on the TCP and Engineering will determine the extent of the striping. When temporary markings are used, the existing markings shall be removed (not painted black). Temporary markings shall be installed by the Contractor. These temporary markings shall be removed when the construction is completed. The permanent markings shall be reinstalled by the Contractor.
- F. Pedestrians shall not be diverted onto the roadway.
- G. Open trenches will not be allowed after work hours, without prior approval of the City Engineer or designee.
- H. Work hours on arterials and collector streets are from 8:30 AM to 3:30 PM, Monday through Saturday, unless other hours are authorized by Engineering. Work hours on local streets are from 7:00 a.m. to 9:00 p.m., Monday through Saturday. Contractor must submit written request addressed to the City Manager for approval of work hours beyond the above limits. Contractor shall also be responsible for all overtime inspection fees for work completed outside these work hours or as stated in the Special Conditions of City Projects.
- I. Spillage and mud trackage from trucks and equipment shall be cleaned up immediately.
- J. When the normal operation of a traffic signal must be interrupted, uniformed officers shall be used to direct traffic. Any expense incurred during this operation shall be borne by the Contractor.
- K. Construction within the right-of-way will not begin until all traffic control devices are in place.
- L. Contractors will notify the Police Department, Fire Department, and Engineering prior to commencing construction.
- M. Contractors will notify all Utilities (Utility Notification Center of Colorado, City of Arvada Utilities, etc.) 48 hours in advance of the start of construction.
- N. The Contractor will keep a signed copy of the TCP at the work area during work hours. This will be available for inspection by City (or State) personnel.
- O. Crossspan repair may require additional traffic control devices at the discretion of the Engineering Division.
  - 1. State Highways
 

Any work performed on a State Highway must have the approval of the Colorado Department of Transportation. Barricading requirements are to be received from the Colorado Department of Transportation. Any detours from a State Highway onto a City of Arvada street must have approval from Engineering prior to the detour being implemented.

2. Major Streets

- a. As a general rule, parkway streets, arterial streets and collector streets will not be completely closed, nor will traffic be detoured.
- b. On multi-lane streets (2 or more through lanes in each direction), two-way traffic must be maintained at all times. One lane may be closed in each direction with proper signing and barricading.
- c. Left-turn lanes or bicycle lanes may be used as a through lane providing pedestrians have adequate protection from traffic.
- d. On single lane streets, (one through lane in each direction), one lane may be closed provided that adequate signs, barricades and a minimum of two flaggers are used.

3. Local Streets

- a. One-half of a local street may be closed if adequate barricading is present and a minimum of one (1) flagger is used to direct traffic.
- b. Total street closures will be allowed if an alternate access is available to all property owners and is approved by Engineering.

4. Advance Signs

- a. On major and/or collector streets, the advance warning signs shall be placed at the following minimum distances in advance of the construction area.
  - i. Road Construction Ahead - 1,000 feet
  - ii. Right/Left Lane Closed Ahead - 750 feet
  - iii. Merge Right/Left or Flagger Ahead - 500 feet
- b. On local streets, the advance warning signs shall be placed at the following minimum distances in advance of the construction area.
  - i. Road Construction/Road Closed Ahead - 500 feet
  - ii. Flagger Ahead (if needed) - 250 feet
- c. In some cases, the City Engineer or designee may determine that a reduction in vehicle speeds is advisable or necessary. This shall be accomplished using advisory speed plaques, and speed limit signs, which conform to the standards of the MUTCD.
- d. In some cases, the City Engineer or designee may require special, advance notice signs.

## 5 Flagpersons

Anytime a flagger is required to direct the flow of traffic, that flagger must be visible to traffic. Orange clothing (vest, shirt or jacket) must be worn by the flagger. For nighttime operations, this clothing must be reflectorized. The flagger must follow the flagging procedures stated in the MUTCD.

### 50.1.4 Typical Construction Zone Drawings

Each work zone is different. The typical drawings shown in this section represent the minimum requirements for the most common situations. However, these drawings are not intended as a substitute for specific Traffic Control Plans. Additional protection must also be provided when special conditions or hazards exist.

## 50.2 TRAFFIC CONTROL MATERIALS

### 50.2.1 Signal Heads

- A. All signal units shall be modular section type, and shall be adjustable with respect to positioning and lense replacement. Heads shall be polycarbonate or approved equivalent, black in color and shall meet the requirements of the latest version of the ITE standard, "Vehicle Traffic Control Signal Heads". Unless otherwise indicated on the plans, all signal and pedestrian displays shall be Institute of City Engineer or designees (ITE) approved Light Emitting Diodes (LED) type and shall conform to the appropriate sections below.
- B. Visors shall be detachable tunnel type, open at the bottom; be black in color on the outside and flat black on the inside.
- C. Lenses shall be in accordance with ITE Specifications.
- D. Sockets shall be fixed focus.
- E. Doors on the signal heads, for the installation of lamps or other maintenance, shall not require use of any tool whatsoever to be opened. Doors and lenses shall be equipped with neoprene weatherproof gaskets to insure against infiltration of moisture, road film, and dust. Each three color signal unit shall have the socket leads from all signal sections connected to a terminal board stamped with identifiable terminals. There shall be a terminal for color indication plus a common terminal where one lead from each socket shall terminate. The terminal board shall be mounted in the middle section and be properly insulated. All openings, top and bottom, shall be for one half inch (1/2") pipe or pipe mounting brackets. Gaskets shall be supplied for top and bottom openings.
- F. Traffic signal heads shall be attached using standard ASTRO-BRAC assembly or approved equivalent. Side of pole signal heads shall be installed with banding blocks and 90 degree elbows with nipple length determined by the size of the head so as not to interfere with closing doors.
- G. All pedestrian indications shall be countdown indication and LED. All heads shall be black.

#### 50.2.2

##### Back Plates

- A. Where shown on the plans, black back plates shall be furnished and installed on signal faces. No background light shall show between the back plates and the signal face or between sections. All back plates are to be of aluminum construction and shall be the louvered type. Back plates shall provide a five inch (5") border for all twelve inch (12") signal heads.
- B. Traffic signal heads requiring back plates shall be drilled for three sixteenths inch diameter by one half inch (3/16" x 1/2") pan head bolt with nut and lock washer. If the manufacturer fails to supply as described, it will then be the contractor's responsibility to do so. When installing back plates on the traffic signal head, the contractor will furnish three sixteenths inch (3/16") fender washers between bolt head and back plate.
- C. The manufacturer will fabricate all back plates with a three sixteenths inch (3/16") washer on both sides of each rivet which is used to hold each section of the back plate together.
- D. Back plates shall have yellow reflective border tape that outlines the outside edge of each back plate.

#### 50.2.3

##### Traffic Signal Lamps

- A. LED indications shall be furnished for all indications unless defined otherwise in the standard drawings and shall include red ball, yellow ball, green ball, and arrow indications. Traffic LED indications shall meet the requirements of the latest version of the ITE Standards.
- B. Verification of LED adherence to ITE standards shall be through a 3rd party "Nationally Recognized Testing Laboratory (NRTL)" to demonstrate compliance to Section 6.3 (Production Tests & Inspections) of the latest ITE VTCSH Full Ball specification dated June 27th 2005 (for LED ball modules), and ITE VTCSH Arrow specifications dated July 1st 2007 (for LED arrow modules), and ITE PTCSI Pedestrian specification dated March 19th 2004 (for LED pedestrian combo or countdown modules). 3rd Party lab must have "Nationally Recognized Testing Laboratory (NRTL)" status. Proof of certification must be documented. Proof of certification must be presented when requested by the City Engineer or designee.
- C. When incandescent bulbs are defined in the plans, traffic signal bulbs shall be General Electric, Durotest, Phillips, or Engineer approved alternate. They shall be 116 watt, 130 volt for all 12-inch indications. Bulbs shall be 69 watt, 130 volt, for all 8-inch indications.
- D. All incandescent lamps shall have an 8,000-hour minimum rating.
- E. If the manufacturer recommends a lower rating, the City of Arvada will be advised of this recommendation and will have the option to decide which rating will be used.
- F. Lenses shall be clear.

#### 50.2.4 Electrical Cable

Use 14 AWG multi conductor, stranded, copper wire manufactured to meet International Municipal Signal Association (IMSA) 19 1 specifications or approved equivalent. Each conductor in the cable will be individually insulated and rated at 600 volts. There shall be a minimum of four (4) and a maximum of nine (9) strands per conductor. There shall be a separate 21-conductor cable installed from the controller cabinet to the bottom hand hole of each signal pole. From that point, a separate 5 or 7-conductor cable for each overhead signal shall be spliced to the 21-conductor cable. Outboard signal heads shall use 7-conductor cable to accommodate for present or future left turns.

#### 50.2.5 Detectors

##### A. Radar Detection

Stop bar detection shall be installed for all mainline approaches that have a protected left turn phase and all side street approaches unless otherwise noted on the plans. Wavetronix SmartSensor Matrix, Part No. WX-SS-225 shall be utilized for stop bar detection unless otherwise pre-approved by the City Engineer or designee. These units will typically be mounted on the back of the opposing traffic's mast arm. Please contact Summit Traffic Solutions, the local Wavetronix representative, for specific mounting locations at each intersection and for turn on assistance and programming.

Advance detection shall be installed on any approach where the posted speed limit is 40 mph or above. Wavetronix SmartSensor Advance, Part No. WX-SS-200V, shall be utilized for advance detection unless otherwise pre-approved by the City Engineer or designee. These units will typically be mounted on the front of the approaching traffic's mast arm. Please contact Summit Traffic Solutions, the local Wavetronix representative, for specific mounting locations at each intersection and for turn on assistance and programming.

##### B. Inductive Loop Detection

1. The remaining portions of this section reference roadway imbedded inductive loop systems and are applicable when specified in the plans.
2. This specification defines the minimum design operational and performance requirements for multiple channel, digital self-tuning inductive loop detectors, detector units shall be card rack mounted plug in type and operate from an external 24 VDC power supply. Detector units shall be in full compliance with the environmental and size requirements of NEMA standard TS1 Section 15 and meet the design, operation, electrical and functional performance requirements of both TS1 and TS2 specifications.
3. The front panel shall include an erasable, write on channel identification area and clearly indicated switch operating position. I.D. area one (1) centimeter square per channel minimum.
4. All component parts and test points shall be clearly identified by permanent markings of circuit referenced on the P. C. Board. Integrated circuit devices having sixteen (16) or more leads shall be socket mounted to facilitate repair and maintenance of units.



Detectors supplied to this specification shall be warranted by the supplier to be free of defects in materials and workmanship for a period of five years from date of shipment from manufacturer.

5. Each detector unit shall include two or four complete detector channels. Each channel shall sequentially energize its loop inputs to eliminate crosstalk (mutual coupling) between large, very closely spaced adjacent loops connected to the same unit. The sequential time sharing and digital processing of loop inductance data shall be accomplished on a single LSI microcircuit per unit for maximum reliability. The method of measuring shall be crystal reference digital period counting and multi-channel scanning. Only one channel input per unit shall be active at any point in time.
  - a. Sequential scanning shall fully prevent crosstalk between channels of a detector connected to closely spaced or overlapped loops for directional detection.
  - b. Sequential scanning shall allow two detection channels to operate with full performance using a common home run cable.
  - c. Sequential scanning shall allow two or more detection channels to be connected to a single detection amplifier with full operating performance, including separate mode and sensitivity selection capability on each channel.
6. Each channel of the sensor unit shall automatically self-tune to any loop and lead in inductance from 20 to 2500 microhenries within 2 seconds with full sensitivity after application or interruption of supply voltage. Units shall also track changes in loop/lead in electrical characteristics, as might reasonably be expected to occur in undamaged loops, properly installed in sound pavements, without producing false indications or changes in sensitivity.
7. Each detector unit shall be provided with a loop test switch position to verify loop system integrity and reduce maintenance costs. The "open loop test" position shall indicate a previous fault via the front panel indicator. The memory shall remain intact and can be queried repeatedly. Existing detections shall not be reset and the memory shall only be reset by power interruption as by removing and re inserting the plug in detector units.
8. Each channel shall include a 16 position push type wheel switch to allow selection of 8 pulse sensitivities, 7 presence levels and a "Reset" and an "Off" position. Each detector unit shall include 8 sensitivity selections in 2:1 steps that can be correlated to the relationship of the number of turns of wire in a loop versus the sensitivity required to detect a specified vehicle. The selections shall be designed to allow detection of licensable vehicles in loops of two (2) or more turns electrically in series, parallel or series/parallel configuration in non-reinforced or reinforced pavements with lead in/homerun combinations from 50 feet to 1,000 feet. The number of turns in a loop, electrical configuration of multiple loops and pavement type will dictate the sensitivity required for proper predictable detection.

9. If specified, channel presence time shall be modified if delay or extension time is selected. The timing switch shall select delay or extension or "Off", if no timing is desired. Internal DIP switches shall provide for selection of "Delay" time of 0 to 31 seconds in 1.0 second increments and "Extension" time of 0 to 7.75 seconds in .25 second increments.
10. Presence indicators shall be wide angle, high brightness type LED suitable for sunlight visibility. When timing is selected and a channel is active that channel's indicator shall flash at 4 Hz during Delay and at 16 Hz during Extension to indicate timing is in progress. Further, the timing shall be aborted when the vehicle is no longer present and/or the channel control input shall become inactive. The Delay timer shall be reset when a vehicle leaves the loop prior to time out and shall abort when the control input becomes inactive. The Extension timer shall operate and reset when a vehicle leaves the loop and be aborted when the control input becomes inactive. Each timer (Delay and Extension) shall be provided with buffer circuitry to enable or disable the timer, based on an external input (green gate) signal. The circuit shall be designed for AC or DC input control on AC powered units and for DC control on DC powered units.
11. Each detector unit shall utilize a  $\Delta L = (\text{Delta } L)$  thresholding technique to provide a more constant, predictable vehicle detection sensitivity with series added inductance, i.e., many loops connected in series and/or long lead in/homeruns will generally require the same sensitivity setting as would be required for a single loop with short lead in, to simplify setup.
12. Each channel shall automatically recover from intermittent opens or multiple shorts to ground. Each channel shall tolerate and continue to operate with no change with a single point short to ground on the loop or lead in system. Each channel shall provide a continuous, non resettable (fail safe) output and indication in response to an open loop/open lead in system. The open loop indication and output shall not be resettable as long as the open exists, except that they shall be defeated when the channel "Off" position is selected.
13. Extended features shall include: Two serial ports (front panel RS232 and Edge connector Xmit/Recve), TS1 and TS2 compatible from manual or software switch, microloop occupancy detection, traffic counting capable to include long-loop presence count from 15 minute to infinite intervals all accessible from either serial interface, Dual Detect and Fault LED indicators per channel, External inputs to control Timing functions and enable Remote Reset, Extended diagnostics, programming and Live status available via serial interface utilizing windows compatible software.

#### C Emergency Vehicle Preemption

Emergency vehicle detectors for emergency vehicle preemption shall be the GTT Opticom Model 711, 721 or 722 Optical Detector or approved equivalent as specified in the construction plan notes. Placement of the Detectors shall be determined by the Engineer. Optical phase selector modules for emergency vehicle preemption shall be GTT Opticom Model M762 or approved equal.

## 50.2.6

### Pedestrian Push-Button

#### A. General

1. Pedestrian push button assemblies shall be Polara Bulldog model BDL3-B, or approved equal. The button housing shall be black in color and shall include a 9" W x 15" H sign, MUTCD Reference # R10-3e, or approved equal, and shall be installed as shown on the Standard Details.
2. Pedestrian push buttons shall be of tamper proof design.
3. The assembly shall be weatherproof.
4. The housing shall be shaped to fit the curvature of the pole to which it is attached to provide a rigid installation. Saddles shall be provided to make a neat fit when required.
5. Push-buttons shall be located in accordance with ADA reach specifications.
6. Push button locators shall only be used where specified in the plans and project specials, and may be considered by the City Engineer or designee on a per project basis. When push button locators are requested, this function shall be integrated as part of the pedestrian push button, the pedestrian push button shall be of the manufacturer and model number specified, and shall conform to the MUTCD.
7. Audible tactile pedestrian indications shall only be used where specified in the plans and project specials, and may be considered by the City Engineer or designee on a per project basis. When audible tactile pedestrian indications are requested, they shall be Polara Navigator 2 Wire EN29UNO-B, Black in color or approved equivalent, and shall conform to the MUTCD. The system shall be backward compatible with the Polara Navigator 2-wire system or equivalent. The system shall consist of a Central Control Unit and Pedestrian Push Button Stations, as described below, and hand held infrared devices, PC with USB A-B cable, or Ethernet connections to CCU2EN for programming the system settings. The System shall be manufactured by an ISO 9001:2008 registered company.

## 50.2.7

### Traffic Signal Poles, Pedestals and Mastarms

Traffic signal poles, pedestals, and mastarms shall be of the general configuration shown on standard drawings.

#### A. New Structures

1. All new signal poles and mast arms shall hot dipped galvanized according to ASTM standard A123.

2. All exterior surfaces shall be coated with a rust inhibitive Epoxy Polyamide Primer to a minimum dry film thickness of 5.0 mils on the bottom 8 feet and 3.0 mils on the remainder of the pole and mast arms. The top coat shall consist of one coat of Semi-Gloss High Build Acrylic Polyurethane Enamel, Tnemec Endura Shield or approved equivalent, to a minimum dry film thickness of 3.0 mils. The finish shall be Arvada Bronze in color, Valmont Specification F540DE.
3. Any surface areas damaged during handling or installation shall be repaired immediately with a spot coat of epoxy primer and a polyurethane finish as specified above. The paint manufacturer's application instructions shall be followed.

B. Existing Structures

1. All designated previously installed signal poles and mast arms shall be field painted. All exterior surfaces shall be cleaned and examined for damaged paint, and any such damage shall be given a spot coat of primer and the entire exterior surface re painted. Previously painted surfaces whether finish or prime coats, shall be scuff sanded to yield 500 PSI of adhesion with particular attention paid to the lower eight feet (8') of the pole. Inspection of the poles prior to application of the finish coat is required.
2. A finish coat of Sherwin Williams DTM (Direct to Metal) Acrylic Gloss or approved equal shall be applied over the primer or previously painted surfaces. Two (2) coatings shall be applied leaving approximately six (6) mils of dry film. The color shall be a dark brown formula which is available from the City Engineer or designee.
3. The painting shall be done in a neat and workmanlike manner and may be applied either by hand brushing or spraying. The engineer reserves the right to require the use of brushes for the application of paint should the work done by the paint spraying machine prove unsatisfactory or objectionable.
4. All designated traffic and pedestrian signal heads shall be painted flat black unless otherwise specified. Previously painted controller cabinets shall be painted white.

50.2.8 Controller Cabinet

A. General

1. All controllers and auxiliary equipment shall be housed in a factory wired, weatherproof, metal cabinet following NEMA specification TS2 type 1. The cabinet shall have minimum interior dimensions, exclusive of stiffeners, shelf brackets, etc., of height 46 inches, width 29 inches, and depth 15 inches.
2. The cabinet shall be constructed of 0.125 minimum thickness bare aluminum. Cabinets shall be braced internally or by folded seams in order to provide sufficient rigidity to withstand normal handling and transport to the field location without deforming.

3. The main door shall have a self-locking, keyed, tumbler lock with two keys. Hinges shall be mounted on the cabinet in such a way that interchange ability of doors is possible between cabinets of like size and manufacturer. Hinge pins shall be stainless steel. Doors shall have neoprene gaskets of sufficient thickness to provide a rain tight and dust tight seal.
4. A police or auxiliary door shall be provided. It shall be constructed so that no sharp edges protrude from the main door and shall provide access to a panel with labeled switches for automatic to flashing operation and signal power on/off.
5. The cabinet shall be equipped with a thermostatically controlled, ball bearing fan with a capability of at least 100 cubic feet per minute. The fan shall be mounted in a weatherproof housing attached to the top of the cabinet. The thermostat shall be adjustable to turn on between 90o F and 150o F and be so mounted as to be easily accessible for adjustment from the front of the cabinet. Cabinet shall have internally mounted florescent tube light and one goose neck incandescent light
6. The cabinet shall have two shelves each capable of supporting 75 pounds. Shelves shall be supported on brackets which provide for height adjustments. Each cabinet shall contain a ten (10) mil thick plastic envelope with side opening. It shall be a minimum size of 10" x 12" and be attached to the door by screws.
7. Assembly wiring All cabinet wiring shall be neatly arranged and laced or enclosed in plastic tubing. No harness or wire shall be attached to any shelf rack or other point where it may be damaged by movement of shelves or doors.
8. Terminal Facilities Terminal facilities (load bays) shall be firmly attached in a position not less than six (6) inches from the bottom of the cabinet so as to provide easy access and maximum convenience to the user.
9. Side mounted auxiliary panels should be firmly installed with the forward edge not more than four (4) inches from the door sill and not less than six (6) inches from the bottom of the cabinet in all cabinets.
10. The load bay and its associated equipment, harness, switches, etc., shall be grouped on removable panels. Each panel or group of receptacles and connecting cables shall be arranged to permit so that work can be performed on panel backs or cables.
11. A load switch bay and flash transfer capability is required for each phase. Load switches shall be provided for only the phases shown on the plans.
12. The load bay shall be protected by a main circuit breaker. A gas tube surge arrester with MOV and a suitable radio interference filter shall be supplied. The arrester shall be a three electrode type with the following ratings:
  - a. Impulse Breakdown less than 1,000 volts in less than .1 microseconds at 10 KV per micro second.

- b. Standby Current less than 1 milliampere
  - c. Striking Voltage greater than 212 VDC
  - d. Energy Capability capable of withstanding pulses of peak current each of which will rise in eight (8) microseconds and fall in twenty (20) micro seconds to one half the peak voltage at 3 minute intervals.
  - e. Peak Current Ratings shall be 20,000 amps. The MOV shall have ratings equal to or better than a General Electric type VI50LA20A. The RFI filter shall have a current rating equal to or greater than the main circuit breaker capacity.
13. Field terminals shall be screw type, capable of accommodating at least three number 12AWG wires. All terminals in the load bay shall be permanently identified by engraving, silk screening or contrasting plastic labels. Terminal blocks shall be the barrier type and no live parts shall extend above the barrier.
  14. A convenience outlet with a ground fault interrupter fused at fifteen (15) amps shall be provided. It should be located in a position which is convenient and safe for service personnel.
  15. All AC power busses, switch or relay lugs and/or similar activity connection points which extend more than one and one-half inches (1 1/2") from the panel are to be protected by insulation for safety. The locations of these items shall provide reasonable protection for service personnel.
  16. Signal power relays shall be mercury wetted, equal to or greater than circuit breaker capacity. Flash transfer relays shall be as manufactured by Midtex Model 136 62 T 3A1, 120 VAC, DPDT, 30 amp with Jones Plug base and dust cover or approved equivalent.
  17. Flasher. The cabinet shall be equipped for flashing operation of signal lights with a two (2) circuit solid state flasher in accordance with the latest NEMA specifications (15 amps per circuit). Flashing operation shall be set for flashing yellow on all main street approaches and red on all other approaches. Pedestrian and turn signals shall be extinguished during flashing operation. The flashing mechanism shall remain in operation during shutdown or removal of controller.
  18. Load Switches. The cabinet shall be equipped with solid state load switching assemblies in accordance with the latest NEMA specification. Each load switch to be equipped with a three (3) input LED indicator. Load switches shall contain three (3) separate cube type solid state relays, which use a solid state switch which is capable of operations at 240 VAC and 25 amps when properly heat sinked but derated to ten (10) amps when used in load pack assembly.

19. Conflict Monitor/Malfunction Management Unit (MMU). The cabinet shall have provision for conflict prevention in accordance with the latest NEMA TS2 specification. Conflict prevention shall be provided by a conflicting display monitor unit that monitors all green, yellow and walk displays and detects absence of reds to cause flashing operation and stop timing if conflicting indications are detected. Removal of the monitor from the cabinet shall cause flashing operation.
20. Emergency Vehicle Preemption. The cabinet shall be equipped and wired with an Opticom Card rack mount for GTT Model or approved equivalent. All equipment shall be capable of accommodating a minimum of two modules with capability of four channel operation.

## 50.2.9

### Controllers

#### A. General

1. **Compatibility:** The local controller and cabinet shall be 100% compatible with the City of Arvada's existing computerized signal system which utilizes Econolite equipment.
2. An actuated controller shall be completely solid state, electronic device capable of selecting and timing traffic movements. It shall provide timing and load switch control for each major vehicular phase, including concurrent associated pedestrian movements. The controller shall conform to the latest NEMA and ATC specifications and shall provide for complete and full operation of eight phases from within either a TS1 or TS2 type 1 cabinet.
3. The controller shall have all electronic components easily accessible and arranged in functional groupings on the printed circuit boards. Printed circuit boards shall be designed to facilitate identification of components for maintenance purposes. Printed circuit design shall be of NEMA specification quality and designed so that components may be removed and replaced without permanent damage to the board or track.
4. Front-panel inputs shall be via touch screen or by clearly labeled elastomeric keypad. These shall use a 10-digit numerical keypad, Main and Sub keys, toggle keys, special function and enter keys, six function keys, status and help keys and a large, four direction cursory control key.
5. The display shall be a 7", color, TFT (Thin Film Transistor) LCD (Liquid Crystal Display) with high brightness. It shall be readable in direct sunlight. The display shall perform over the NEMA temperature range and shall have a resolution of 800 X 480 with an 18-bit color depth. The luminous intensity shall be a minimum of 800 nits. The display shall include an industrial, resistive touch screen that can be operated with gloved hands. The touch screen and display shall not be affected by condensation or water drops.
6. All circuitry components shall be available on the open market and the original manufacturer's part number shall be shown on the part's list.

7. Overlap programming shall be provided by through the keyboard. Protected Permissive Left Turn, Flashing Yellow Arrow shall be an overlap programming choice.
8. An entry mode to any single phase parameter of a keyboard controller shall not affect any other parameter or the same parameter on another phase, unless programmed by specific keyboard instructions, such as, "copy" sequences or other prescribed methods of rapid program entry.
9. Every controller supplied shall be the manufacturer's latest, first line production model tested and delivered by a domestic manufacturer who is regularly engaged in the construction of such equipment.
10. Each controller shall be supplied with a complete set of operational and service manuals, wiring schematics and parts layout up to a maximum of ten sets per order. Any controller for which these documents are not available is not a production model within the meaning of these specifications.
11. Each controller shall have a SD card slot.
12. Pre-emption. All actuated controllers shall be equipped to accommodate four (4) E.V.P. inputs and one railroad preemption input. Controller software shall be capable of being updated, database copied, or logs from a USB memory stick or a SD card.
13. A Logic Processor shall be capable of testing inputs, outputs and timers. If true, it shall set inputs, outputs or other functions. The logic processor shall be programmed by the end user to accomplish unusual operations.
14. The controller shall offer Peer to Peer operation using the logic processor to testable for conditions at neighboring intersections over Ethernet.
15. The controller shall offer sequence choices following preemption to service the longest queue, pedestrian movements interrupted, phases interrupted or free for one cycle with special timing before returning to coordination.

B. Coordination Unit

1. The coordination unit shall be an internal function within each local controller and shall meet, as a minimum, the following functional requirements.
2. The coordinator shall provide 120 patterns each consisting of a cycle length, splits in seconds or percentages and an offset in seconds or percentage.
3. Standard NEMA functions shall be used to control the intersection timing.
4. The coordinator shall be capable of changing the controller's phase sequence upon command.
5. The coordinator shall be capable of setting the intersection free by loss of system sync, cycle/offset false commands, free command and telemetry failure.



6. The coordinator shall be capable of setting the intersection into a flashing operation in accordance with the Manual on Uniform Traffic Control Devices, latest edition.
7. The controller shall be capable to operate using an internal Ethernet or serial port.
8. Time base coordination mode shall be provided as a backup with all standard coordination features available. At least two (2) 7 day programs shall be available with 50 additional holiday programs in the event of a master controller or communications failure. Time base standby mode shall be programmable for an entire year with automatic daylight savings and leap year changes.

50.2.10 Uninterrupted Power Supply (UPS)

A. General

1. A UPS shall be incorporated in all new traffic signals and where otherwise specified in the plans and/or project specials. The UPS shall be a DBL700MX UPS, as manufactured by Econolite, or approved equal.
2. The UPS shall be installed per manufacturer's specifications.
3. Programming software and manuals shall be supplied with each UPS and shall become the property of the City at the completion of the project.
4. A UPS shall include all labor, equipment, and materials necessary to install the UPS complete-in-place.

B. Cabinet

1. Unless otherwise specified in the plans and/or project specials, a pony cabinet shall be used to house the UPS batteries and ancillary materials/equipment UPS component installation within the traffic cabinet shall be limited to the head unit, UPS bypass switch, and additional terminal block(s) as may be required for rerouting and landing of the service feed.
2. The pony cabinet shall be constructed from type 5052-H32 aluminum with a minimum thickness of 0.125 inches.
3. All seams that are not welded shall be sealed with RTV sealant or equivalent material on the interior of the cabinet.
4. The UPS cabinet shall be sized at 35" H x 19" W x 8.5" D (Maximum), fully enclosed, with a single locking door for access to the batteries. The UPS cabinet shall be manufactured for outdoor installation and shall include all fans and venting, as required by the manufacturer, to ensure UPS batteries remain within storage and operating parameters.
5. Door(s) shall close against a weatherproof and dust-proof closed-cell neoprene gasket seal of adequate size to provide full seal coverage of each door. The gaskets shall be permanently bonded to the cabinet.

6. Door(s) shall be equipped with a Corbin tumbler lock number 1548-1 or exact equivalent.
7. Pony cabinets shall be supplied with aluminum shelves of the quantity necessary for proper battery storage. Stacking of batteries, one on top of another shall not be permitted.
8. The UPS pony cabinet shall be mounted to the side of the traffic cabinet such that the door swings open toward the road as to best provide maintenance personnel with a readily accessible escape route from oncoming traffic.
9. The cabinet finish shall match the controller cabinet finish.
10. All UPS components shall be rated for use in the cabinet provided.
11. Where the Contractor proposed as alternate UPS system requiring an alternate battery type, battery count, and/or pony cabinet configuration, the Contractor will be required to submit to the City for review and approval prior to installation.

C. Operational Specifications

1. Power Input/Output
  - a. Use 120VAC, 60Hz, single phase source input.
  - b. Provide for input surge suppression.
  - c. Output a single phase pure AC sine-wave regulated at 120VAC ( $\pm 3\%$ ), 60 Hz.
  - d. Be capable of operating in the voltage range of 85VAC to 135VAC without using the batteries.
  - e. Be of double-conversion/true on-line design.  
  
Double-Conversion/True On-Line:  
As a double-conversion/true on-line design, the UPS shall be in an "always on" condition such that it continuously monitors the input and provides continuous frequency and voltage regulation of the output. Upon loss of power, the UPS shall transfer to battery mode in 0ms. No transfer time shall be experienced when transitioning to/from full UPS operation.
  - f. Be installed in series with the utility power such that the UPS powers the entire traffic signal cabinet and all associated equipment.

2. Temperature
  - a. -34.6 Degrees F to 165.2 Degrees F (-37 Degrees C to +74 Degrees C).
  - b. Humidity – 10% to 90% non-condensing.
3. Run Time
  - a. Provide for full signal operation at an average of 700 Watts for a minimum of two hour, with additional minimum flash time of two hours.
  - b. Provide for user definable full run time settings to define full run time prior to the UPS transitioning to flash operation.
  - c. Provide for user definable battery level flash settings by which the user can change battery level flash settings.
  - d. Remain in, or automatically transition to flash operation, when utility power fails and the UPS battery levels are below, or fall below, the user defined battery level settings.
  - e. Restore the signal to full operation any time utility power is restored or power is supplied via the generator receptacle.
  - f. Include a low battery cutout to prevent critical discharge of, and damage to, the UPS batteries.
  - g. Provide a battery recharge of 95% within eight hours.
4. Indications, Alarms, Faults
  - a. Provide a means by which the user can accurately check the battery charge level, and UPS load level.
  - b. Provide indications which display the current condition of the UPS including the presence or absence of a critical UPS fault, and the presence or absence of utility power.
  - c. Provide an automatic bypass switch by which the UPS unit is bypassed and runs off utility power if a critical internal UPS fault occurs.
  - d. Provide a single dry contact relay output and alarm trigger with user definable trigger options to notify the owner of critical events and/or failures to include:
    - UPS critical fault
    - Loss of utility power input
    - Low battery condition

5. Switches, Ports, Receptacles, Controls

- a. Provide Ethernet SNMP port for remote configuration and monitoring of the UPS via the traffic/transportation network.
- b. Provide a bypass switch by which the user can manually bypass the UPS and power the signal via utility power. This feature is to be used in the case of UPS failure and/or the need for UPS maintenance or repair services.
- c. Include a generator receptacle accessible via the exterior of the traffic and UPS cabinets.
- d. Provide automatic sensing of generator power. The UPS shall be configured such that the UPS provides regulated 120VAC, 60Hz, single phase output power to run the signal in full operation and recharge the UPS batteries while under generator power. The UPS shall be configured to run the signal in full operation regardless of the UPS' battery charge level.

The UPS unit shall automatically sense when generator power is applied, and when generator power fails. The UPS shall be configured such that it automatically reverts to generator power when generator power is applied.

When generator power fails (generator power falls outside of acceptable signal tolerances), the UPS shall automatically revert back to either utility power or UPS battery power respectively based upon the availability at the time.

- e. Provide all required software and cabling for both networked remote and local UPS monitoring and management.

6. Hardware, Software, Cabling

All UPS units shall include all components, hardware, cabling, installation manuals, and software required for complete installation, operation, programming, monitoring, and maintenance of the UPS system.

7. Warranty

All proposed UPS equipment shall be warranted for a period of two years by the manufacturer.

50.2.11 Aluminum Pedestal Mounts

Aluminum Pedestal Mounts. Aluminum pedestal mounts (Type III) shall be either of two (2) types, as called for in the plans and specifications. Center mount with two (2) side ports, plain or offset mount serrated with one (1) side port

50.2.12 Mast Arm Brackets

Mast Arm Brackets. Mast arm brackets shall be Astro brackets or City approved equivalent and shall be installed 90 degrees to the roadway.

50.2.13 Instructions and Wiring Diagrams

All equipment shall be provided with three sets of complete installation instructions, including a complete chart of field connections as well as a manual for the controller, containing service instructions, wiring diagrams, trouble-shooting procedures, etc. Each and every component used shall be clearly referenced in the service manual and its value, ratings and manufacturer part number shall be given.

50.2.14 Guarantee

The contractor shall include in his proposal all warrants and/or guarantees with respect to materials, parts, workmanship and performance of the product to be supplied. The minimum guarantee period for the product shall be one (1) year from the date of final acceptance of the contract. The contractor shall attach to the bid a statement that all material to be supplied is either in exact accordance with the specifications or shall list in detail any and all deviations therefrom. The supplying of equipment that is not in accordance with the specification and on which the contractor has indicated no exception shall be cause for rejection of the equipment and correction of the non-specification items entirely at the contractor's expense.

**50.3 SYSTEM COMMUNICATIONS**

50.3.1 Ethernet Managed Switch

- A. An Ethernet Managed Switch shall be provided with all traffic signals. The Ethernet switch shall be a Ruggedcom of the model number specified in plans or project specifications.
- B. An Ethernet Managed Switch shall include all equipment, and materials necessary to install the item complete-in-place, including, but not limited to, switch operating system, SFPs, hardened power supplies, power cords, CAT5e Ethernet cables, console serial cables, and single-mode fiber patch cords.
- C. Unless otherwise specified, the contractor shall be responsible for proper programming, setup, and testing of the Ethernet Managed Switch. The City shall provide IP addresses to the contractor. At the City's discretion, the City may opt to have their maintenance contractor, or other third party, complete Ethernet Managed Switch, setup and/or testing. When the City's maintenance contractor or other third party is enlisted for programming, setup, and/or testing of the Ethernet Managed Switch, associated costs for the maintenance contractor or third party labor shall be the responsibility of the City.

50.3.2 Radio/Wireless Communications

- A. When radios are specified in the project plans and/or specifications, and unless otherwise specified, radios shall be the Microwave Data Systems (MDS) iNET 900 and shall include the radio, power supply, antenna, antenna surge/lightning suppressor, equipment mounts, and all associated cabling, connectors and strain relief hardware as required to support Ethernet communications to the local traffic signal controller. All materials shall be as approved by the radio manufacturer.

Unless otherwise specified, Yagi antennas shall be used. The antenna gain for each Yagi antenna shall be determined as a result of the wireless site survey.

When specified in the project plans and/or specifications, a wireless site survey shall be required and shall include both a site analysis and spectrum analysis to verify line-of-sight and define existing wireless link interference prior to installation. A wireless site survey report shall be issued to the City following a wireless site survey and shall define, installation requirements, including use of an antenna riser(s), and anticipated link signal loss.

Where use of antenna pole risers are specified or requested, antenna riser lengths shall be limited such that the riser extends no more than ten feet beyond the top of the traffic signal pole or structure. Where additional height is required, written authorization shall first be required from the City's City Engineer or designee.

While installation includes radio programming, the City may opt to have the radio turned over to them for programming prior to install, returning the radio to the Contractor after programming for completion of field installation. Where the Contractor is to complete radio programming, the City shall provide programming parameters as required.

Where being directed by the City, and prior to antenna installation, the City shall define the structure on which to mount the antenna, the antenna orientation, and the direction in which to point the antenna.

### 50.3.3 Traffic Signal Interconnect Cable – Fiber Optic

#### A. General Fiber Specifications

1. Unless otherwise noted, all traffic signal interconnect communications shall be accomplished through a fiber optic cable system.
2. Fiber optic cable shall be of the count and configuration specified in the Plans or supplemental documentation as provided by the City
3. Fiber optic cable shall comply with the latest version of all industry standards designated herein, including all addendums and revisions. Applicable standards development organizations are expected to include, but are not limited to, Telcordia Technologies (formerly Bellcore), Electronic Industries Alliance (EIA), Telecommunications Industry Association (TIA), International Telecommunications Union (ITU), International Electrotechnical Commission (IEC), American Society for Testing and Materials (ASTM), Insulated Cable Engineers Association (ICEA), National Fire Protection Association (NFPA).
4. Fiber optic cable used for projects in the City and Community of Arvada (henceforth referred to as City) shall be new and unused, unless otherwise specified in the Plans or directed by the Engineer.
5. Fiber optic cable construction shall conform to the requirements of ICEA S-87-640 Optical Fiber Outside Plant Communications Cable and Telcordia GR-20 Generic Requirements for Optical Fiber and Optical Fiber Cable. The cable shall employ a non-armored, all-dielectric, loose tube design for outside plant installation with a single outer jacket and dry water blocking materials in the cable interstices and buffer tubes.

6. Fiber optic cable installation into a building shall conform to the requirements of Article 770 of NFPA 70 National Electrical Code (NEC).
7. All fibers in the fiber optic cable must be usable single mode optical fibers conforming to the requirements of ITU-T G.652D for zero water peak and low polarization mode dispersion. It shall also conform to the requirements of Telcordia GR-20.
8. All optical fibers shall be sufficiently free of surface imperfections and inclusions to meet the optical, mechanical and environmental requirements of this specification.
9. Unless otherwise specified in the Plans or directed by the City, no less than 20 feet of fiber cable slack shall be neatly coiled within each pull box (non-splice location) included as part of the fiber optic cable run.

B. Fiber Specification Parameters

1. Color Code

The individual colors for optical fibers and cable buffer tubes shall comply with the TIA-598 Optical Fiber Cable Color Coding standard.

2. Central Strength Member

The central strength member functions as an anti-buckling element, and shall be a glass/epoxy composite dielectric rod. A polyethylene overcoat may be applied to the central member to provide the proper spacing between buffer tubes during stranding.

3. Cable Buffer Tubes

- a. Optical fibers are enclosed within buffer tubes that have a diameter several times larger than the diameter of the fibers. The optical fibers are loose within the buffer tubes allowing the fibers to move freely. The loose buffer tubes should have a minimum 2.3 mm diameter depending on the number of fibers contained within each buffer tube.
- b. Buffer tubes shall be constructed out of industry standard polybutylene terephthalate or similar thermoplastic polymer.
- c. Each buffer tube shall contain twelve fibers.
- d. Filler rods may be included in the cable core to lend symmetry to the cable cross-section where needed.
- e. The buffer tubes (and filler rods, if necessary) shall be stranded in a Reverse Oscillation Lay (ROL) technique around the central strength member to allow for easy mid-span access. The core of buffer tubes shall be wrapped with two counter helically applied threads to bind together the cable core.

- f. Binders shall be applied with sufficient tension to secure the buffer tubes to the central strength member without crushing the buffer tubes. The binders shall be non-hygroscopic, non-wicking, and dielectric with low shrinkage.
- g. Tensile strength shall be provided by high tensile strength aramid yarns, fiberglass yarns, or both.
- h. Water blocking of the cable core interstices and inside the buffer tubes shall be accomplished via dry water blocking elements.
- i. Each buffer tube shall be color coded with distinct and recognizable colors in accordance with EIA-359 Colors for Color Identification and Coding and TIA-598. Buffer tube coloring shall be stable during temperature cycling and shall not be subjected to fading or smearing onto each other or into the dry water blocking material in each buffer tube. Colorings shall not cause fibers to stick together.

4. Cable Outer Jacket Characteristics

- a. All-Dielectric cables shall be sheathed with medium or heavy density polyethylene. The minimal nominal jacket thickness shall be 1.4 mm. Jacketing material shall be applied directly over the tensile strength members and dry water blocking material. The polyethylene shall contain carbon black to provide ultraviolet light protection and shall not promote the growth of fungus.
- b. The cable sheath shall be free of holes, splits, and blisters.
- c. For ease of outer jacket removal, a minimum of one clearly identifiable polyester ripcord shall be provided directly under the cable sheath.

5. Cable Outer Jacket Markings

- a. For standard outer jackets, printed characters shall be indent printed with white characters for black jackets, and black characters for non-black jackets.
- b. The characters shall be of proper height and space to produce good legibility. A minimum character height of 2 mm shall be required.
- c. The cable length shall be sequentially marked in "feet" at a minimum spacing of 1 meter intervals. The length intervals shall not be reset to zero on any length of the cable. The actual cable length must be within  $\pm 3\%$  of the marked length.
- d. Each length of the cable shall be marked with manufacturer's name, manufacturer's part number, month and year cable was manufactured, fiber counts, fiber type, telephone handset symbol (as required by Section 350G of the National Electrical Safety Code) and manufacturer's serial number.



6. Cable Packaging

- a. The manufacturer shall supply the product using their standard reel sizes, methods, apparatus, and lagging. The Contractor shall order standard reel sizes specific to the project in an effort to minimize the introduction of passive attenuation due to unnecessary reel-to-reel cable splices. The minimum barrel diameter of the reel shall not be less than 30 times the cable diameter
- b. Reels are assumed to be in good working condition, firm, and able to support the product through shipping and final installation. Reels shall be clean, dry, and free of excessive dirt. All reels shall be checked for high nails, stave fit, and proper stenciling.
- c. Each wood reel shall be permanently marked with the manufacturer's name, "OPTICAL CABLE", an arrow with the words "CABLE END" to indicate the position of the outer cable end, an arrow with the words "ROLL THIS WAY" to indicate direction reel should be rolled to prevent loosening, and reel number.
- d. Outer layers of the reel shall be covered with a protective wrap to limit the solar heating of the cable.
- e. Each end of the cable shall have end seals in order to prevent moisture ingress into the cable during shipping, storage, or installation.
- f. The top end of the cable shall be securely fastened to the inside of the reel flange to prevent the cable from becoming loose in transit or during handling. The bottom end, "test tail", shall be approximately three meters in length and easily accessible. The end shall be protected within a cable slot and be securely fastened to the outside of the reel flange with wire ties or walkout straps.
- g. Each cable shall have certified test data securely fastened to the reel in a waterproof wrapping. The certified test data shall include the following information:
  - Cable Number
  - Date
  - Customer Name
  - Ordered Length
  - Customer Order Number
  - Ship Length
  - Customer Cable Code
  - Customer Reel Number
  - Customer Attenuation Specifications
  - Final Attenuation Inspection Test Report for Each Fiber
    - Number of Fibers
    - Type of Fibers
    - Cable Construction
    - Authorized Signature

h. Each cable shall have a reel tag securely fastened to the reel in a waterproof wrapping. The reel tag (Cut Length Data Sheet) shall include the following information:

- Cable Number
- Date
- Customer Name
- Ordered Length
- Customer Order Number
- Ship Length
- Customer Cable Code
- Customer Reel Number
- Customer Attenuation Specifications
- Number of Fibers
- Beginning and Ending Sequential Length Markings
  - Gross Weight
  - Net Weight
  - Inspected By Signature

C. Service Cable

Two (2) No. TRW 8, seven (7) strands, tinned, soft drawn copper wire, one sixteenth inch (1/16") neoprene insulation, black and white in color.

D. Loop Wire

Detect A Duct Cable consisting of single conductor No. 14 stranded THHN with an outer protective sleeve.

E. Pedestrian Push-Button Cable

Two (2) conductor No. 14, seven (7) strands, tinned, soft drawn copper wire, one sixteenth inch (1/16") neoprene insulation. Conductors to be twisted. Color coded one (1) white and one (1) black.

F. Loop Lead-In Cable

Detector loop lead in cable shall be a four conductor .25 inch diameter, shielded and jacketed cable suitable for installation in a pavement sawslot, conduit or direct burial. Conductors shall be AWG No. 18 stranded copper with polypropylene insulation. The conductors shall be twisted at least six turns per foot. Color rotation shall be black, red, white, green. The interior of the cable shall be filled with an amorphous material which prevents water penetration. Aluminized polyester shielding shall be applied around the conductors to prevent electromagnetic interference. The Cable jacket shall consist of black high density polyethylene. The jacket shall not be degraded by prolonged exposure to typical pavement runoff components. The cable shall be suitable for operation at temperatures of 60oC to +80oC. (Canoga 30003 43#18 AWG shielded loop detector lead in cable or approved equivalent.)

G. Ground

Single conductor, AWG No. 8, soft-drawn bare copper wire.

H. Optical Detector Lead-In Cable

The lead-in cable for the Emergency Vehicle Optical Detectors shall be 3M Type 138 or approved equivalent.

50.3.4 Fiber Optic Splicing and Terminations

A. Description

This work consists of furnishing and installing hardware used to splice and terminate single mode fiber optic cable. All fiber optic industry standards referenced herein shall be the current, adopted version that is active, including all amendments, changes and revisions noted by its respective standards development organization.

B. Materials

1. Fiber optic splice closures shall utilize a dome closure design with an end plate system that allows independent access to each cable port without disruption to the surrounding cables. For backbone to lateral splices and backbone to backbone splices, the fiber optic splice closure shall not exceed 9 inches in diameter by 18 inches in length. The closure shall be able to accommodate a maximum of 144 single fusion splices and support the corresponding management of buffer tubes and trays required. The closure shall accommodate both loose tube butt and mid-span access splicing. A minimum of four cable ports shall be provided on the end plate system and the closure shall be rated for below grade installation within a splice vault or manhole. The closure shall have the capability to be assembled and disassembled without the need for any special tools. The closure shall be tested and approved in accordance with Telcordia GR-771 Generic Requirements for Fiber Optic Splice Closures by an independent outside laboratory. Closures shall be re-enterable, re-usable, hermetically sealed and utilize flexible grommet cable seals at each cable port appropriate for the fiber optic cables being fusion spliced. At a minimum, each closure shall include an end plate with buffer tube organizer, one dome, one dome gasket, one dome collar, silicone lubricant, hose clamps (appropriate for number of cable ports), flexible grommet cable seals appropriate for the number of cables, strength member brackets (as needed), port seals (for sealing unused cable ports), mounting bracket kit (for installation within splice vaults and manholes), cable support hooks (for orderly coiling of fiber optic cable in splice vaults and manholes) and other required accessories not specifically mentioned herein.
2. Fusion splicing of backbone-to-backbone and backbone-to-lateral fiber optic cables shall be stored and protected within the fiber optic splice closure. The Contractor shall utilize a fusion splicer that automatically positions, aligns and fuses together two stripped, cleaned and cleaved optical fibers with an electric arc. The Contractor shall provide strain-relief and protection of each stripped fiber splice by utilizing heat-shrink sleeves and housing the splices in splice trays within the closure. The maximum individual splice loss of single-mode fiber shall not exceed 0.10 dB.

3. Fiber optic termination assemblies shall be configured with the required number of connector ports as shown in the Plans. If no connector port information is provided in the Plans, a minimum of six ports shall be required for a six fiber lateral cable and a minimum of 12 ports shall be required for a 12 fiber lateral cable, unless otherwise specified by the City. Each fiber optic termination assembly shall consist of a factory-terminated patch panel with a cable pigtail. It shall utilize single mode fiber with Straight Tip (ST) connectors. The cable pigtail end of each fiber optic termination assembly shall be of an appropriate length as noted on the Plans for splicing to the backbone fiber optic cable at the splice vault or manhole adjacent to the traffic signal controller cabinet. If no length is provided on the Plans, the minimum cable length shall be 100 feet. Fiber optic termination assemblies shall be designed and tested in accordance with:

- Telcordia GR-3152 Generic Requirements for Hardened Multi-Fiber Optical Connectors

4. Each fiber optic termination assembly utilized for projects in the City shall be outdoor-rated for operation in temperatures ranging from -40°F to +158 °F. Its single mode fiber cable (with pigtail end) shall be rated for outside plant installation and use all-dielectric cable construction.
5. Each ST connector in the fiber optic termination assembly shall have an Ultra Physical Contact (UPC) finish for single-mode fiber with an insertion loss not exceeding 0.5 dB and a reflectance of  $\leq -50$  dB as specified by TIA-568-C.3 Optical Fiber Cabling Components. Each connector shall utilize a ceramic ferrule and the durability of the connector shall change  $\leq 0.2$  dB by 500 rematings in accordance with TIA-455-21 Mating Durability of Fiber Optic Interconnecting Devices.

#### C. Construction Requirements

The Contractor shall provide the City with one copy of the manufacturer's installation instructions for each type of fiber optic splice closure and fiber optic termination assembly. All installations shall be in accordance with the manufacturer's recommendations, except as otherwise directed by the City. All additional costs including damage to fiber optic cables, splice closures, fiber optic termination assemblies and optical end equipment caused by the Contractor's neglect of recommended procedures shall be the Contractor's sole responsibility.

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

Each fiber optic termination assembly's integrated fiber optic cable pigtail shall be back fed in a continuous runs from the traffic signal controller cabinet to the backbone splice location. The length of the fiber optic termination assembly's fiber optic cable pigtail shall be sized adequately when ordering the product to accommodate both the run distance and coiling requirements in splice vaults and manholes as designated on the Plans or described in the City's fiber optic specifications. Strain relief for the lateral fiber optic cable shall be provided at a minimum of two locations within the traffic signal controller cabinet.

The Contractor shall splice fiber cables at locations shown on the Plans and as approved by the City in the Contractor's Method Statement. All splices shall be enclosed within a splice closure as approved by the City. Following successful splicing, the splice closure shall be placed inside the splice vault or manhole. The Contractor shall use tools and hardware recommended by the splice closure manufacturer.

Only proposed active (lit) fibers shall be spliced in the closure and terminated in the field communications cabinet, unless otherwise specified by the Plans. All unused (dark) fibers of both the backbone and fiber optic termination assembly's cable pigtail shall remain uncut and be neatly coiled in the splice tray within the closure. All unused buffer tubes shall remain uncut and neatly coiled along with the buffer tubes used for splicing in appropriate location in the splice closure.

Backbone cable and each fiber optic termination assembly's cable pigtail buffer tubes and fiber strands shall be labeled on the splice tray prior to sealing of the closure.

Unless otherwise specified on the Plans, the Contractor shall coil a minimum of 80 feet of backbone cable and the fiber optic termination assembly's cable in splice vaults and manholes.

The Contractor shall ensure that all cable coils are attached to the cable management hardware in all splice vaults and manholes as stipulated by the City.

The Contractor shall utilize a fiber optic termination assembly at each traffic signal controller cabinet, unless otherwise shown on the Plans or directed by the City.

Unless otherwise specified by the Plans or directed by the City, all fiber jumpers terminating on the fiber optic termination assemblies in traffic signal controller cabinets shall utilize single-mode fiber that conforms to the requirements stated in the City's fiber optic specifications and have a ST connector on the fiber optic termination assembly end and an appropriate connector type for connection to the optical end equipment. The reflectance value of the connectors on both ends of each jumper shall conform to the connector requirements previously stated.

### 50.3.5 Testing, Identification and Administration of Fiber Optic Infrastructure

#### A General

##### 1. Work Included

- a. Provide all labor, materials, tools, field-test instruments and equipment required for the complete testing, identification and administration of the fiber optic work called for in the Contract.

##### 2. Scope

- a. This section includes the minimum requirements for acceptance testing, identification and administration of backbone and lateral fiber optic cabling.

- b. This section includes the minimum requirements for the following:
  - i. Fiber optic test instruments
  - ii. Fiber optic testing
  - iii. Identification
    - Tags and associated labeling
    - Labels and associated labeling
  - iv. Administration
    - Test results documentation
    - As built drawings
- c. Testing shall be carried out in accordance with this document. This includes testing the attenuation of the installed fiber optic cable plant with an Optical Loss Test Set (OLTS) and the installed condition of the cabling system (and its components) with an Optical Time Domain Reflectometer (OTDR).
- d. OLTS testing shall be performed on each terminated strand of fiber in the cable (connector-to-connector).
- e. OTDR testing shall be performed on each strand of fiber in the cable (terminated with a connector or bare end).
- f. All tests shall be documented including the following:
  - i. OLTS dual-wavelength attenuation measurements for single mode fiber optic links.
  - ii. OTDR traces and event tables for single mode fiber optic links.

### 3. Quality Assurance

- a. All testing procedures and field-test instruments shall comply with applicable requirements of the following recognized standards:
  - i. TIA-455-78 – (FOTP 78) Optical Fibers – Part 1-40: Measurement Methods and Test Procedures – Attenuation
    - TIA-455-133 – (FOTP 133) Optical Fibers – Part 1-22: Measurement Methods and Test Procedures – Length Measurement
    - TIA-455-160 – (FOTP 160) Optical Fibers – Part 1-50: Measurement Methods and Test Procedures – Damp Heat (Steady State)

- TIA-526-7 – (OFSTP 7) Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant
  - TIA-568-C.3 – Optical Fiber Cabling Components Standard
  - TIA-606 – Administration Standard for the Commercial Telecommunications Infrastructure (including the requirements specified by the City, unless the City specifies their own labeling requirements)
- b. Only trained technicians who have successfully attended an appropriate fiber optic training program, which includes testing with an OLTS and an OTDR, and have obtained a certificate as proof thereof shall be allowed to perform fusion splicing, fiber connectorization and fiber optic cable testing as specified in Section 50.3.5 Section C of these specifications. These certificates must have been issued by any of the following organizations or a City-approved equivalent organization:
- i. Fiber optic cable manufacturer
  - ii. Fiber optic patch panel and/or connector manufacturer
  - iii. Test equipment manufacturer
  - iv. Approved training organizations:
    - Association of Cabling Professionals (ACP)
    - Building Industry Consulting Service International (BICSI)
    - Electronics Technicians Association (ETA)
    - Fiber Optic Association (FOA)
    - International Municipal Signal Association (IMSA)

The Contractor shall provide a copy of each proposed technician's valid certificate or ID card to the City for review and approval, including a list of task(s) associated with each technician.

- c. The City or its designated representative shall be invited to witness and/or review field testing.
- i. The City or the City's designated representative shall be notified of the start date of the testing phase five (5) business days before testing commences.

4 Submittals

- a. Manufacturers catalog cutsheets and specifications for fiber optic field test instruments including OLTS (power meter and source) and OTDR.
- b. A list of all cable segments and corresponding fiber optic strands to be tested (unless already called out in Plans).
- c. Test reports.

5 Acceptance of Test Results

- a. Unless otherwise specified in writing by the City, each cabling link shall be in compliance with the following test limits:

- i. Optical Loss Testing

- Single Mode Fiber – The link attenuation shall be calculated by the following formulas:

- $\text{Link Attenuation (dB)} = \text{Cable Attenuation (dB)} + \text{Connector Attenuation (dB)} + \text{Splice Attenuation (dB)}$
    - $\text{Cable Attenuation (dB)} = \text{Attenuation Coefficient (dB/km)} \times \text{Cable Length (km)}$

- Attenuation Coefficient = 0.35 dB @ 1310 nm  
and 0.25 dB @ 1550 nm

- $\text{Connector Attenuation (dB)} = \# \text{ of Connector Pairs} \times \text{Connector Loss (dB)}$

- Maximum Allowable Connector Loss = 0.50 dB

- $\text{Splice Attenuation (dB)} = \# \text{ of Splices} \times \text{Splice Loss (dB)}$

- Maximum Allowable Splice Loss = 0.30 dB

- ii. OTDR Testing

- Reflective events (connections) shall not exceed 0.50 dB.
    - Non-reflective events (splices) shall not exceed 0.30 dB.

- b. All installed cabling links shall be field tested and pass the test requirements and analysis as described in 50.3.5 section C. Any link that fails these requirements shall be diagnosed and corrected. Any corrective action that must take place shall be documented and followed with a new test to prove that the corrected link meets performance requirements. Test results for all links shall be provided in the test results documentation in accordance with Part 3.



- c. Acceptance of the test results shall be given in writing after the project is fully completed and tested in accordance with the Contract and to the satisfaction of the City.

6 Measurement and Payment Procedures

- a. Measurement of fiber optic cable warning tags and labels shall be as specified in 50.3.5 section C. Compensation for the fiber optic cable warning tags and labels shall be considered as included in the price paid for total LINEAR FEET of new fiber optic cable and no additional compensation will be allowed thereof. The compensation for fiber optic cable warning tags and labels shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals required to perform the work.
- b. Measurement of record copy drawings and asbuilt drawings shall be as specified in 50.3.5 Section D. Compensation for the record copy drawings and asbuilt drawings shall be considered as included in the price paid for total LINEAR FEET of new fiber optic cable and no additional compensation will be allowed thereof. The compensation for record copy drawings and asbuilt drawings shall include full compensation for furnishing all labor, materials, equipment and incidentals required to perform the work.
- c. Measurement of OLTS testing shall be as specified in Section 1.02D. Compensation for OLTS testing shall be based on the total number of new fiber STRANDS tested and no additional compensation will be allowed thereof. The compensation for OLTS testing shall include full compensation for furnishing all labor, materials, tools, equipment, calibration and incidentals required to perform the testing, including completion of the End-to-End Attenuation Testing table(s) provided in the Plans in accordance with 50.3.5 Section C2i of these Specifications.
- d. Measurement of OTDR testing shall be as specified in Section 1.02E. Compensation for OTDR testing shall be based on the total number of new fiber STRANDS tested and no additional compensation will be allowed thereof. The compensation for OTDR testing shall include full compensation for furnishing all labor, materials, tools, equipment, calibration and incidentals required to perform the testing, including test results documentation in accordance with Sections 50.3.5 Sections C2J and D.

B. Products

1 Fiber Optic Cable Testers

- a. The field test instrument shall be within the certified calibration period of one calendar year as specified in Section 3.02(C).

b. OLTS

i. Single mode fiber optic light source

- Provide dual laser light sources with central wavelengths of 1310 nm ( $\pm 20$  nm) and 1550 nm ( $\pm 20$  nm).
- Output power of -10 dBm minimum.

ii. Power meter

- Provide 1310 nm and 1550 nm wavelength test capability.
  - Power measurement uncertainty of  $\pm 0.25$  dB.
  - Store reference power measurement.
- Save at least 100 results in internal memory.
- PC interface (serial or USB).

iii. Length measurement (optional)

Length measurements may be made with an OLTS only if it is capable of measuring the optical length of the fiber using time-of-flight techniques.

c. OTDR

i. OTDR shall have internal non-volatile memory and removable memory device with at least 8 MB capacity for results storage.

ii. OTDR shall have serial and USB ports to transfer data to a PC.

iii. OTDR shall provide wavelengths of 1310 nm ( $\pm 20$  nm) and 1550 nm ( $\pm 20$  nm).

iv. OTDR shall provide event dead zones of 11.5 ft. (3.5 m) maximum at 1310 nm and 1550 nm.

v. OTDR shall provide attenuation dead zones of 32.8 ft. (10 m) maximum at 1310 nm and 39.4 ft. (12 m) maximum at 1550 nm.

vi. OTDR shall support a distance range of not less than 32,810 ft. (10,000 m).

vii. OTDR shall have a dynamic range of at least 10 dB at 1310 nm and 1550 nm.

- d. Integrated OLTS and OTDR
  - i. Test equipment that combines into one instrument an OLTS and an OTDR may be used.
- 2. Identification
  - a. Fiber Optic Cable Warning Tag



Figure 1 FIBER OPTIC CABLE WARNING TAG

- i. Tag shall have the following minimum dimensions: 1.75” (width) x 3.875” (length).
- ii. Each tag shall have three (3) 0.167” holes on each side as shown in Figure 1.
- iii. Tag shall have an orange background with black foreground and text as shown in Figure 1 indicating: CAUTION - FIBER OPTIC CABLE
- iv. Below the text FIBER OPTIC CABLE in Figure 1, the Contractor shall write-in SMFO for single mode fiber optic cable and XX for the fiber count of the cable, e.g., “SMFO 48” for 48-strand single mode fiber optic cable. A permanent industrial marker shall be utilized for writing on the tag such as the Sharpie Mean Streak® Permanent Marking Stick or Sharpie Industrial Fine Pen.
- v. Tag shall be made from 0.02” thick vinyl.
- vi. Two 8” black cable ties shall be included with each tag.
- vii. Tag must have a minimum five (5) year written warranty for outdoor durability.
- vii. One tag shall be placed on each fiber optic cable (e.g., backbone or lateral) entering a pull box, splice vault, manhole, traffic signal controller cabinet or building as required in Part 3 of this document. Where a splice closure is located in a splice vault or manhole, tags shall be placed on each side of the splice closure for the backbone and lateral cable(s).

b. Fiber Optic Cable Label

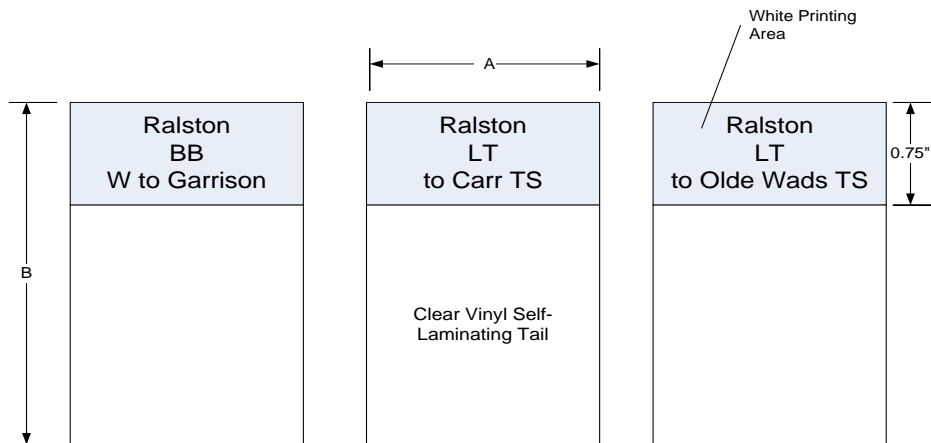


Figure 2 FIBER OPTIC CABLE LABEL

- i. Label must have the following minimum dimensions:
  - A = 1.00"
  - B = 2.50 "
  - C = 0.75"
- ii. Label shall meet the adhesion, defacement, exposure and legibility requirements of UL 969 Marking and Labeling Systems.
- iii. Labels shall be temperature stable from -94°F to +158°F.
- iv. Labels shall either be preprinted using a mechanical means of printing (e.g., laser printer) or field printable using a handheld or portable label printer (e.g., smear-proof ribbons or thermal printing).
- v. Labels shall have a vinyl substrate with a white printing area and a clear "tail" that self laminates the printed area when wrapped around the cable.
- vi. One label shall be placed on each fiber optic cable (e.g., backbone or lateral) entering a pull box, splice vault, manhole, traffic signal controller cabinet or building as required in Part 3 of this document. Where a splice closure is located in a splice vault or manhole, labels shall be placed on each side of the splice closure for the backbone cable(s).
- vii. The text on each label shall be as defined in 50.3.5 Section C.

3. Administration

- a. Administration of the documentation shall include test results of each fiber link.
- b. The test result information for each link shall be recorded in the memory of the field test instrument upon completion of the test.
- c. The test result records saved within the field test instrument shall be transferred into a Microsoft Windows™ -based spreadsheet or database utility that allows for the review, archiving and maintenance of these test records.

C. Execution

1. General

- a. All tests performed on single mode fiber optic cabling that use a laser in a test set shall be carried out with safety precautions in mind by the Contractor.
- b. All cables, termination panels and associated components shall be fully assembled and labeled prior to the initiation of field testing. Any testing performed on incomplete systems shall be redone on completion of the work.

2. Fiber Optic Cable Testing

- a. Contractor shall verify that the test jumpers (OLTS) and test fiber box (OTDR) are of the same fiber core size and connector type as the cable system.
- b. Contractor shall verify that optical sources are stabilized and have center wavelengths within  $\pm 20$  nm as stipulated in 50.3.5 Section B of this document.
- c. Contractor shall ensure that the power meter and light source are calibrated at each of the nominal test wavelengths and traceable to the National Institute of Standards and Technology (NIST) Special Publication 250-54 calibration standard. The OTDR must also be calibrated and traceable to the NIST calibration standard. Calibration certificates shall be provided to the City for review and approval to ensure that the power meter, light source and OTDR have each been calibrated within the past calendar year. Any test equipment whose calibration certificate is over two years old, must be recalibrated and a copy of the new calibration certificate provided to the City for review and approval prior to use on this Contract.
- d. Contractor shall verify that all field test instruments have the latest software and firmware installed.
- e. Contractor shall verify that the power meter and the light source are set to the same wavelength.

- f. Contractor shall ensure that all system connectors, adapters and jumpers are properly cleaned prior to and during measurement.
- g. Link test results from the OLTS and OTDR shall be recorded in the test instrument upon completion of each test for subsequent uploading to a PC in which the administrative documentation (reports) should be generated.
- h. Testing of the cabling shall be performed using high quality test jumpers of the same fiber type and core diameter as the cabling under test. The test jumpers for OLTS testing shall be between 3.3 ft. (1 m) and 16.4 ft. (5 m) in length. The test fiber for the OTDR testing shall be approximately 984 ft. (300 m) for the launch cable so that the first connector on the link is visible in the trace.
- i. **OLTS Testing**
  - i. Single mode links shall be tested at 1310 nm and 1550 nm in accordance with TIA-526-7 for patch panel to patch panel testing.
  - ii. The Contractor shall follow the test procedures established by the referenced standard to accurately conduct performance testing.
  - iii. Prior to the initiation of OLTS testing, a reference reading shall be made and recorded between the light source and power meter using the test jumper. The reference reading shall be re-measured after every 200 measurements or every eight (8) hours, whichever occurs first. The reference readings shall be provided to the City as part of the test results documentation described in Section 3.04 of this document.
  - iv. End-to-end link attenuation does not include any active or passive devices other than cable, connectors and splices.
- j. **OTDR Testing**
  - i. Single mode links shall be tested at the appropriate operating wavelength for anomalies and to ensure uniformity of cable attenuation, determine connector insertion loss and measure splice loss. Refer to Section 2.01(C) for operating wavelengths.
  - ii. Each fiber link shall be tested at the dual-wavelength and bi-directionally to meet transmission equipment certification.
  - iv. A test fiber box shall be installed between the OTDR and the first patch panel, unless otherwise recommended by the OTDR manufacturer.

v. Cable Acceptance: The Contractor shall evaluate the integrity, overall length and fiber attenuation in dB/km for each fiber strand in the cables before and after installation. The City will use this information to check the cable against its specification, uncover point defects due to handling during transport or installation and effectively measure terminated and unterminated fibers.

- Before Installation Cable Inspection – Prior to cutting a reel into sections and installing the various cable segments, the Contractor shall utilize an OTDR to evaluate the fiber optic cable's initial quality and integrity.

The Contractor shall access one cable end from the reel to verify the length and attenuation of each fiber in the cable for comparison to the cable manufacturer's factory test results. All detected point faults and/or discontinuities caused by shipping and handling shall be brought to the attention of the City or the City's Inspector. All test results shall be provided to the City or its designated representative and approved in writing before cable installation can begin.

vi. Trace Documentation: All OTDR traces shall be stored electronically.

vii. Connector and Splice Loss: The Contractor shall measure and document all field-installed connectors and fusion splices so that a determination can be made about their acceptability or if they need to be redone.

### 3 Identification

#### a. Labeling

i. Fiber Optic Cable Warning Tag: The fiber optic cable type and fiber count shall be handwritten by the Contractor as specified in 50.3.5 Section B2.

ii. Fiber Optic Cable Label: The labeling strategy for this type of label shall conform to the requirements below, as specified in Section 50.3.5 Section B2 and as shown in Figure 2.

- Highway where the fiber optic cable is located.
- Backbone (BB) or lateral (LT) fiber optic cable.
- Destination of fiber optic cable from building, controller cabinet, pull box, splice vault or manhole.

- Allowable abbreviations consist of the following:

- Building (BLDG)
- City Hall (CH)
- East (E)
- Eastbound (EB)
- Manhole (MH)
- North (N)
- Northbound (NB)
- Pull box (PB)
- Quadrant of intersection or interchange (QD)
- South (S)
- Southbound (SB)
- Splice vault (SV)
- Traffic Signal controller cabinet (TS)
- West (W)
- Westbound (WB)

## D Administration

### 1. Test Results Documentation

- a. Provide one digital copy either by email or CD-ROM version of test results documentation to the City for review and approval.
- b. Test results shall be organized and bound in a logical order. It should start at one end of a corridor and logically progress to the end of the corridor rather than skipping around. OLTS and OTDR test results shall be separated within the same document.
- c. Results of every attenuation test shall be included.
- d. The Contractor shall expand the vertical and horizontal scales used on the OTDR display to maximize the amount of detail shown on the OTDR traces, even if these parameters can be adjusted later using the display software. The software and applicable licenses required to read the OTDR traces shall be provided to the City at no extra charge.
- e. OTDR traces must identify the end points of the fiber under test and the fiber designation. If this information is not provided by the trace itself, the Contractor shall provide a cross-reference table between the stored trace file name and the fiber designation.
- f. For each field-installed connector and fusion splice performed by the Contractor, an OTDR measurement will be made bi-directionally unless approved by the City Engineer or designee at the 1310 and 1550 nm wavelength and averaged to ensure it meets the required specifications.
- g. Test results saved within the field test instrument shall be uploaded to the PC unaltered. The file format, Comma Separated Value (CSV), shall not be accepted because it does not provide adequate protection of these records.



- h. The test results documentation shall be provided to the City within ten (10) working days of completion of tests. The Contractor shall retain a copy to aid preparation of asbuilt documentation.
- i. The detailed test results documentation data is to be provided for each tested optical fiber and shall contain the following information;
  - i. The identification of the highway corridor where the fiber was installed (as specified by the City).
  - ii. The name of the test or test limit and its relationship to the segment of the highway corridor.
  - iii. The name of the Contractor and its personnel performing the test.
  - iv. The date and time that the tests were conducted.
  - v. The manufacturer, model number and serial number of the field test instrument.
  - vi. The name and version of the test software and firmware.
  - vii. The fiber identification number.
  - viii. The length for each optical fiber as calculated by the OLTS or OTDR.
  - ix. The index of refraction used for length calculation when using a length capable OLTS.
  - x. Test results of OLTS attenuation for each link at the appropriate wavelengths and the margin (difference between measured and calculated).
  - xi. Test results of OTDR link traces and event tables at the appropriate wavelengths.
  - xii. The overall Pass/Fail evaluation of the link under test for OLTS and OTDR measurements.

2. Record Copy and Asbuilt Drawings

- a. The intent of the asbuilt drawings is to provide accurate and detailed information, in a useful format, to any party, private or public, that may have a need to locate, excavate, modify or expand installed infrastructure. Questions regarding asbuilt drawings shall be directed to the City Engineer or designee. Discretion shall be employed in the drafting of asbuilts in terms of the functional quality of the drawings. If too much information is included on one sheet as to make its use impractical to comprehend, a second or third drawing may be necessary.

- b. It is recommended that the Contractor maintain a tabloid sized set of approved plans on site and, during construction, accurately mark these plans with record information. As an example, the color green could be used to indicate all additions and the color red to indicate all deletions. Clear and concise notes and sketches shall accompany changes marked on the plans to document the basis for the modifications.
  
- c. The following requirements shall be applied to each asbuilt plan developed for the City. Asbuilt drawings shall be prepared by revisions to the original, approved plans. At no time shall the original plan data be accepted as asbuilt data. The following general requirements shall be required for all asbuilt drawings:
  - i. All drawings shall bear the name, address and telephone number of the firm preparing the drawing and the date the asbuilt data is added to the original via the revision block.
  - ii. All drawings shall bear the name of the Contractor(s) along with a statement (with an original signature on each sheet) stating that the asbuilt drawings reflect the true conditions in the field and that all construction standard specifications and product qualities have been met or exceeded.
  - iii. "ASBUILT DRAWING" shall be clearly labeled on each sheet.
  - iv. Street names shall be on all streets. All easements and right-of-way shall be shown and clearly labeled.
  - v. If the fiber optic infrastructure is to be private (not to be dedicated to the City), then it shall be clearly stated on each sheet.
  - vi. The locations and description of any existing utility lines (overhead or underground, as applicable) known to exist within the construction area.
  - vii. The locations and dimensions of any changes to poles, cabinets and buildings, as applicable.
  - viii. Changes in details of the design or additional information such as approved placement details, conduit sizes, material changes, etc.
  - ix. Where plans or specifications allow options, only the option actually used in the construction shall be shown on the asbuilt drawings.

- d. Record copy drawings shall be provided by the Contractor to the City at the end of the project on electronic format. The drawings shall be in AutoCAD or pdf format and include notations reflecting the asbuilt conditions of any additions to or variation from the drawings provided such as, but not limited to, cable routing, fiber assignments and terminations. AutoCAD or pdf drawings should include OLTS results in a tabular format for historical baseline information.
  
- e. The asbuilt drawings shall include, but are not limited to, network layout diagrams, splice diagrams and port-to-port jumper terminations. The asbuilts shall include all field changes made up to construction completion including:
  - i. Field directed changes to splicing
  - ii. Field directed changes to terminations
  - iii. Backbone cable type or routing changes
  - iv. Lateral cable type or routing changes
  - v. Pull box or splice vault type or location changes
  - vi. Splice closure and associated components changes
  - vii. Patch panel changes
  - viii. Jumper and/or connector type changes
  - ix. End equipment changes
  - x. Associated detail drawings to help explain changes

50.3.6 Hardwire Interconnect

- A. This section references hardwire interconnect systems and is applicable when specified.
  
- B. The telephone hardwire interconnect wire shall be #19 AWG, 6 twisted pairs, shielded cable, with petrolatum-polyethylene gel filled compound. The cable shall meet R.E.A. Specification PE-39 (Clifford of Vermont Catalog #6P19 B1 BJFC or approved equivalent).
  
- C. No splicing of the interconnect cable will be allowed. The cable shall be installed between two adjacent controller cabinets in continuous runs.
  
- D. All telephone interconnect cable pairs will be connected to either active or spare terminal points provided in the controller cabinet. The contractor shall identify and label all terminal points.

- E. All interconnect wires shall be checked after installation to determine their resistance and resistance to ground. Each pair shall be shorted together at one end and a resistance check will be made at the other end or wherever a splice exists. Resistance will be checked between each conductor and ground. All resistance readings shall be recorded showing value, color and location of wire. Data is to be supplied to the City's Traffic Department within 30 days of completion of the project.
- F. At the terminal points the jackets shall be stripped and the ends taped. Gel filling compound shall be removed using filled cable cleaner.

**50.4 TRAFFIC CONTROL CONSTRUCTION STANDARDS**

50.4.1 Traffic Signals

A. General Requirements

The work specified in this section describes the installation of necessary material and equipment to complete traffic signals and/or other electrical systems as specified on the drawings, in the special contract provisions, or herein.

B. Traffic Control and Street Closure

The contractor will be required to maintain access to all private drives throughout the period of construction for this project. The contractor shall be required to erect and maintain all barricades, traffic control signs, cones, and other traffic control items necessary to provide proper traffic control during construction. The contractor shall submit three (3) copies of the traffic control plan to the City Engineer or designee for approval 72 hours prior to beginning construction. At the completion of the project the contractor shall remove all barricades, traffic control signs, cones and other necessary construction traffic control items and return all areas or permanent traffic control devices damaged during construction to their original condition at no cost to the City. Traffic control signs and devices shall be in accordance with the "Manual on Uniform Traffic Control Devices for Streets and Highways", latest edition, published by the Federal Highway Administration, and as directed by the Engineer.

C. Testing

The City may at its option and cost retain the services of an independent testing lab to perform all testing consultation and to assist in the review of the work and equipment.

D. Intersection Power

The contractor shall notify the engineer two (2) weeks prior to the signal turn on so that orders may be issued for power connection to the intersection on the specified turn on date.

E. Equipment Salvage

All traffic signal equipment which is removed shall remain the property of the City unless specified in the plans or by the City Engineer or designee. Such property is to be removed from the work site and returned by the contractor to the City of Arvada Municipal Service Center located at 6701 Indiana St.

F. Existing Traffic Signals

When existing traffic signal installations are modified or completely rebuilt, the contractor shall avoid disturbing existing traffic signal equipment until the new or modified traffic signal system has been installed and put into operation. If the existing traffic signal equipment must be removed to accommodate the new construction, the contractor shall, with the engineer's approval and at the contractor's sole expense, install temporary overhead traffic signal equipment. The contractor shall at all times maintain a minimum of two (2) three section (red, yellow, and green) traffic signal heads for each roadway approach.

G. Signal Heads

Signal heads installed on standards or poles at new signal locations which are not ready for actual electrical operation shall be bagged.

H. Field Location

All loops, poles, control cabinets, pull box locations, and pole foundations shall be field located by the engineer. Traffic signal poles and mast arms shall not be ordered until field verification of pole foundations is complete.

I. Utilities

All utilities shall be shown on the maps to the extent that they can, based upon utility records, surface field indications and proposed installations. During the progress of the work, all utility locations and elevations will necessarily require field verification in cooperation with the affected companies and public agencies. The contractor shall be responsible for locating all valve boxes, manholes, etc., and insuring that they are properly protected and/or adjusted.

J. Notification of Work

The contractor shall work only on weekdays between the hours of 8:30 a.m. and 3:30 p.m. The contractor must receive written approval from the engineer to work at any other time.

50.4.2 Regulations and Code

All electrical equipment and material shall conform to the standards of the National Electrical Manufacturers Association (NEMA) or the Colorado Department of Transportation (CDOT), whichever is applicable. In addition to requirements of these specifications, the plans, the special contract provisions, all material, and work shall conform to the requirements of the National Electrical Code (hereinafter referred to as the "Code"), the Rules for Overhead Electrical Line Construction of the Public Utilities Commission, the Standards of the American Society for Testing Materials (ASTM), the American Standards Association (ASA), and any local ordinance which may apply.

Wherever reference is made in these specifications or in the special contract provisions to the code, rules, or the standards mentioned above, the reference shall be construed to mean the code, rule, or standard that is in effect at the date of bidding.

#### 50.4.3 Equipment List and Drawings

The contractor shall submit a list of equipment and material which he proposes to furnish within five days of the execution of the owner-contractor agreement. The submittal shall include all equipment and material as identified on the plans or in the specifications by the manufacturer's name which is necessary or customary in the trade to identify such equipment and material. The list shall be complete as to name of manufacturer, unit size, material composition and shall be supplemented by such other data as may be required by the City Engineer or designee.

Inspection or sampling of any materials, other than those already approved, according to the material specifications must be made by the engineer or his designee prior to installation. If the contractor proposes a substitution of equipment called for in the plans or specifications, he shall provide additional information to prove the substitution item is of equal or superior quality. Any material and/or equipment installed by the contractor that is not in conformance with the City of Arvada specifications will be removed or changed at the contractor's expense. Upon completion of the work, the contractor shall submit two (2) copies of "as built" drawings or corrected plan showing, in detail, all construction changes including, but not limited to, wiring, cable, and location and depth of conduit.

#### 50.4.4 Excavating and Backfilling

Excavations for the installation of conduit, foundations, and other traffic signal items shall be performed in such a manner as to cause the least possible damage to the streets, sidewalks, and other improvements. The trenches shall not be excavated wider than necessary for the proper installation of the electrical appliances and foundations. Excavating shall not be performed until immediately before installation of conduit and other appliances. The material from the excavation shall be removed as the trenching progresses.

Trenches in existing or proposed roadways shall be backfilled with concrete or approved flow-fill material. After backfilling, during construction, all trenches shall be kept well filled and maintained in a smooth and well drained condition until permanent repairs are made. Compaction must be in conformance with City of Arvada Standards and Specifications. Compaction testing may be required of the contractor at the discretion of the City Engineer or designee.

Excavations in streets or highways shall be performed in such a manner that one (1) lane of traffic in each direction shall be open to public traffic. All lane closures shall be approved by engineer prior to closure. At the end of each day's work and any other time construction operations are suspended, all construction equipment and other obstructions shall be removed from that portion of the roadway open for use by public traffic. Trenches shall not be left open overnight unless prior approval is obtained from the City Engineer or designee. When excavations must remain open overnight, they shall be properly marked to warn motorists and/or pedestrians according to guidelines established in the latest edition of the "Manual on Uniform Traffic Control Devices for Streets and Highways".

#### 50.4.5 Removing and Replacing Improvements

The contractor shall at his sole expense, replace or reconstruct sidewalks, curbs, gutters, rigid or flexible pavement, and any other City or privately owned property which is removed, broken, or damaged by contractor with material which conforms to current City Standards and Specifications. Whenever a part of a square or slab or existing concrete, sidewalk, or driveway is broken or damaged, the entire square or slab shall be removed and the concrete reconstructed as above specified.

The outline of all areas to be removed in Portland cement concrete sidewalks and in pavements shall be cut to a minimum depth of one and one half inches (1 1/2") with an abrasive type saw prior to removing the sidewalk and pavement material. Cut for remainder of the required depth may be made by a method satisfactory to the engineer. Cuts shall be neat and true with no shatter outside the removal area.

#### 50.4.6

#### Underground Facilities

##### A. Foundations

1. All foundations shall be Portland cement concrete conforming to the applicable requirements of construction specifications of the City of Arvada, except as herein provided..
2. The bottom of concrete foundations shall rest on firm ground. Cast in place foundations shall be poured monolithically where practicable. The exposed portions shall be formed to present a neat appearance.
3. Forms shall be true to line and grade. Tops of foundations, except as noted on plans, shall be finished to curb or sidewalk grade or as ordered by the engineer. Forms shall be rigid and securely braced in place and inspected prior to the pouring of concrete. Conduit ends and anchor bolts shall be placed in proper position and in a template until the concrete sets.
4. Anchor bolts shall conform to the specifications and each individual bolt shall have two (2) flat washers, one (1) lock washer, and two (2) nuts. Shims or other similar devices for plumbing or raking will not be permitted.
5. Both forms and ground which will be in contact with the concrete shall be moistened before placing concrete. Forms shall not be removed until the concrete has thoroughly set.
6. All abandoned foundations shall be removed and disposed of by the contractor. All conduit runs associated with an abandoned foundation shall be extended or abandoned as called for on the plans. When a foundation is removed, the hole shall be backfilled in accordance with State of Colorado and City of Arvada standard practices.

##### B. Conduit

1. All cables and conductors not shown on the plans as aerial cable shall be installed in conduit unless installed in poles, pedestals, or mastarms. PVC schedule 80, or greater, conduit shall be used unless otherwise specified. When specified, all metal conduit referred to in the specifications and shown on the plans shall be rigid and adequately galvanized.
2. All trenches excavated in roadways, including new construction areas, shall be backfilled with concrete or State of Colorado approved flow fill, and capped with six inches (6") of Grade E Asphaltic Pavement.
3. The following conduit schedule is in effect unless otherwise specified in the plans:

## Conduit Schedule

<u>Run Type</u>	<u>Quan.</u>	<u>Size</u>	<u>Use</u>
Street Crossings	1	3"	120 voltage
Street Crossings	1	2"	Low voltage
Street Crossings	1	2"	Xcel use
Street Crossing	1	3"	Spare
Signal Pole	1	3"	Signal cables
Signal Pole	1	2"	Xcel use
Controller Cabinet	2	3"	120 voltage
Controller Cabinet	2	2"	Low voltage
Controller Cabinet	1	3"	Spare
Interconnect	1	3"	Interconnect
Service Point	1	2"	Xcel use
Service Point	1	2"	Telephone line
Special Use	1	2"	Advanced Detection

4. The contractor, at his sole expense, may use larger conduit if desired. Where larger conduit is used, it shall be for the entire length of the run from outlet. No reducing couplings will be permitted underground.
5. Where a "stub out" is called for on the plans, a sweeping ell shall be installed in the direction indicated and properly capped. The locations of ends of all conduits in structures or terminating at curbs shall be marked by a "Y" at least three inches (3") high cut into the face of the curb, gutter, or wall directly above the conduit.
6. Conduit bends, except factory bends, shall have a radius of not less than six (6) times the inside diameter of the conduit. Where factory bends are not used, conduit shall be bent without crimping or flattening, using the longest radius practicable.
7. Conduit shall be laid at a depth of not less than twenty four inches (24") below the top of curb grade in sidewalk or grass areas and to a depth of not less than thirty inches (30") below the finished grade in all other areas. Conduit under railroad tracks shall be specified and approved by appropriate railroad authority.
8. Trench excavations for conduit shall be two inches (2") wider than the outside diameter of the conduit. Backfilling of conduit trenches shall be accomplished by placing concrete or approved flow-fill up to the bottom surface of the existing or new roadway surface material. The remaining portion of the excavation shall be backfilled with the same type of material used to construct the existing roadway surface.
9. Conduit shall always enter a foundation, pull box, or any other type structure from the direction of the run only.
10. Conduits terminating in a pole shall extend approximately two inches (2") vertically above the foundation.
11. All conduit runs that exceed ten feet (10') in length shall have a continuous nylon line pulled into the conduit along with the specified electrical cables. The line shall be firmly secured at each end of the conduit run with a minimum slack of three feet (3'). The purpose of this line is to be able to pull future electrical cable through the existing conduit runs.



12. Existing underground conduit to be incorporated into a new system shall be cleaned with a mandrel or blown out with compressed air.
13. A 12 AWG locate wire shall be installed for the complete length of all new conduit runs installed as part of the project. No less than three (3) feet of slack shall remain in each pull box in which the conduit terminates. Where joint trenching is used, only one locate wire need be installed for each joint trench. Locate wire within interconnect conduits shall be continuous from cabinet to cabinet. Splicing of the locate wire within conduits shall not be permitted.
14. New conduit runs shown on the plans are for bidding purposes only and may be changed with approval of the engineer.

C. Pull Boxes

1. A pull box shall always be installed in combination with a steel strain pole and at all other locations shown on the plans and at such additional points as ordered by the engineer. The contractor may install, at his own expense, any additional pull box that he may desire to facilitate the work.
2. Special pull boxes which are required shall be fabricated and installed in general conformance with the size and details shown on standard drawings.
3. Pull boxes shall be installed so that the covers are level with curb or sidewalk grade or level with the surrounding ground when no grade is established. The bottoms of all pull boxes shall be bedded in six (6) inches of crushed rock.
4. When a new conduit run enters an existing pull box, the contractor shall remove the pull box or tunnel under the side at no less than eighteen inches (18") and enter from the direction of the run. No new conduit will be allowed to enter a new or existing pull box in any other manner than that shown on standard drawings.
5. Loop detector pull boxes installed in the street shall be water valve type and placed according to the plans or as directed by the engineer. The lids shall have the word "Traffic" cast into them.
6. Pull box lids shall be imprinted with markings. Painted markings shall not be permitted.
7. Pull box sizes shall be as shown in the standard drawings. Pull boxes shall be stackable and manufactured of a pre-cast polymer concrete material such as "Quazite" or an approved equal. Both the box and lid of all pull boxes shall be rated for loads of 20k lbs. or greater.
8. Interconnect pull boxes, installed at intermediate locations between traffic signal cabinets, shall be installed at a maximum increments of 500', and shall be of the size defined in the pull box schedule.
9. Interconnect pull boxes, installed adjacent to existing traffic signal controller cabinets, shall be of the size defined in the pull box schedule.

10. The following pull box schedule is in effect unless otherwise specified in the traffic signal design or standard drawings:

Pull Box Schedule

<u>Pull Box Usage</u>	<u>Size</u>	<u>Lid Marking</u>
Cabinet Home Run Pull Box	24"x36"x18"	Traffic
Signal Pole Pull Box	13"x24"x12"	Traffic
Advanced Detection Pull Box	12"x12"x12"	Traffic
Interconnect (Intermediate)	24"x36"x18"	Arvada Fiber
Interconnect (T/S Cabinet)	30"x48"x18"	Arvada Fiber
Electrical Demarcation	12"x12"x12"	Electric
Telephone Demarcation	12"x12"x12"	Communication

D. Detector Loop Wire Installation

1. Each individual detector loop is to be terminated within a water valve housing as specified on the construction drawing, and each loop shall consist of one continuous wire, without splicing, to the termination point. Any required series or parallel connections are to be at the termination point.
2. All loops shall have a tag attached to the leading clockwise lead of the loop. This tag shall be marked to indicate the relative location of the loop. This marking shall correspond directly to the loop designations on the intersection drawing provided in the contract.
3. Detector loop roadway slots shall be cut in asphalt that has a 6 inch minimum depth and sealed one fourth inch (1/4") below the surface level of the roadway with 3M or approved equal. This sealer is to be used whether or not the roadway is to be overlaid.
4. The contractor shall include cost for loop wire, saw cutting, sealant, splice and test for a complete installation of the loop to the termination point at a pay per item price.

E. Conductor and Cable

1. Wiring shall conform to appropriate articles of the National Electric Code. Wiring within cabinets, junction boxes, etc., shall be neatly arranged and labeled appropriately.
2. Powdered soap stone, talc, or other approved lubricant shall be used in placing conductors in conduit.
3. A common neutral conductor, separate from the signal light circuit neutral, shall be used for all low voltage circuits, including the detectors and pedestrian push button circuits.
4. Splicing of cable will not be permitted in conduit or pull boxes or outside of signal heads, standards or foundations.
5. In no case shall any shellac compounds be used. Wire nut type connectors shall not be used. All wire connections shall use crimps and insulating covers. Detector loop lead in splices in underground systems shall be

waterproofed with 3M splice kits or City approved equivalent. A minimum of twelve inches (12") of slack shall be left at each splice except within hand holes where twenty four inches (24") shall be left.

- 6. When conductors and cables are pulled into the conduit, all ends of conductors and cables shall be taped to exclude moisture and shall be so kept until the splices are made or terminal appliances attached. Ends of spare conductors shall be taped and marked.
- 7. Cable shall be stranded. For span wire type installations, cable shall be installed where specified on the plans and secured to messenger cable with cable rings in accordance with standard practices. Aerial cable shall be supported by strand vices of proper size and strength as well as insulators used where necessary.
- 8. A small permanent tag on which the direction and phase is printed, in the order named, using the codes given in the cable schedule below shall be securely attached near the end of each conductor at each controller, standard, or pull box where conductors are separated. Where direction and phase are not clearly indicated by conductor insulation, additional tags shall be used.

Cable Schedule

<u>Phase/Tag</u>	<u>Tape Color</u>
1. NBLT	Red/White
2. NB	Red
3. SBLT	Green/White
4. SB	Green
5. EBLT	Orange/White
6. EB	Orange
7. WBLT	Blue/White
8. WB	Blue
9. Pedestrian	Yellow

**NOTE:** This is a typical cable schedule and shall be used for the wiring of all signal installations. A new cable schedule will be noted on the plans at each intersection where different phasing and/or special equipment is required. It should be noted that a band of white is used to indicate a left turn and yellow for a pedestrian movement. This is in addition to directional tape for the phase. For cable size and number of conductors see traffic signal material specifications and/or standard drawings.

- 9. Inboard and outboard heads, mounted on mastarms and/or poles, are to be wired separately from head to base of pole.

F. Bonding and Grounding

- 1. Metallic cable sheaths, conduit, metal poles, and foundations shall be made mechanically and electrically secure to form a continuous system and shall be effectively grounded. Bonding and grounding jumpers shall be copper wire, No. 8 AWG, for all systems. Belden cable sheath for loop detectors to be grounded in control cabinet only. The other end of the sheath to be left ungrounded.

2. Bonding of standards shall be by means of a bonding wire attached to a bolt or a three sixteenths inch (3/16") or larger bolt installed in the lower portion of the shaft.
3. At each pull box the ground electrode shall be a one piece copper ground rod of five eighths inch (5/8") diameter and eight feet (8') in length, driven into the ground so that the top is two inches (2") above the bottom of the pull box. The ground rod connector will be placed so that the bare copper wire, No. 8, can be pulled into a pole, foundation, or attached to the control cabinet ground buss.

G. Maintenance

The contractor shall have full maintenance responsibility of the traffic signal from the date of the written notification by the City Engineer or designee to the final inspection and date of written approval of the work performed. Continuous maintenance and emergency service shall be provided by the contractor 24 hours each day during the time frame outlined above. The contractor shall provide and maintain a 24 hour a day continuous one number telephone answering service. All malfunctions of a controller and its accessory equipment shall be considered an emergency unless otherwise identified by the City. Equipment malfunctions and/or damage, which in the opinion of Arvada's City Engineer or designee, constitutes a serious hazard or inconvenience to the public shall be considered an emergency. Such malfunctions or damage may include, but not necessarily be limited to, situations where:

1. All indications are out including bulbs, LEDs and lenses, for any one traffic movement;
2. Signal heads give conflicting indications to any intersection approach;
3. A signal has been knocked down;
4. An overhead red indication is out

Contractor shall undertake each emergency repair no later than one hour after Arvada notifies contractor of the emergency.

In instances of repairs that are not of an emergency nature, such repairs shall be undertaken at the site within one working day after Arvada notifies contractor of the needed repair. Arvada shall pay the contractor for the materials, parts and/or supplies actually used by the contractor in making any such repair in the amount of the contractor's cost plus five percent (5%). Labor and equipment rates associated with work performed due to vandalism or vehicle accident damage will be reimbursed at the rate set forth in the City's traffic signal maintenance contract. All warranties shall be in effect and enforced.

Should the contractor fail to perform any maintenance responsibilities within the prescribed time periods, the City Engineer or designee shall employ the services of the City's designated traffic signal maintenance contractor to perform said maintenance work. The contractor shall reimburse the City for labor and equipment charges associated with the utilization of the City's designated traffic signal maintenance contractor plus a fifteen percent (15%) administration fee.

H. Field Testing

Prior to completion of the work, the contractor shall cause the following tests to be made on all traffic signals in the presence of the engineer or his designee.

1. A visual inspection of all wiring will be conducted.
2. A functional test shall be made in which it is demonstrated that each and every part of the system functions as specified or intended herein. The functional test for each traffic signal system shall consist of not less than fourteen (14) days of continuous, satisfactory operation commencing with full operation of all electrical facilities. During the fourteen day period, the contractor will maintain the system or systems. The cost of any maintenance necessary, except electrical energy and maintenance due to damage by public traffic, shall be borne by the contractor and will be considered as included in the price paid for the contract item involved, and no additional compensation will be allowed.

50.4.7 Traffic Signing and Pavement Markings

A. General

The installation of all traffic control devices shall conform to the latest edition of the Manual on Uniform Traffic Control Devices and the Colorado Standard Specifications for Road and Bridge Construction.

B. Traffic Control Devices on Private Property

1. Responsibility: All traffic control devices on private property; i.e., pavement markings, regulatory signs, fire lane signs, and handicapped parking signs shall be installed and maintained by the property owner..
2. Placement: A signage and striping plan specifying the various types and combinations of traffic control devices shall be submitted to the City Engineer or designee for approval.

C. Pavement Markings

All pavement markings required to be installed as a result of new construction or development shall be inlaid tape for long lines and thermoplastic for crosswalk markings and symbols as per CDOT specifications 627 and 713. Temporary pavement markings necessary to facilitate construction (i.e. detours) may be installed using paint as per CDOT specifications 627.

The contractor shall submit a plan for all pavement markings to the City Engineer or designee for approval prior to the beginning of the work. The pavement marking plan shall meet the requirements for such work as outlined in the Manual on Uniform Traffic Control Devices. All pavement marking materials must be approved by the City Engineer or designee.