

Chapter 9 - Signage, Pavement Markings, and Traffic Signals

9.1 General Requirements

Signage, pavement markings, and traffic signals shall be designed and installed in accordance with the City of Castle Pines Standards. All traffic control devices shall conform to the most recent version of the federal *Manual on Uniform Traffic Control Devices for Streets and Highways* (MUTCD), the Colorado Supplemental MUTCD, and the Castle Pines Roadway Design and Construction Standards Manual. Further specifications and illustrations can be referenced in the Colorado Department of Transportation (CDOT) Standards.

Notes on signage and pavement markings shall be included in all sets of construction plans. Permanent signage and striping shall be completely in place before any new roadway is opened to the public. The City Public Works Department shall perform a field inspection of location and installation of all signs and markings prior to completion and acceptance of the work. All discrepancies identified during the field inspection must be corrected before the 2-year warranty period will begin.

9.2 Traffic Signage Criteria

9.2.1 Sign Blanks

Aluminum blanks shall be 0.080 gauge.

9.2.2 Sign Sheeting

All STOP (R1-1) signs, YIELD (R1-2), and overhead signs mounted on structures shall have ASTM D-4956 Type VII retroreflective material (3M Diamond grade or approved equivalent). All other ground signs shall have ASTM D-4956 Type III retroreflective material (3M High Intensity Prismatic grade or approved equivalent).

9.2.3 STOP Sign Size

Where STOP sign control is appropriate, 36-inch STOP signs shall be used for approaches to any roadway that is classified as a Major or Minor Collector or greater.

9.2.4 Street Name Signs

For all new streets, the street names are to be obtained from Douglas County for all intersections.

Street name signs shall be limited to 12 letters/characters, excluding street type prefix and suffix. All street name signs shall be visible from both directions, and the legend shall be affixed to both sides of the sign panel.

A 7-foot minimum height shall be maintained from the bottom of the sign panel to the top grade of the sidewalk (at top grade of pavement edge where no sidewalk exists). Refer to Standard Detail SS-1.

Refer to Standard Details SS-2 and SS-3 for street name assembly requirements and sizes. When street name assembly is combined with regulatory sign(s), minimum mounting height shall apply to the regulatory sign(s).

If installing with a SignFix bracket and one panel, the legend shall be affixed to both sides of the sign panel.

All public road street name signs shall include the City of Castle Pines logo on the left side of the sign (except for allowances listed in Section 9.4). When arrows are used or required, the City of Castle Pines logo shall be omitted.

Street name sign coloring shall be white legend on green background, unless approved otherwise.

The longer street name sign shall be installed on the bottom, so it is right above the stop sign, and the shorter name sign should be installed on the top.

Special care shall be taken in the sign's location to create an unobstructed view of each sign.

All removed signs shall be returned to the City Public Works Department if requested.

Capital Improvement Program and Special projects for roadway improvements shall require all existing traffic signs to be replaced with new traffic signs. All signs shall be returned to the City Public Works Department if requested.

All sign locations shall be in accordance with the current version of the MUTCD or as approved by the City Public Works Department and placed in accordance with Standard Detail SS-1.

9.3 Posts and Anchor Posts

9.3.1 Ground-mounted Signs

Ground-mounted signs shall be mounted on standard 12-gauge, 2-inch-by-2-inch, galvanized square steel tube posts, all four sides punched with 3/8-inch holes at 1-inch centers. Posts must be of appropriate length to meet MUTCD specifications for the location and must meet Federal Breakaway Standards. Anchor posts are to be 2-and-1-quarter-inch by 2-and-1-quarter-inch by 3-foot square tubing with all four sides punched with 3/8-inch holes at 1-inch centers, driven down to 4 inches above grade. Longer anchor posts may be required by the City because of soil composition and compaction.

9.3.2 Island Signs

For all signs installed in raised median islands and Roundabouts and mounted in concrete, KLEEN BREAK MODEL 425 anchors also need to be installed (in accordance with Xcessories Squared Development and Manufacturing Inc. Drawing #XKB425-20-CI Square Post Sign Support Installation Instructions) at the time of island construction for all known future signs.

9.3.3 Large Signs

Xcessories Squared 1.25-inch Aluminum Sign Brace Non-Perforated (or equivalent) shall be used on all signs that are greater than or equal to 1,152 square inches (or as directed by the City Public Works Department). Install according to manufacturer's recommendations and specifications.

9.4 Criteria on Special Allowances for Street Name Sign Variances

Plans for any variances must be submitted to and reviewed by the City Public Works Department. Engineering-specific variances from City Standards must be listed in the special footnote box on the first page of the plans.

Only Metro Districts or Home Owners Associations (HOA) may apply for variances. The Metro District must submit a draft agreement to be reviewed by the City and the City Attorney.

The agreement shall be addressed to the City and must specify that the requesting Metro District shall be responsible for maintenance and supply in perpetuity of their specific signs and materials. The agreement must stipulate that the District/HOA shall respond within 24 hours after notification by the City Public Works Department that maintenance or repair is required.

This agreement will be recorded in the City of Castle Pines; notification of the book and page number will be returned to the Metro District/HOA.

9.5 Designer's Responsibility

These standards are intended for typical applications of signage and striping for standard conditions. These standards do not alleviate the responsibility of the designer from sound engineering judgment or from exceeding minimum standards in specific cases where conditions warrant.

9.6 Pavement Marking Criteria

9.6.1 Material

Standard pavement marking materials shall be as follows for all City roadways (Table 9-1). All materials listed shall conform to the most recent edition of the CDOT Standard Specifications for Road and Bridge Construction, sections 627 and 713. Other pavement marking materials may be used as requested or approved by the City Public Works Department.

Table 9-1. Standard Marking Materials

Marking Type/ Surface Type	Edge, Lane, and Channelizing Lines	Crosswalk Bars and Stop Bars	Turn Arrows and Written Legends
Concrete Pavement	Modified Epoxy	Preformed Plastic ^[a] or Preformed Thermoplastic	Preformed Plastic or Preformed Thermoplastic
Asphalt Pavement	Modified Epoxy	Preformed Plastic or Preformed Thermoplastic	Preformed Plastic or Preformed Thermoplastic

^[a] Crosswalk bars shall be recessed.

Note:

Preformed Plastic minimum thickness is 60 mils for legends and symbols, 75 mil minimum for stop bars and crosswalk bars.

Preformed thermoplastic may be used for spot repair or replacement of all marking types on asphalt surfaces.

9.6.2 Dimensions and Application

The following striping widths shall be used unless otherwise directed by the City Public Works Department (Table 9-2).

Table 9-2. Striping Widths

Stripe	Widths
Edge Line	6 inches
Skip/Lane Line	6 inches
White Channelizing	8 inches
Bike Lane	6 inches
Double Yellow	5 inches (3-inch gap)
Stop Bar	24 inches (4 feet from crosswalk)
Diagonal Shoulder Marking	4 inches
Yield Line	16-inch-by-24-inch layout based on lane widths, or size to be determined by the City Public Works Department.
Crosswalk Bar ^[a]	2 feet by 10 feet on Arterials, all others to have a 2-foot-by-8-foot (centered in lane) layout, or size to be determined by the City Public Works Department.

^[a] Unless otherwise directed by the City.

Note: Broken or dotted marking patterns shall be in accordance with CDOT specifications.

9.6.3 Surface Preparation

Note: Surface preparation includes cleanup and disposal of removed material.

New concrete pavement shall have all residues removed, such as mud, dirt, and curing compound. Removal shall be by water blasting, sand blasting, or other method approved by the City Public Works Department.

New asphalt pavement shall be dry and free of dirt and debris.

For all restriping on existing concrete or asphalt pavement, the surface shall be clean, dry, and free of debris. Cleaning shall be by water sweeping, water or air blasting, or other method approved by the City Public Works Department. Surface grinding shall be performed where directed by the City Public Works Department.

Surface temperatures shall be 50 degrees Fahrenheit (°F) and rising for all pavement marking applications.

When the surface temperature does not reach 50°F (seasonal), the Contractor may, with the City Public Works Department approval, substitute designated pavement markings with temporary marking materials to be replaced with permanent materials when weather dictates. Temporary pavement markings shall be refurbished as determined by the City.

9.6.4 Installation

All pavement markings shall be applied according to the manufacturer's recommendations, unless otherwise authorized by the City Public Works Department.

The Contractor shall use equipment that meets the following requirements, as approved:

- Equipment shall permit traffic to pass safely within the limits of the roadway.
- Equipment shall be designed for placement of both solid and broken line stripes with a reasonably clean-edged stripe of the width and location as shown on striping plan and no overspray on the road surface.
- Equipment shall have a glass bead dispenser directly behind and synchronized with the paint applicator. Each applicator shall have individual control and automatic skip control that will paint a stripe with a gap as shown in the striping plan.
- The equipment may be equipped with a heat exchanger to heat the paint to reduce drying time.
- The operation shall include a trailing vehicle equipped with a flashing arrow board.

The Contractor shall prevent traffic from crossing a wet stripe. Stripes that have been marred or picked up by traffic before they have dried shall be repaired at the Contractor's expense. Removal of paint from vehicles that crossed wet paint shall be at the Contractor's expense.

9.6.5 Pavement Marking Warranty

A 1-year warranty under normal traffic wear is required for pavement marking installations. Material shall not peel or lift in this time period. Approval of all work must be obtained from the City Public Works Department prior to the start of this warranty period.

9.6.6 Use of Stop Bars

The following must include a stop bar:

- Any STOP sign controlled approach to a crosswalk adjacent to a school
- Any multiway, stop-controlled approach
- Any approach to a signalized intersection that does not have a crosswalk.

Stop bars may be staggered longitudinally on a lane-by-lane basis or as determined by the City Public Works Department.

9.6.7 Word or Arrow Pavement Marking

Pavement arrows shall be placed 70 feet upstream of the back of a stop bar or crosswalk on approaches to signalized intersections. For multiple turn arrows in a single lane, number and spacing shall be in accordance with CDOT S Standards. Refer to MUTCD Chapter 3B for all other word or arrow pavement marking placement or as determined by the City.

9.6.8 Bike Lanes

Bike lanes are lanes that have been designated with pavement markings for the preferential use of bicyclists. They are typically one-way facilities located to the right of the general travel lanes on both sides of two-way streets.

9.6.8.1 Bike Lane Width

The minimum bike lane width on a roadway with no curb and gutter is 5 feet. On a roadway with curb and gutter, the minimum width of a bike lane is 5 feet, measured from the face of curb. Exceptions shall be approved by the City on a case-by-case basis.

9.6.8.2 Designating Bike Lanes

Bike lanes shall be designated with the bicycle symbol, which consists of the bike lane rider symbol in combination with the directional arrow (refer to Standard Detail SS-11). The directional arrow encourages bicyclists to ride with traffic, as the law requires.

Bicycle lane markings should be placed after intersections and major driveways (confer with the City Public Works Department for questions about placement). In rural areas, the maximum spacing of bike lane markings should not exceed 1,500 feet. In urban areas, the spacing should not exceed 700 feet or as determined by the City Public Works Department.

9.6.8.3 Bike Lanes at Driveways and Intersections

In Colorado, bicycles are vehicles, so bicyclists are required to follow the rules of the roadway when riding on the streets. Consequently, the striping and marking of bike lanes at intersections should support the operations of bicycles as vehicles and the safe mixing of bicyclists with motorists at conflict points such as driveways and intersections. For both motor vehicles and bicycles, the approach to a right turn and the right turn itself shall be made from as close as practicable to the right-hand curb or edge of the roadway. To support crossing a bike lane to execute a right turn, the bike lane striping transitions to dotted markings on the approach to the intersection. A minimum 50-foot dotted line should be provided, but the length of the dotted line may vary based on the speed of the parallel roadway.

When motorists cross a bike lane to move into a right-turn lane, motorists are required to yield the right-of-way to bicyclists in the bike lane. The BEGIN RIGHT TURN LANE YIELD TO BIKES sign (R4-4) (Standard Detail SS-15) is appropriate when the right turn lane is added to the roadway at the intersection approach. However, in the right-turn drop lane condition (Standard Detail SS-13) the through bicyclists must cross the motorists' path to continue through the intersection. In this case, the bicyclists must yield to the motorist before moving left; therefore, the R4-4 is not appropriate in these conditions.

9.6.8.4 Shared Lanes

A shared lane is a lane of a traveled way that is open to bicycle travel and vehicular use. On local roadways with low volumes and speeds, a shared lane may be all that is needed to comfortably accommodate a bicyclist. Refer to Standard Details SS-17 and SS-18 for proper placement of shared lane markings. Confirm with the City Public Works Department prior to including shared lane markings in a design plan.

9.6.8.5 Buffered Bike Lanes

A buffered bike lane is separated from adjacent through lanes by a striped out buffer area (Standard Detail SS-17). In some locations, it may be desirable to use less than the full width available for a bike lane. The buffer markings consist of two longitudinal white lines and may incorporate an interior diagonal cross hatch or chevron. These transverse markings shall be included when the buffer space is greater than 3 feet in width. The City Public Works Department prefers a 3-foot maximum buffer lane width.

9.6.8.6 Design of Bicycle Signs

If the sign or plaque applies to motorists and bicyclists, then the size of sign shall be as shown for the conventional roads in accordance with Chapter 2 of the MUTCD. The minimum sign and plaque sizes for shared-use paths shall be in accordance with Chapter 9 of the MUTCD and shall be used only for signs and plaques installed specifically for bicycle traffic applications. The minimum sign and plaque sizes for bicycle facilities shall not be used for signs or plaques that are placed in a location that would have any application to other vehicles.

9.6.8.7 City of Castle Pines Signage and Striping Notes for Construction Plans

- 1) ALL TRAFFIC CONTROL DEVICES SHALL CONFORM TO THE MOST RECENT VERSION OF THE FEDERAL MANUAL ON UNIFORM TRAFFIC CONTROL DEVICES (MUTCD), THE "COLORADO SUPPLEMENTAL MUTCD", AND THE "CITY OF CASTLE PINES ROADWAY DESIGN AND CONSTRUCTION STANDARDS". FURTHER SPECIFICATIONS AND ILLUSTRATIONS ARE LOCATED IN THE COLORADO DEPARTMENT OF TRANSPORTATION (CDOT) "M AND S STANDARDS".
- 2) A FIELD INSPECTION OF LOCATION AND INSTALLATION OF ALL SIGNS & MARKINGS SHALL BE PERFORMED BY CITY PUBLIC WORKS DEPARTMENT. ALL DISCREPANCIES IDENTIFIED DURING THE FIELD INSPECTION MUST BE CORRECTED BEFORE THE ONE-YEAR WARRANTY PERIOD WILL BEGIN.
- 3) THE CONTRACTOR INSTALLING SIGNS SHALL BE RESPONSIBLE FOR LOCATING AND PROTECTING ALL UNDERGROUND UTILITIES.
- 4) TYPE III LIGHTED BARRICADES SHALL BE SET AT ENDS OF ROADWAYS WITH AN R11-2 ROAD CLOSED SIGN MOUNTED TO THE RAILS, SEPARATING FINISHED (AND/OR ACCEPTED) AND UNFINISHED CONSTRUCTION AREAS AND SHALL BE MAINTAINED BY THE CONTRACTOR/DEVELOPER. A "ROAD CLOSED AHEAD" WARNING SIGN SHALL BE INSTALLED APPROPRIATELY IN ADVANCE OF THE TYPE III BARRICADES.
- 5) SPECIAL CARE SHALL BE TAKEN IN SIGN LOCATION TO ENSURE AN UNOBSTRUCTED VIEW OF EACH SIGN.
- 6) WHERE STOP SIGN CONTROL IS APPROPRIATE, 36" STOP SIGNS SHALL BE USED FOR APPROACHES TO ANY ROADWAY THAT IS CLASSIFIED AS A COLLECTOR OR GREATER.
- 7) A 7-FOOT MINIMUM HEIGHT SHALL BE MAINTAINED FROM BOTTOM OF SIGN PANEL TO THE TOP GRADE OF SIDEWALK (AT TOP GRADE OF PAVEMENT EDGE WHERE NO SIDEWALK EXISTS).
- 8) DELINEATION OF ROADWAYS WITHOUT CURB AND GUTTER SHALL BE AS SPECIFIED IN THE CDOT "M AND S STANDARDS". SEE STANDARD DETAIL SS-7 FOR RAISED MEDIAN SIGNS AND DELINEATION.
- 9) SIGNAGE AND STRIPING HAS BEEN DETERMINED BY INFORMATION AVAILABLE AT THE TIME OF REVIEW. PRIOR TO INITIATION OF THE WARRANTY PERIOD, CITY PUBLIC WORKS DEPARTMENT RESERVES THE RIGHT TO REQUIRE MODIFICATIONS TO EXISTING, OR INSTALLATION OF, ADDITIONAL SIGNAGE AND/OR PAVEMENT MARKING IF IT IS DETERMINED THAT AN UNFORESEEN SAFETY CONDITION WARRANTS SUCH MODIFICATION ACCORDING TO THE MUTCD OR THE CDOT M AND S STANDARDS. ALL SIGNAGE AND STRIPING SHALL BE SUBJECT TO THE REQUIREMENTS OF THE ONE (1) YEAR WARRANTY PERIOD FOR NEW CONSTRUCTION. ADDITIONALLY, ALL PAVEMENT MARKINGS SHALL NOT LIFT OR PEEL DURING THE FIRST YEAR AFTER INSTALLATION.
- 10) DIAMOND GRADE MATERIAL SHALL BE USED ON ALL STOP SIGNS AND OVERHEAD SIGNS. ALL OTHER ROADSIDE TRAFFIC CONTROL DEVICES SHALL BE HIGH INTENSITY PRISMATIC RETROREFLECTIVE.

- 11) ALL PUBLIC ROAD STREET NAME SIGNS SHALL HAVE CITY OF CASTLE PINES LOGO ON LEFT SIDE OF SIGN.
- 12) ALL REMOVED SIGNS SHALL BE RETURNED TO CITY PUBLIC WORKS DEPARTMENT IF REQUESTED. CALL THE CITY FOR DROP OFF LOCATION.
- 13) CROSSWALKS SHALL:
 - A) BE CONSTRUCTED OF MATERIAL SPECIFIED BY CITY PUBLIC WORKS DEPARTMENT.
 - b) BE LONGITUDINAL TYPE.
 - c) BE CENTERED ON ADA CURB RAMPS.
 - d) BE CENTERED ON LANE LINES SO AS TO BE STRADDLED BY VEHICLES.

- 14) ALL PAVEMENT MARKING MATERIAL (INCLUDING WORDS AND SYMBOLS) SHALL BE AS FOLLOWS:

Marking Type/ Surface Type	Edge, Lane, and Channelizing Lines	Crosswalk Bars and Stop Bars	Turn Arrows and Written Legends
Concrete Pavement	Modified Epoxy	Preformed Plastic ^[a] or Preformed Thermoplastic	Preformed Plastic or Preformed Thermoplastic
Asphalt Pavement	Modified Epoxy	Preformed Plastic or Preformed Thermoplastic	Preformed Plastic or Preformed Thermoplastic

^[a] Crosswalk bars shall be recessed.

Note:

Preformed Plastic minimum thickness is 60 mils for legends and symbols, 75 mil minimum for stop bars and crosswalk bars.

Preformed thermoplastic may be used for spot repair or replacement of all marking types on asphalt surfaces.

- 15) SAND OR WATER BLAST CURING COMPOUND PRIOR TO INSTALLATION OF MARKINGS.
- 16) INSPECTION AND APPROVAL OF STRIPING AND CROSSWALK LAYOUT TO BE DONE BY CITY OF CASTLE PINES ENGINEERING INSPECTION DEPARTMENT PRIOR TO APPLICATION OF FINAL STRIPING.

9.7 Castle Pines Traffic Signal Specifications

City of Castle Pines will enforce the following requirements for all Traffic Signal Construction Projects and roadway construction projects requiring traffic signal modifications or installations.

- 1) International Municipal Signal Association (IMSA) Level II or Level III Traffic Signal Bench Technician/Signal Technician certification (BB certification) for any work within the traffic signal cabinet. This includes corrective maintenance and signal turn-on. Signal Contractor shall produce copies of certificates at the preconstruction meeting.
- 2) IMSA Level II or Level III Traffic Signal Field Technician/Electrician (BE certification) or Traffic Signal Bench Technician/Signal Technician Certification (BB Certification) for any work external to the traffic signal cabinet. An IMSA Level II Traffic Signal Electrician (minimum BE certification) must be on the jobsite at all times to supervise construction. Signal Contractor shall produce copies of certificates at the pre-construction meeting.
- 3) The United States Department of Labor – Bureau of Apprenticeship and Training can be substituted for the IMSA Level II Traffic Signal Electrician. Signal Contractor shall produce copies of certificates at the preconstruction meeting.

9.7.1 Scope and Intent

These specifications describe the installation of necessary material, equipment, and work procedures to complete traffic signals, or other electrical systems as shown on the drawings, in the special contract provisions, or herein, for projects in the City of Castle Pines, Colorado. These specifications provide minimum functional requirements that must be satisfied for all such work.

9.7.2 Roadway Work and Permits

Unless stated otherwise, all roadway and sidewalk work shall be in accordance with the latest version of the City of Castle Pines Roadway Design and Construction Standards. For all work, the Contractor shall obtain Permits from the City Public Works Department (on the City website) and shall pay the required City construction Permit fees.

9.7.3 City Engineer Representative

City of Castle Pines Project Engineer or authorized City personnel shall be the responsible person overseeing all work on the City's behalf. For all required inspections, the Contractor shall give at least 48 hours' prior notice to the City Public Works Department.

9.7.4 Private Access and Traffic Control Plan

The Contractor will be required to maintain access to all private drives throughout the period of construction. The Contractor shall be required to erect, maintain, and remove all barricades, traffic control signs, and devices. Such barricades and traffic control signs and devices shall be in accordance with the latest version of the MUTCD published by the U.S. Department of Transportation, Federal Highway Administration, and as directed by the City Public Works Department. Construction signs not applicable during nonconstruction times shall be set so traffic cannot see the signs, in accordance with section 630 of the latest edition of the CDOT Standard Specifications for Road and Bridge Construction. Should this not occur, Section 9.13.4 of this document shall be enforced.

A Traffic Control Plan prepared by a certified traffic control supervisor shall be submitted and approved prior to issuance of the Permit by the City Public Works Department. The Traffic Control plan shall be submitted along with a set of construction drawings signed and approved by the City. The Contractor shall submit the plan at least 5 working days in advance of the intended start date. A City-approved copy shall be kept at the site and shall be exhibited upon request to any authorized City representative. The City reserves the right to require the Contractor to modify the traffic control in the field as necessary. The City also reserves the right to issue a stop-work order. Permitting information can be found on the City's website.

9.7.5 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.

Refer to Section 9.14.18 for requirements regarding early delivery of controller and cabinet to the City for testing purposes.

9.7.6 Equipment Salvage

All traffic signal equipment that is removed shall remain City property. Such property is to be removed from the work site, tagged with date removed and location, and returned by the Contractor to the City if

requested. When signal pole and mast arm assemblies are removed, all components shall be marked as a set with permanent markings. The equipment shall be returned in the same condition as prior to removal. Contact the City Public Works Department to coordinate delivery.

9.7.7 Existing Traffic Signals

When existing traffic signal installations are modified or completely rebuilt, the Contractor shall work around existing traffic signal equipment until the new or modified traffic signal system has been installed and put into operation. Signal heads installed on mast arms or poles for new installation that are not ready for actual electrical operation shall be bagged with orange plastic. The Contractor shall at all times maintain a minimum of two three-section (red, yellow, and green) traffic signal heads and pedestrian heads (if required) for each roadway approach. These displays and all other signal elements shall conform to MUTCD. Special consideration shall be made to avoid the left-turn trap situation.

9.7.8 Intersection Power

Unless otherwise directed in the plans, the Contractor shall be responsible for coordinating with the power company to obtain power hook-up to the intersection and luminaires 2 weeks prior to signal flash. Refer to Section 9.14.4.1. The City's Building Division will inspect all installations prior to meter installation.

9.7.9 Utilities

Utilities are shown on the plans to the extent that they can be, based on records and surface field indications. All utility locations will require field verification in cooperation with the affected utility companies and public agencies. The Contractor shall be responsible for locating all valve boxes, manholes, and the like, and confirming that they are properly protected and that signal equipment locations are adjusted accordingly, with approval from the Engineer. The Contractor is also responsible for filling all holes made by vacuum potholing (required utility locates) with appropriate material (concrete, asphalt, or other fill to match existing) to restore the area back to previous condition. Reuse of the core toward pothole restoration is prohibited.

9.7.10 Work Hours

The Contractor shall work only on weekdays between the hours of 7:00 a.m. to 4:00 p.m. Lane closures shall only be allowed between 8:30 a.m. and 3:00 p.m. The Contractor must receive written approval from the City to work at any other time.

9.7.11 Project Schedule

The following schedule shall apply (Table 9-3):

Table 9-3. Project Schedule

Item	Schedule
Pole Foundation installation	Refer to 9.14.44.3
Shop Drawing Submittals	At the preconstruction meeting, which normally will be about 2 to 3 weeks prior to the Notice to Proceed.
Groundwork (conduit, mast arm pole foundations, etc.)	May start up to 30 calendar days after Notice to Proceed but no less than 30 calendar days prior to essential equipment delivery date.
100% Completion	Prior to signal flash
Overall Project	90 calendar days for mast arm project; 60 calendar days for span wire project.

9.7.12 Failure to Complete Work on Time

A daily charge, in the applicable amount set forth in the schedule of liquidated damages in Table 9-4, will be made against the Contractor for each calendar day that any work remains uncompleted after the expiration of contract time. This daily charge will be deducted from any money due the Contractor. This deduction is not a penalty but is liquidated damages.

The schedule of liquidated damages set forth in Table 9-4 is the amount agreed to by the Contractor and the City as reasonably representing additional construction engineering costs incurred by the City if the Contractor fails to complete performance within the contract time.

Table 9-4. Schedule of Liquidated Damages

Original Contract Amount From More Than (\$) to and Including (\$)	Daily Charge (\$)
0 to 25,000	270
25,000 to 50,000	465
50,000 to 100,000	540
100,000 to 500,000	950
500,000 to 1,000,000	1,250

Due account shall be taken of any adjustment of the contract time for completion of the work granted by the City at the City's discretion, as a result of supplier delays beyond the Contractors' control. The Contractor shall provide written documentation of such delays to the City's satisfaction.

Permitting the Contractor to continue and finish the work or any part thereof after expiration of contract time will not operate as a waiver on the part of the City of any of its rights under the contract.

Any deduction assessed as liquidated damages for delay under this subsection shall not relieve the Contractor from liability for any damages or costs resulting from delays to other contractors on the project or other projects caused by a failure of the assessed Contractor to complete the work according to contract times.

9.7.13 Job Site Conditions

The Contractor shall maintain a safe and clean job site throughout construction. Upon project completion, the job site shall be neat and clean with all trash and dirt picked up and barricades removed. Landscaping

shall be restored, sidewalks swept, and utility locate markings removed. The intent is that the job site appears as good or better than it appeared before construction.

9.8 Regulations and Codes

9.8.1 Reference Documents

All equipment, material, and construction methods shall conform to the standards of the ITE, IMSA, CDOT Standard specifications for Road and Bridge Construction (latest edition), and CDOT Intelligent Transportation Systems (ITS) Specifications (latest edition) unless noted otherwise. In addition to the requirements of these specifications, the plans, standard details, and the special contract provisions, all material and work shall conform to the requirements of the MUTCD, National Electrical Code (NEC), NESC, the Rules for Overhead Electrical Line Construction of the Colorado Public Utilities Commission (Rules), ASTM Standards, the American National Standards Institute, and local ordinances that may apply.

Wherever reference is made in these specifications or in the special contract provisions to the MUTCD, NEC, NESC, Rules, or the standards mentioned previously, the reference shall be construed to mean the document that is in effect at the date of bidding.

9.9 Equipment List, Approvals, and As-Built Drawings

9.9.1 Bid Requirements

Shop drawings are not required for the bid, but the Contractor shall submit with its bid a list of equipment and materials that it proposes to furnish for those items listed in Section 9.8.1, including all equipment and materials as identified on the plans or in the specifications, by the manufacturer's name that is necessary or customary in the trade to identify such equipment and material. The list shall be complete as to the name of manufacturer, unit name, and model number.

Items to which Section 9.8.1 applies include, but are not limited to, the following: traffic signal poles and mast arms, pedestrian push buttons, traffic signal controller and cabinet, uninterruptable power sources (UPS), vehicle detection, vehicle and pedestrian signal heads, pedestrian signs, pre-emption devices, mounting hardware for signal heads, street name signs, pull boxes, wire, communication equipment, fiber or radio (fiber-optic cable shall include interconnect schematic diagram), ethernet switches, point-tilt-zoom cameras, travel time equipment, meter disconnect pedestal, and any additional items indicated in the project special provisions or requested at the preconstruction meeting. Sign panel layouts for both illuminated and aluminum street name signs shall also be submitted for City approval.

9.9.2 Sampling and Substitutions

Inspection or sampling of any materials, other than those already approved, must be made by the City prior to installation. Whenever particular material or equipment is identified by manufacturer name in the plans or specifications, the term "or approved equivalent" is implied. If the Contractor proposes a substitution, the Contractor shall provide additional information with the bid to prove the substitution item is of equal or superior quality, and it shall be at the City's sole discretion whether to approve such substitution. If not approved, Contractor shall agree to supply the originally stated material or equipment at no additional cost. Otherwise, the City may reject the bid as nonresponsive.

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 substitutions and request the approval of the City for the substitutions. The City may request further technical information to support the substitution.

During execution of the work, the supplying of equipment that is not in accordance with the specifications and on which the Contractor has not received the City's approval shall be cause for rejection. Correction of the non-specification items will be entirely at the Contractor's expense.

9.9.3 As-Builts

Upon completion of the work, the Contractor shall submit an "as-built" or corrected plan showing, in detail, all construction changes, including, but not limited to, wiring, cable, poles, controller cabinet, vehicle detection, and location of all conduit. Red lined, signed, stamped plans may be submitted as "as-built" plans.

9.10 Excavating and Backfilling

9.10.1 General

Street cuts for conduit on existing pavements shall not be allowed unless included in Right-of-Way Permit. Excavations for the installation of conduit, foundations, and other equipment shall be performed in such a manner as to cause the least possible damage to the streets, sidewalks, and other improvements or landscape and sprinklers. Trenches shall not be excavated wider than necessary for the proper installation of the electrical appliances, and foundations and shall be kept clean and as free of moisture as possible. Excavations shall be backfilled or poured with Flow Fill within 24 hours of opening, unless otherwise approved in writing by the City Public Works Department. The material from the excavation shall be removed as the trenching progresses.

After backfilling, excavations shall be kept well filled and maintained in a smooth and well-drained condition until permanent repairs are made.

Excavating and backfilling for foundations shall be incidental to the pay item for which a foundation is required. Excavating and backfilling for conduit trenches shall be paid for under the appropriate conduit trenching pay item.

At the preconstruction meeting, the Contractor will be provided contacts for landscape and sprinkler repair. The Contractor is responsible for contacting these entities when damage occurs and coordinating repairs. Any necessary repairs will not be paid for separately but shall be included in the project cost. Damages found subsequent to project completion, and related costs, will be the Contractor's responsibility.

9.10.2 Traffic Maintenance

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. Construction signs not applicable during nonconstruction times shall be set so traffic cannot see the signs, in accordance with section 630 of the latest version of the CDOT Standard Specifications for Road and Bridge Construction. Should this not occur, Section 9.13.4 of this document shall be enforced.

Excavations in streets or highways shall be performed in such a manner that at least one lane of traffic in each direction shall be open to public traffic at all times. All lane closures shall be approved by the City prior to closure.

When excavations must remain open overnight, they shall be properly marked to warn motorists and pedestrians according to the MUTCD. Flashing barricades shall be provided unless otherwise authorized in writing by the City.

9.11 Removing, Replacing, and Resetting Improvements

9.11.1 General

The Contractor shall, at its sole expense, replace or reconstruct sidewalks, curbs, gutters, rigid or flexible pavement, and any other improvements removed, broken, or damaged by it with material and methods that conform to current City standards.

Whenever a part of a square or slab of existing concrete, sidewalk, or driveway is broken or damaged, the entire square or slab shall be removed and the concrete reconstructed as specified in the previous paragraph.

Concrete pavement and sidewalk designated for removal shall be removed as marked by the City or its designee. The concrete pavement or sidewalk shall be cut to the existing depth of concrete prior to removal. Any overbreak, separation, or other damage to the existing concrete outside of the designated removal limits shall be replaced at the Contractor's expense. Payment for removal of concrete pavement or sidewalk shall be based on square yards of surface area regardless of the concrete thickness.

Removal items shall be as indicated in the pay item list or items specifically identified on the plans, or in writing by the City. It shall be the Contractor's responsibility to assure that it has a full and complete understanding of included removal items prior to bidding.

Reset pay items shall be as indicated in the pay item list. These items are to be initially removed, then adjusted or modified as directed by the City, and finally reinstalled to full operational capability. Modifications and adjustments shall be detailed on the plans or project special provisions and shall be incidental to the reset pay item. It shall be the Contractor's responsibility to assure that it has a full and complete understanding of included reset items prior to bidding.

The "Reset Traffic Signal Equipment" pay item list shall consist of the items specifically identified in the plans or in the project special provisions. Reset traffic signal equipment typically shall include the traffic signal poles, arms, controllers, cabinets, signal and pedestrian heads, detectors, coordination and interconnect equipment, and all other related equipment and materials necessary to remove the items from their existing location and reset them at the new location. This shall include all mounting hardware, bases, other electrical equipment and service, including temporary power, and all other materials and work necessary to complete the reset item in service at the new location. It shall be the Contractor's responsibility to assure that it has a full and complete understanding of included reset traffic signal equipment items prior to bidding.

Equipment and materials shall be cleaned and touched up prior to reset. This work shall be included in the cost of "Reset Traffic Signal Equipment."

9.12 Underground Facilities

9.12.1 Drilled Caissons and Foundations

All drilled caissons and foundations shall be Portland cement concrete conforming to the applicable requirements of the City's construction standards, except as herein provided.

The bottom of concrete drilled caissons and 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. Concrete shall be Class BZ in accordance with the latest edition of the CDOT's Standard Specifications for Road and Bridge Construction.

All poles shall be grounded as indicated in the standard details and shall be incidental to the installation pay item.

For drilled caissons requiring casing, casings shall be removed in a manner such that voids between the excavation and the casing will be completely filled with fresh concrete.

Anchor bolts shall conform to the manufacturer's specifications, and each individual bolt shall have two flat washers and two nuts. Shims or other similar devices for plumbing or raking will not be permitted. Stirrups shall be installed on all caissons. Refer to City of Castle Pines Standard Signal Details for additional requirements.

All caissons will be measured and paid for separately.

Forms shall be true to line and grade. Tops of caissons and foundations, except as noted on plans, shall be finished to curb or sidewalk grade or as ordered by the City. Forms shall be rigid and securely braced in place and inspected prior to the concrete pour. Conduit ends and anchor bolts shall be placed in proper position and in a template until the concrete sets.

Both forms and ground that will be in contact with the concrete shall be thoroughly moistened before placing concrete. Forms shall not be removed until the concrete has thoroughly set.

Whenever excavation for a foundation requires removal of excess ground materials, the excavation shall be backfilled to within 12 inches of ground level with 60 to 120 pounds per square inch (psi) of Flow Fill as specified by the City, and then backfilled to ground level with compacted native material.

Any abandoned caisson or foundation shall be fully or partially removed and disposed of by the Contractor according to the City's direction. Any conduit runs associated with an abandoned caisson or foundation shall be extended or abandoned as called for on the plans.

The Contractor is responsible for filling all holes made by vacuum potholing, in regards to locating utilities for caisson placement, with appropriate material or replacing curb, sidewalk or roadway panels, or stones as specified in City of Castle Pines Roadway Design and Construction Standards to restore these back to previous condition. Reuse of the core toward pothole restoration is prohibited.

9.12.2 Conduit

All intersections undergoing initial development or construction that are anticipated to require immediate or short-term future signalization shall include signal conduit at the time of initial road construction, in conformance with this section. Those intersections not completely built out or anticipated to be signalized within a year's timeframe, shall have construction funds escrowed for construction costs at a later date. Roadway developers should consult with the City to identify intersections to which this requirement applies.

Pull boxes made of fiberglass reinforced polymer concrete (refer to Section 9.12.3) shall be used at termination points, as shown in the standard details.

All cables and conductors not shown on the plans as aerial cable shall be installed in conduit unless installed in poles, pedestals, or mast arms. All metal conduit referred to in the specifications and shown on the plans shall be the rigid pipe type of ductile steel that is adequately galvanized. All polyvinyl chloride (PVC) conduit shall be Schedule 80 or heavier. Poly pipe commonly used for boring shall be Schedule 80 or heavier. All transitions from poly pipe to PVC shall be by means of Etco "E-LOC" couplings or approved equal.

New conduit runs shown on the plans are for bidding purposes only and may be changed at the City's direction.

All conduit installed, including poly pipe, shall be at full depth (minimum 30 inches below finish grade) for the entire conduit run. Sweeps of 90 degrees shall not be cut to achieve proper entrance to pull box. Conduit runs shall have no more than a 180 degree bend.

Conduit shall always enter a pedestal base, pull box, or any other type of structure from the direction of the run only. Conduit connections at junction boxes shall be tightly secured.

Conduit under railroad tracks shall be at the minimum depth below the bottom of the tie required by the particular railroad company.

The following conduit schedule is in effect unless otherwise specified in the plans (Table 9-5):

Table 9-5. Conduit Schedule

Run Type	Quantity	Size (inches)	Use
Street Crossings	2	3	High-voltage load wiring
	1	2	Low-voltage detection and communications
	1	2	luminaire load
Signal Pole	2	3	High voltage
	1	2	Low voltage
Pedestal Pole	1	3	High voltage
	1	2	Low voltage
Controller Cabinet	2	3	High-voltage load wiring
	2	2	Low-voltage detection – size per Code
	1	2	Service power
	1	2	Interconnect
Interconnect	1	2	Interconnect run only
Service Points Signal	1	2	Utility company service run for traffic signal

Existing underground conduit to be incorporated into a new system shall be cleaned with a mandrel or blown out with compressed air.

All conduit in pull boxes shall extend a minimum of 3 inches above crushed rock.

All conduit shall terminate in pull boxes such that when cable is pulled and coiled within the pull box, there is a minimum clearance of 3 inches between the pull box lid and the conduit and cable. Cable and conduit shall not be crushed or damaged. All underground conduit ends within pull boxes shall be capped or sealed for protection against ingress of water and debris.

Ends of unpopulated conduits shall be capped.

Ends of populated conduits shall be sealed with brass wool–embedded duct seal putty. The putty shall be installed to create a tight seal around cables without gaping.

Conduit terminating in a standard power pedestal, signal pole, or pedestal pole base shall extend a minimum of 3 inches above foundation vertically.

All underground interconnect conduit runs shall have a single number (No.) 14 AWG (American Wire Gauge) (minimum), fully annealed, solid conductor tracer wire with an orange sheath or jacket, installed for locating purposes.

Field cuts of existing or new conduit shall be made square and true, and the ends shall butt together for the full circumference thereof. Slip joints or running threads will not be permitted for coupling metal conduit. When a standard coupling cannot be used, an approved threaded union coupling shall be used. All couplings shall be screwed tight until the ends of the metal conduits are brought together. The ends of all metal conduit, existing or new, shall be well reamed to remove burrs and rough edges.

Where a "stub out" is called for on the plans, a minimum 18-inch radius sweeping elbow shall be installed in the direction indicated and sealed with a metallic cap to facilitate future locating. The locations of ends of all conduits in structures or terminating at curbs shall be marked by a "Y" at least 3 inches high, cut into the face of the curb, gutter, or wall directly above the conduit.

Where factory bends are not used, conduit shall be bent without crimping or flattening, using the longest radius practicable. Conduit bends feeding pull boxes and foundations shall be as shown on the standard details, typically 18 inches.

All conduit runs that exceed 10 feet in length shall have at a minimum a continuous half-inch, 1,250-pound pull strength, flat-woven polyester tape (Muletape, BullLine, or equivalent) 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 4 feet. The purpose of this rope is to be able to pull future electrical cable through the existing conduit runs and the rope shall not be tangled or twisted around cables.

Any spare or unused conduits installed for future use shall be sealed with a metallic cap and a single No. 14 AWG (minimum), fully annealed, solid conductor tracer wire installed for locating purposes. Conduit shall also have at a minimum a continuous half-inch, 1,250-pound pull strength, flat-woven polyester tape (Muletape, BullLine, or equivalent) 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 4 feet.

Split duct may be allowed on a case-by-case basis approved by the City.

9.12.3 Pull Boxes

A pull box shall be installed at all locations as shown on the plans and at such additional points as ordered by the City. Pull boxes shall be installed at intervals of every 500 feet or as specified in the plans for all fiber interconnect conduit runs. Pull boxes shall be fiberglass reinforced polymer pre-cast concrete with a minimum Tier 22 rating (Refer to Standard Details).

The Contractor shall install City-provided delineators at all pull box locations. The delineators shall be anchored into the ground with minimum quarter-inch-diameter bolt, minimum 2 inches in length so they cannot be easily pulled out of the ground. Refer to recommendation in standard notes.

At new roadway construction sites where conduit for future traffic signals is installed, pull boxes shall be installed at conduit termination points and single 14 AWG (minimum), fully annealed, solid conductor tracer wire installed through the entire conduit run to facilitate future locating.

At sites where operational traffic signals are being installed, permanent fiberglass reinforced polymer concrete precast pull boxes shall be installed (refer to standard details).

Pull boxes shall be installed so that the covers are level, as well as flush with curb or sidewalk grade or level with the surrounding ground when no grade is established. The entire excavation required to install 90 degree sweeps into a future pull box shall be backfilled from the full depth of the conduit run to the bottom of the pull box with crushed rock. The depth of crushed rock from the bottom of the excavation to the bottom of the pull box shall be a minimum of 18 inches.

The interior of the pull box shall be backfilled with crushed rock from the base of the pull box to a minimum depth of 3 inches below the top of conduit runs. The area of the excavation surrounding the pull box may be backfilled with excavated soil.

When a new conduit run enters an existing pull box, the Contractor shall temporarily remove the pull box, or tunnel under the side at no less than 18 inches below the pull box bottom and enter from the direction of the run. Backfill shall be gravel. No new conduit will be allowed to enter a new or existing pull box in any other manner than that shown on the standard details.

9.12.4 Loop and Micro Loop Detectors

Each individual loop or micro loop is to be terminated and spliced within a side-of-road pull box as specified on the standard details. Each loop shall consist of one continuous wire, without splicing, to this termination point, and each micro loop detector shall include two continuous wires, without splicing, to this termination point. Each loop or micro loop shall have its own dedicated lead-in pair (of wires) to the cabinet from the side of road pull box. Detector lead-in wire shall be continuous from the controller to the side-of-road pull box.

All detectors shall have a color-coded tag attached to the lead-in to indicate the relative location and the direction served by the detector. Refer to Section 9.13.1.

Loop sealant is to be used in all saw cuts whether or not the roadway is to be overlaid. Refer to standard details.

Stop line detection for designated phases shall be provided, as indicated in the plans. Advance detection may be provided on a site-specific basis, to extend green time on high-speed approaches.

The use of preformed loop detectors shall not be allowed.

9.13 Conductor and Cable

9.13.1 General

Wiring shall conform to appropriate NEC articles. Wiring within cabinets, junction boxes, and the like shall be landed and labeled as shown in the specifications and details as well as neatly arranged.

Powdered soapstone, talc, or other approved lubricant shall be used in placing conductors in conduit. Unless otherwise approved by the City, wiring shall not occupy more than 40% of the inside area of all

conduit. If more than 40% of the inside area is occupied, the Contractor shall provide additional conduit to satisfy this requirement.

Half-inch, 1,250-pound pull strength, flat-woven polyester tape (Muletape, BullLine, or equivalent) shall be installed in new conduit and in existing conduit where a cable is added or an existing cable is replaced. A minimum of 4 feet of slack shall be left in each conduit at each termination.

At least 5 feet of slack shall be left for each conductor at each span wire support pole.

Except in accordance with Section 9.12.4, splices will not be allowed in pull boxes. Splices shall be kept to a minimum and will only be allowed in hand holes at pole bases. A minimum of 24 inches of slack shall be left on each splice wire. In no case shall any shellac compounds be used.

Signal load splices shall use a copper crimp sleeve connector that is compressed from four directions, for example, as manufactured by the Buchanan Company. All hand hole splices shall be compressed by a C-24 four-way pres-SURE-tool, such as produced by the Buchanan Company. The crimped sleeve shall then be protected within a flexible rubber insulating cover; for example, an Ideal Wrap Cap. All splices or splice bundles shall face upward in the hand hole compartment.

Detector loop lead-in splices in pull boxes (refer to Section 9.12.4) shall be fully waterproofed using a splice kit or epoxy wire nuts (Buchanan BTS2 or BTS4 or approved equal). A minimum of 12 inches of slack shall be left on the detector loop.

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.

All high-voltage home run signal wiring shall use IMSA spec 19-1, 25 conductor cable, continuous from the cabinet to the base of each pole or hand hole. Conductor cable shall be installed where required in the plans. Overhead cable shall be secured to messenger cable with cable rings or stainless steel wire wrap only.

All signal cables terminating at the cabinet shall contain a small permanent tag identifying phase and direction. All signal cables shall be phase taped in the cabinet and at each hand hole using the codes given in the "Conductor Schedule" in the following paragraph. Loop detector lead-ins shall be tagged in the splice pull box behind curb.

Conductor Schedule Key-Phase: Color of Signal Load Conductor "Code" (on tag at each end of conductor):

- 1) Northbound Left Turn: Red/White, "x-NBLT"
- 2) Northbound: Red, "x-NB"
- 3) Southbound Left Turn: Green/White, "x-SBLT"
- 4) Southbound: Green, "x-SB"
- 5) Eastbound Left Turn: Orange/White, "x-EBLT"
- 6) Eastbound: Orange, "x-EB"
- 7) Westbound Left Turn: Blue/White, "x-WBLT"
- 8) Westbound: Blue, "x-WB"
- 9) Pedestrian: Yellow, "x-PED"

10) Supplemental: Brown, Right turn overlap

11) Supplemental: Purple, spare

Note: x = phase number. This is a typical conductor identification schedule and shall be used for the wiring of all signal installations. An individual conductor wire schedule is in the standard signal details. Deviations from these standards will be noted on the plans at each intersection where different phasing or special equipment is required. It should be noted that a band of white is used to indicate a left turn, a band of brown is used for a right turn, and a band of yellow is used for a pedestrian movement.

Each pedestrian push button shall have a dedicated wire pair lead-in to the controller cabinet.

Separate luminaire wire shall be a 12/2 conductor, plus ground and UL listed.

Signal heads mounted on mast arms or poles shall be wired individually with IMSA spec 19-1, 7-conductor cable from the head to the hand hole at the bottom of the pole.

Span wire and tether cable shall be affixed to the pole using short bail strand vices. If required by the City, insulators shall be provided, in which case, long bail strand vices shall be used.

9.13.2 Bonding and Grounding

Metal poles, pedestals, and cabinets shall be made mechanically and electrically secure to form a system of isolated grounded components. Each pole and pedestal shall have a separate ground rod, located in an adjacent pull box and connected to the system component. The controller cabinet shall have a ground rod located in its foundation. Separate ground rod locations shall not be directly connected to one another with ground wire, in order to minimize transient distribution among the components.

Bonding and grounding jumpers shall be copper wire, No. 8 AWG, for all systems. Loop lead-in drain wire is to be grounded in the control cabinet only. The other end of the sheath is to be taped and left ungrounded.

Bonding of poles and pedestals shall be by means of connecting to the ground rod, a bonding strap attached to an anchor bolt or a 3/16-inch diameter or larger brass or bronze bolt installed in the lower portion of the shaft.

At each grounded pull box, the ground electrode shall be a one-piece copper ground rod driven into the ground so that the top is at least 2 to 4 inches below the bottom of the pull box lid. The ground rod connector shall be placed so that the bare copper wire, No. 8, can be pulled into a pole, pedestal, or attached to the control cabinet ground bus.

Loop lead-in drain wire is to be grounded in the control cabinet only. The other end of the sheath shall be taped and left ungrounded. All poles shall be bonded to the signal power source.

9.13.3 Field Testing and Maintenance

9.13.3.1 Field Testing

- Prior to completion of the work, the Contractor shall run the following tests on all traffic signals in the presence of the City or the City signal maintenance contractor.
- Each circuit shall be tested for continuity and for grounds.

- 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 20 days of continuous, satisfactory operation commencing with full operation of all electrical facilities.
- For all fiber-optic cable testing requirements, refer to Section 9.14.23.

9.13.3.2 Maintenance during Construction

- The Contractor shall have full maintenance responsibility of the traffic signal from the time of the Notice to Proceed to substantial completion. Continuous maintenance and emergency service shall be provided by the Contractor 24 hours each day during the time period defined previously. The Contractor shall provide and maintain a 24-hour continuous telephone answering service with one number with a response time of 2 hours or less. Should this not occur, Section 9.13.4 of this document shall be invoked.
- If the Contractor must close lanes or otherwise shift traffic for construction purposes, the Contractor shall have full responsibility of bagging existing or new signal indications or traffic control signs as directed by the City for the impacted approach for the duration of each phase of work impacting that approach. Should this not occur, Section 9.13.4 of this document shall be invoked.

9.13.4 Emergency and Non-emergency Repairs

During the 2-year warranty period, all hazardous conditions or all malfunctions of a controller and its accessory equipment following turn on shall be considered an emergency unless otherwise identified by the City. Site conditions, equipment malfunctions, or damage, which in the opinion of the City constitute 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, the following situations:

- 1) All indications are out, including bulbs and lenses, for any one traffic movement.
- 2) Signal heads give conflicting indications to any intersection approach or approaches.
- 3) Any signal head or sign becomes loose and or twisted.
- 4) Any accessory equipment malfunction.
 - a) Contractor shall dispatch personnel to undertake each such repair no later than 1 hour after the City notifies Contractor of the emergency.
 - b) Personnel responding shall arrive within 1 hour after notification during regular City working hours and within 2 hours during non-working hours after notification.
 - c) In instances of repairs that are of a non-emergency nature and determined to be the Contractor's responsibility by the City, such repairs shall be undertaken at the site within 1 working day after the City notifies the Contractor of the needed repair.
 - d) Should the Contractor fail to perform any maintenance responsibilities within the prescribed time periods, the City shall employ the services of the City's traffic signal maintenance contractor to perform said maintenance work. The Contractor shall reimburse the City as specified in Chapter 13 – Public Infrastructure Acceptance Procedures and Warranty Requirements.

9.14 Traffic Signal Material Specifications

9.14.1 Vehicle Signal Head

All vehicle signal heads shall be the modular section type and shall be adjustable with respect to positioning and lens replacement. Heads shall be polycarbonate and black in color and shall meet the requirements of the latest version of the ITE standard, "Vehicle Traffic Control Signal Heads." Unless otherwise indicated, traffic signal faces shall be light-emitting diodes (LED). Refer to Section 9.14.6 for LED requirements.

Visors shall be the detachable tunnel type and black in color.

All mast-arm-mounted vehicle signal heads shall be equipped with louvered aluminum backplates, black in color, with 2-inch diamond-grade fluorescent-yellow retroreflective border.

Doors on the signal heads for the installation of lamps and lens replacement or other maintenance shall not require use of any tool whatsoever to open. Doors and lenses shall be equipped with neoprene weatherproof gaskets to protect against infiltration of moisture, road film, and dust. Each signal indication shall have 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 LED indication shall terminate. The terminal board shall be mounted in the middle section and be fully insulated. Gaskets shall be supplied for top and bottom openings.

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.

9.14.2 Pedestrian Signal Head

Pedestrian signal heads shall be 16-inch, clamshell type, McCain or approved equal, and shall be adjustable with respect to positioning. Heads shall be polycarbonate, black in color, and shall meet the requirements of the latest version of the ITE standard, "Pedestrian Traffic Control Signal Indications." Countdown pedestrian indications shall be the symbol type with a minimum height of 11 inches. Countdown pedestrian indications shall be LED indications. Countdown numerals shall have a minimum height of 9 inches. Doors and lenses shall be installed with weatherproof gaskets to protect against infiltration of moisture, road film and dust. Visors shall be eggcrate type.

9.14.3 Countdown Pedestrian Signal Head

There should be two message overlays, combining Portland Orange LED for the "Hand" and White LED for "Walking Person." LED should be incandescent style. The double-digit display for countdown should be made of Red LEDs; LED should be incandescent style.

Timing is derived directly from the controller and no timing shall be programmed, or otherwise initiated. Countdown numerals shall be illuminated continuously during countdown and not alternating. Pedestrian signal head shall blank out countdown portion if the countdown is different from the controller.

Hand and Walking Person indications shall be LED.

9.14.4 Blank-Out Regulatory/Warning Sign

9.14.4.1 General Description

- LED Blank-Out Signs are designed to display single or multiple messages. The messages shall be clear and legible, under any lighting conditions. When not energized, the sign shall be completely dark without any ghost images. LED blank-out signs shall comply with applicable MUTCD and ITE specifications on LED signals.
- Illumination of the messages shall be provided by an assembly of LEDs. LEDs shall be wired to incorporate fault tolerance or bypass to isolate LED failures – failure of one LED string shall not cause the failure of any other LED strings.
- When energized, the messages shall provide a minimum 30 degree viewing angle centered about the optical axis.

9.14.4.2 Housing

- LED Blank-Out Sign housing shall be an aluminum alloy that is moisture proof and mechanical vibration protected.
- Housing shall have neoprene gaskets installed between sign panels and fixture housing to prevent water entry. Screened weep holes shall be provided on housing bottom for drainage.
- Housing shall be mounted with Astrotype mounting brackets.
- Sign fixture and panels shall withstand 90 mph wind loading, with structural requirements meeting the latest edition of AASHTO's "Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals."

9.14.5 Illuminated Street Name Sign (LED)

All street signs shall be consistent in nature with the existing signs. At the City's discretion, the sign design may be changed.

When indicated on the plans, illuminated street name signs (LED) shall be used, conforming to the following requirements:

- **Mechanical Specifications.** Illuminated street name sign housings shall be constructed of 5052 aluminum alloy with a minimum one-eighth-inch thickness. All hardware parts shall be stainless steel. The outer dimensions of the sign assembly (excluding the mounting bosses) shall be standard widths of 15 to 30 inches (in 3-inch increments), and standard lengths of 4 to 10 feet in 1-foot increments, unless otherwise approved. The maximum thickness of the sign shall be 3.95 inches for single-sided signs, and 5.4 inches for double-sided signs. The overall weight, excluding mounting hardware, shall not exceed 6 pounds per square foot (psf) for single sided signs, and 8 psf for double-sided signs. Signs shall be mounted either free swinging or rigid on approved Pelco or equivalent mounts. No tools shall be required to open the sign. Finish shall be polyester powder coated to required color specification. The signal panel shall rotate open with a bottom hinge.
- **Sign Panel and Sheeting.** The sign panel shall be polycarbonate, white with an eighth of an inch minimum thickness. Sign sheeting shall be 3M 4000DG3 series reflective sheeting or equivalent. The sign colors shall not fade when exposed to an accelerated test of ultraviolet light equivalent to 5 years of outdoor exposure. The Electrocut film shall be 3M 1170 Green. The font type is FHWA Hwy. Series "D" unless otherwise specified. The street name shall be 10-inch initial upper case letters with a combination of lower case letters, and the designator shall be 8-inch initial upper case with a combination of lower case letters.

- **LED Light Engine and Light Intensity.** LED drive current shall be regulated using a pulse width modulated 24-volt direct current (DC) drive and limited to approximately 300 mA through the LED chain at normal room temperature. A stable light intensity under varying voltage shall be provided having a color temperature of 6,500 degrees Kelvin (°K). Sign elements to be illuminated shall include the sign legend and background, in accordance with MUTCD section 2A.08. The entire surface of the sign panel shall be evenly illuminated.
- **Light Source.** The light source for the sign shall be LEDs that are mounted along the top or bottom edges of the sign. The LEDs shall evenly illuminate a light panel that is the same dimensions as the sign face. The LEDs shall have a minimum projected life of 60,000 hours and provide a color temperature of 6,500°K. LEDs shall be wired to incorporate fault tolerance or bypass to isolate LED failures of a particular LED, allowing remaining LEDs to operate normally. Thermal monitoring shall be provided to protect LED chains. Light sources shall be readily accessible through hinged doors or sliding panels.
- **Electrical.** The power supply shall be housed inside the sign frame assembly. Power supply shall be UL Class 2 limited output voltage and current plus isolation for safe operation, and UL Outdoor damp location rated. Power supply shall be IP66 Outdoor Rated.
- **Energy Requirements.** The overall power required shall not exceed 3 watts per square foot for single-sided signs, and 4 watts per square foot for double-sided signs.

Photoelectric cell provision for photoelectric control shall be available. The photoelectric cell shall have a power unit that plugs into a twist lock receptacle mounted on top of the housing.
- **Environmental Specifications.** The sign shall be designed and constructed to withstand 150 mph wind loads in conformance with the requirements of the most recent edition of the AASHTO publication, "Standard Specifications for Structural Supports of Highway Signs, Luminaires, and Traffic Signals." The sign and power supply should be able to withstand and operate at temperature extremes of -40 degrees Celsius (°C) to +60 degrees °C. UL-approved neoprene gaskets shall be installed between the sign panel and fixture housing to prevent water or other debris from entering. Screened weep holes shall be provided on housing bottom for drainage.

Quality Assurance Manufacturer must be ISO 9001 certified.

- **Product Guarantee.** Product must be guaranteed for a minimum of 7 years.
- **Weight.** The overall weight of the complete sign assembly, including mounting hardware, shall not exceed 70 pounds for a 6-foot sign and 95 pounds for an 8-foot sign.

9.14.6 Traffic Signal Faces

All traffic signal faces (vehicular and pedestrian) shall be LED type unless otherwise specified by the City. The LED traffic signal faces shall conform to the following requirements:

- LED optical units shall be installed in accordance with the manufacturer's instructions.
- LED optical units shall meet or exceed the latest ITE Vehicular Traffic Control and Pedestrian Signal indication specifications. In addition to this, LED optical units shall conform to the following wattage requirements:
 - Max. 35 watts, +/-5 watts for 12-inch red, yellow, or green ball
 - Max. 15 watts, +/-5 watts for 12-inch red, yellow or green arrow
 - Max. 15 watts, +/-5 watts for PED hand and man symbol
 - Maximum total harmonic current distortion shall be less than 20%.
- Power factor shall be greater than 90%.
- Load balance requirement: load in one phase shall not exceed the load in any other phase by 15%.

Voltage operating shall be between 85 and 130 volts alternating current (VAC). Electronic circuitry shall assure proper operation of the load switch and monitor in the control cabinet.

The minimum number of LEDs per optical unit shall be as specified by the manufacturer to meet ITE luminance specifications for signal installation.

Manufacturer's warranty repair or replacement guarantee of 5 years covering all but accidental damage.

9.14.7 Electrical Cable

Signal cable shall be No. 14 AWG multiconductor, stranded, copper wire manufactured to meet IMSA Specification 19-1. Each conductor in the cable shall be individually insulated and rated at 600 volts.

Power service conductors shall be THWN soft-drawn copper, installed according to the NEC, and shall be black and white in color.

Ground wire shall be single conductor, No. 8 AWG, soft-drawn bare copper wire.

Luminaire wire shall be 12-2 plus ground and UL listed.

Pedestrian push-button and detector loop lead-in cable shall be shielded single or multiple twisted pairs in jacketed cable. Conductors shall be No. 14 AWG stranded copper continuous runs – no splicing to the cabinet. The pairs shall be twisted at least six turns per foot. The cable jacket shall consist of black, high-density polyethylene (HDPE). The jacket shall not be degraded by prolonged exposure to typical pavement runoff components. A stranded, tinned, copper drain wire shall be provided. The cable shall be suitable for operation at temperatures of -70°F to +170°F.

Loop detector wire shall meet IMSA specification 51.5. Loop detector wire shall be encased in quarter-inch-outer-diameter PVC or polyethylene tubing.

Optical detector lead-in cable for the emergency vehicle pre-emption optical detectors shall be GTT Model M138 or approved equivalent.

Where specified on the plans, overhead interconnect wire shall be a quarter-inch strand, galvanized-steel messenger cable integrated into the jacket to form a figure 8 cross-section and shall meet Rural Electrification Administration Specification PE-38.

9.14.8 Radio Communications Equipment

Where specified in the plans, radio communication shall be included on the project. The radio communication system shall be compatible with the existing spread spectrum radio system and meet the requirements set forth in the following paragraphs.

Data Radio Requirements: The spread spectrum radio transceiver will use a dual-band 2.4/5.8 megahertz (Mhz) frequency-hopping spread Spectrum Transceiver Encom 5800 series or approved equal. All associated cables and surge suppression equipment required to connect the radio shall be provided at no extra cost.

Master Antenna: The Master antenna shall be as specified on the plans, and the mounting arrangement shall be with the appropriate degree tilt to assure communications to all local transceivers. All associated cables and surge suppression equipment required to connect the antenna shall be provided at no extra cost.

Supplier Onsite Service: The supplier shall have a qualified, factory-trained, engineer, or technician onsite when requested during the radio equipment installation.

9.14.9 Emergency Vehicle Detector

Optical detectors for emergency vehicle pre-emption shall be the GTT Model 711 Optical Detector or latest model, as needed. Placement of the detectors shall be determined by the City.

Timer modules for emergency vehicle pre-emption shall be the GTT Discriminator, Model 762, which handles two channels of detection. Modules shall be capable of locking out unauthorized users by means of emitter coding.

Optical emitter for emergency vehicle pre-emption shall be the GTT Model latest model. The emitter shall be programmable for priority and identification purposes via internal programming.

The Contractor shall notify the City when optical detectors are operational for testing prior to Final Acceptance.

9.14.10 Video Detection

Where specified on the plans, video detection shall be installed. The following describes the minimum requirements for providing a complete video detection system. Initially, the system shall be capable of providing vehicle presence detection at selected intersections. The video system shall be expandable without removing or replacing existing units. A four-channel video image processor and a two-channel expansion module shall be provided for each camera regardless of phasing unless otherwise noted.

Acceptable system is the Flir system. Using standard image sensor optics and in the absence of occlusion, the system shall be able to detect vehicle presence with 98% accuracy under normal conditions (days and nights), and 96% accuracy under adverse conditions (fog, rain, snow). All items and materials furnished shall be new, unused, current production models installed and operational in a user environment and shall be items currently in distribution. The product's algorithms shall have a proven record of field use at other installations for at least 2 years of service (in other words, not including prototype field trials prior to installation).

Video Vehicle Detection System – General: These technical specifications describe the minimum physical and functional properties of a video detection system. The system shall be capable of monitoring all licensed vehicles on the roadway, providing video detection for areas outlined in the construction drawings. The entire video detection system shall consist of the following:

- Video Image processing unit(s)
- Video camera(s) with infrared (IR) filter, enclosure, and sunshield
- Camera lens
- Surge suppresser
- All other necessary equipment for operation

9.14.10.1 Video Image Processing Unit Specifications

1) Software Specs:

The video image processing (VIP) unit shall be Flir Model VIP3D.1s or VIP3D.2s, the second releases of the VIP3 board. The new boards shall fit directly into the 170 and NEMA racks without an interface box. The VIP3D.1s shall monitor one camera, and the VIP3S.2s shall monitor two separate cameras. Video inputs to either unit shall enter through the input file or detector rack edge connector. The VIP unit shall be located

on one module; daughter PC cards connected through ribbon cables shall not be allowed. On each camera, vehicle presence shall be detected on 24 zones. Counting data shall be stored for up to six different lanes. Up to 4,000 records shall be stored on board that can be retrieved via a RS232 port on the front. All zones (24 for two cameras) shall be able to be combined in different relationships (AND, OR, NOT) to 24 outputs. Twenty digital inputs shall allow expansion of the conditional outputs with external equipment. Also, conditional counting shall be possible. All zones and parameters shall be able to be changed without adversely affecting the detection. For example, when one of the zones is modified, all zones shall continue to work. When the new position is confirmed, the new zone shall enter a learning phase. Once the new zone has learned, it shall function properly.

Four detector configurations shall be able to be stored on board. Software download from PC via serial port shall be possible.

Specifications:

- 1 or 2 camera inputs
- 24 digital outputs
- 20 digital inputs
- Fits direct into the 170 and NEMA rack without additional adapter
- 24 direction-sensible detector zones per camera, including up to 6 counting zones per camera
- Stores counts for 4,000 intervals
- Detection results of all detection zones can be combined with the inputs to the related outputs AND, OR, NOT
- 4 configurations stored on board
- Modifications with no interruption on all zones
- Setup via keypad and monitor (no pointing device needed)
- Software update via RS232

The video detection board shall have only four outputs and shall use expansion boards for additional input and output.

The video detection (Main) board shall have the following on the front:

- One RJ11 connector for connection to expansion boards
- One Female DB9 for setup with keypad (Service port)
- LEDs for outputs on board (two for camera 1 and two for camera 2), power, Video Cam 1 and Video Cam 2, communication with expansions
- One video output for setup via keypad
- A switch to select which image to be on the service output

The input/output expansion board shall have the following on the front:

- LEDs for power, expansion communication, input/output activity
- Two DB9 ports for communication with Master or other expansion boards

- An 8-dipswitch device to select the following:
 - Input or Output Range: 1-12 or 13-24
 - Input or Output number (refer to example for more info)
- 2) PIN usage on 170:
- a) video detection (Main) board

There are four outputs free selectable over the two cameras. The master cannot have inputs.

The master shall have an RJ11 connector to be connected to the first operative (Exp Comm IN). The first operative (Exp Comm OUT) shall be connected to the second one (Table 9-6). Input file connectors and function are shown in Table 9-7.

Table 9-6. [VIP specifications 1]

Input File Connector	TB2	TB1
SP	SPARE	SPARE
F	DET #1 Out	DET #2 Out
W	DET #3 Out	DET #4 Out
D	VIDEO #1 IN (+)	VIDEO #2 IN (+)
E	VIDEO #1 IN (-)	VIDEO #2 IN (-)
J	VIDEO OUT (+)	RS485 (+)
K	VIDEO OUT (-)	RS485(-)
L	EQ GND	EQ GND

Table 9-7. Input File Connectors and Function

Input File Connector	Function
A	DC-GND
B	+24 VDC
C	NOT USED
D	VIDEO #1 IN (+)
E	VIDEO #1 IN (-)
F	DET #1 OUTPUT
H	LOGIC GROUND
J	VIDEO OUT (+)
K	VIDEO OUT (-)
L	EQUIPMENT GROUND
M	AC-
N	AC+

Input File Connector	Function
P	VIDEO #1 IN (+)
R	VIDEO #1 IN (-)
S	DET #2 OUTPUT
T	LOGIC GROUND
U	RS485(+)
V	RS485(-)
W	DET #3 OUTPUT
X	LOGIC GROUND
Y	DET #4 OUTPUT
Z	LOGIC GROUND

b) Input/output expansion board

The operative card is only one slot wide. Two or four input/outputs can be used. With dipswitches, it is possible to select which output (defined in the VIP3) will be connected on the expansion board (Table 9-7). Input file connectors and their function are listed in Table 9-8.

Table 9-8. [VIP specifications 2]

Input File Connector	TB2	TB1
SP	SPARE	SPARE
F	DET #A In/Out	DET #C In/Out
W	DET #B In/Out	DET #D In/Out
D	NC	NC
E	NC	NC
J	NC	NC
K	NC	NC
L	EQ GND	EQ GND

Table 9-9. Input File Connector and Function

Input File Connector	Function
A	DC-GND
B	+24 VDC
C	NOT USED
D	NOT USED
E	NOT USED
F	DET #A INPUT/OUTPUT

Input File Connector	Function
H	LOGIC GROUND
J	NOT USED
K	NOT USED
L	EQUIPMENT GROUND
M	AC-
N	AC+
P	NOT USED
R	NOT USED
S	DET #C INPUT/OUTPUT
T	LOGIC GROUND
U	NOT USED
V	NOT USED
W	DET #B INPUT/OUTPUT
X	LOGIC GROUND
Y	DET #D INPUT/OUTPUT
Z	LOGIC GROUND

9.14.10.2 Video Camera

1) Camera

- One-third-inch color charge-coupled device (CCD)
- 650 television (TV) lines horizontal resolution
- 0.05 lux minimum illumination
- Digital wide dynamic range
- Up-the-coax on-screen display (OSD) controller (option)
- Can be set to Color, Day/Night, or black and white modes (camera is not IR sensitive)

2) Lens

- 10X zoom range
- 6.5 to 65-millimeter (mm) focal length
- 40.5 to 4.2-degree horizontal field of view

Table 9-10 provides video camera model information and specifications.

Table 9-10. Video Camera Equipment and Specs

Model	TC660AZD65
Image Sensor	1/3" Interline Transfer Color CCD
TV System	NTSC
Picture Elements (pixels)	768 (H) x 494 (V)
Horizontal Resolution	650 TV Lines

Model	TC660AZD65
Min. Illumination	0.05 lux
Signal-to-Noise Ratio	More than 50 cfs
Video Output	1Vp-p 75 ohm
Auto-Iris Drive	DC or Video Type (-pin square connector)
White Balance	ATW/AWC/Manual
Electronic Iris	1/60-1/100,000 – On/Off Selectable
BLC (Backlight Compensation)	On/Off Selectable (5 zones)
AGC (Automatic Gain Control)	0, 10, 18, 24 dB selectable (Off, Low, Middle, High)
Digital Wide Dynamic Range (WDR)	On/Off Selectable
OSD Options	Privacy Zone – On/Off Selectable (six Programmable zones)/Mirror Monitor – CRT LCD User/DNR On/Off, Level/Camera Title
Day/Night Function	Color/B&W/Auto (camera is not IR sensitive)
RS-485 Input	Pelco – D
Power Requirement	12-24VAC/DC +/-10%, 250mA Max
Synchronizing System	Internal
Operating Condition	+14°F to 122°F (-10°C to +50 degrees C) within 85% RH
Lens Mount	CS with Cam-type Back-focus Adjustment
Dimensions: w/h/d	2.6 x 2.6 x 7.6 inches (90 x 58 x 192.6 mm)
Weight	1.2 lbs (520 g)
Zoom Lens	6.5 to 65 mm F 1.4 motorized zoom/focus with DC auto-iris 40.5" to 4.2" horizontal field of view

Notes:

cfs = centroid frequency-shift

dB = decibel(s)

g = gram(s)

lbs = pound(s)

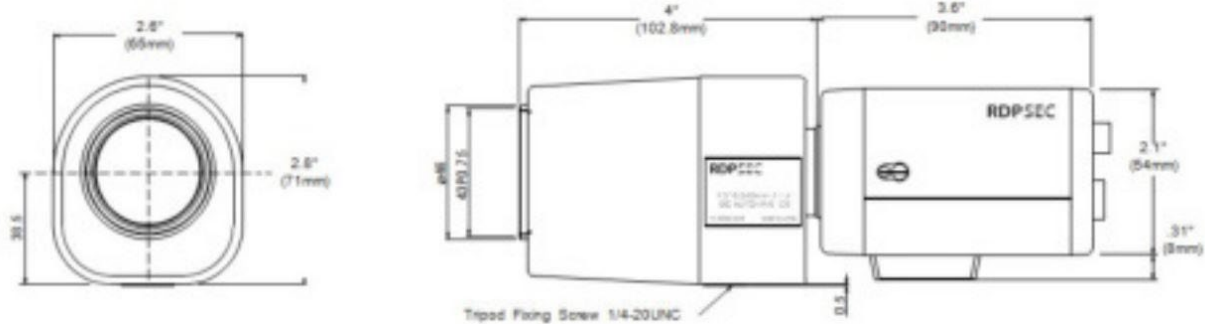
mA = milliampere(s)

NTSC = National Television System Committee

RH = relative humidity

3) Video Camera Housing (Figure 9-1)

Figure 9-1. Video Camera Housing

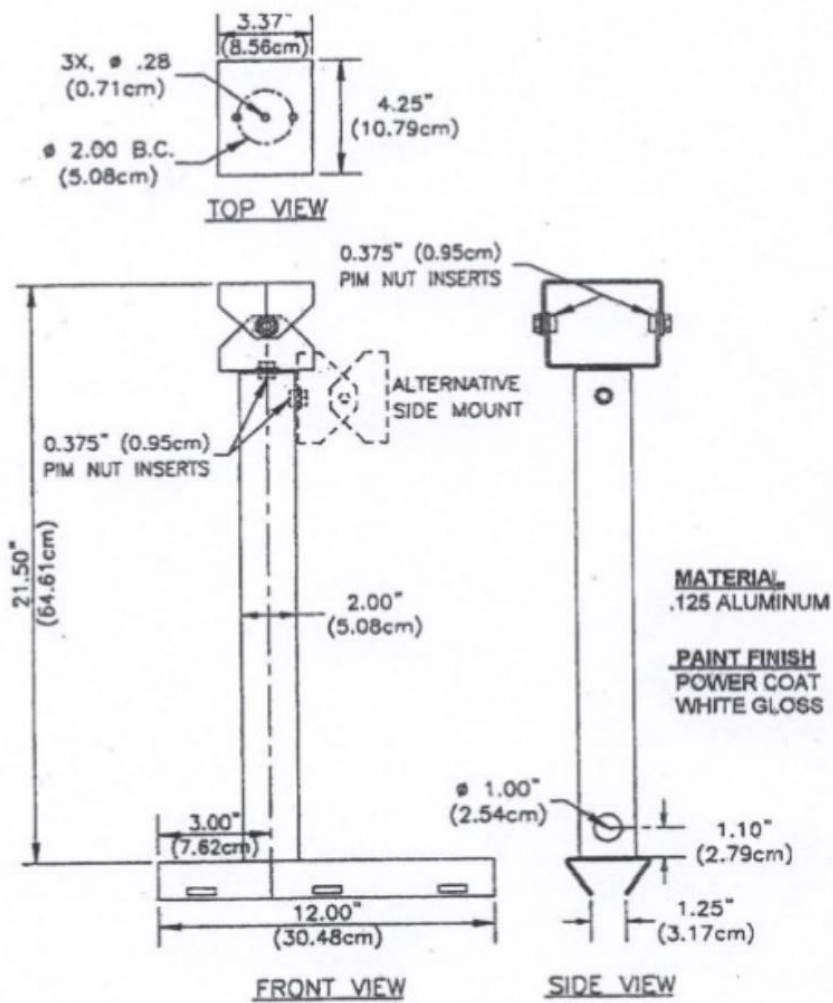


9.14.10.3 Housing and Sunshield

- General
 - All aluminum construction
 - IP68/NEMA-6P rated
 - Adjustable sunshield
 - Thermostatically controlled window heater/defogger
- Environmental
 - Temperature: -40°F to 140°F (-40°C to +60°C)
 - Salt Atmosphere: MIL-STD-810E, Method 509, Procedure 1
- Safety
 - CE: LVD Requirements: 72/34/EEC; EN60065
 - UL: UL2044
 - cUL: CSA 22.2, No. 1
- Electrical
 - 115VAC 50/60Hz
 - 30 watts
- Dimensions and Weight
 - Without sunshield (w/h/d): 4.0 by 4.4 by 18.4 inches (100 by 112 by 468 mm)
 - 10.5 lbs (4.8 kilograms)
- Warranty
 - 5-year warranty

9.14.10.4 Universal Mount (Figure 9-2)

Figure 9-2. Universal Mount



9.14.10.5 Cable

DESCRIPTION: 6 CONDUCTOR COMPOSITE CABLE: 16 AWG 5 CONDUCTOR 19/29 BARE COPPER .016" LDPE, OVERALL CLEAR MYLAR WRAP, 20 AWG 1 CONDUCTOR SOLID BARE COPPER .080" PE. OVERALL 96% TINNED COPPER DOUBLE BRAID. .032 PE JACKET BLACK; OVERALL .030" PVC JACKET BLACK 105C DIRECT BUR & SUN RES RESISTENT

CONDUCTOR/PAIR COUNT:	5 CONDUCTOR	1 CONDUCTOR	CABLE LAY	N/A
GAUGE & STRANDING	16 AWG 1929 BC	20 AWG SOLID BC	BINDER	N/A
D.C. RESISTANCE	3.35 Q/MFT	10.13 QMFT	JACKET THICKNESS	.030"
PRIMARY INSULATION TYPE:	LDPE	PE	JACKET COLOR	BLACK
INSULATION THICKNESS:	.016"	.080"	JACKET MATERIAL	PVC
COLOR CODE	BLACK, BROWN, WHITE, BLUE RED	N/A	RIPCORDER	YES
SHIELD	N/A	90% TC BRAID	NOMINAL O.D.	XXX
TAPE	Q CM WRAP	N/A	VOLTAGE RATING	N/A
SHIELD	N/A	96% TC BRAID	TEMP RATING	105C
JACKET THICKNESS	N/A	.032"	UL TYPE OR STYLE	N/A
JACKET COLOR	N/A	BLACK	PACKAGING	TBD
JACKET MATERIAL	N/A	PE	COPPER WEIGHT	41.075 LBS/MFT
			SHIPPING WEIGHT	105 LBS/MFT

PRINT LEGEND: AM SIGNAL INC 75 OHM VIDEO COAX 15 AWG 5 CDR 600 V DR BUR & SUN RES

Surge Suppressor

A video interface panel shall be available for installation inside the traffic signal controller cabinet. The panel shall provide coaxial cable connection points and an EDCO CX06-BNCY or approved equal transient suppresser for each image sensor.

- Peak Surge Current (8 x 20 us): 5 kiloamperes
- Technology: Hybrid, Solid State
- Attenuation: 0.1db @ 10Mhz
- Response Time: < 1 nanosecond
- Protection: Line to Ground
- Shield to Ground: (isolated shield modules)
- Clamp Voltage: 6 volts
- Connectors: BNC
- Impedance: 75 ohms
- Temperature: -40°C to +85°C
- Humidity: 0 to 95% non-condensing
- Dimensions: 4.5 inches by 1.5 inches by 1.25 inches
- UL Listed: UL 497B

Installation and Training

The product supplier of the video detection system shall supervise the installation and the testing of the video equipment. A factory-certified representative from the manufacturer shall be onsite during installation. The factory representative shall install, make fully operational, and test the system as indicated on the intersection drawings and this specification. Video detection cameras shall be mounted using "Band-It" banding material only (not hose clamps).

Warranty

The video detection system shall be warranted against manufacturing defects in materials and workmanship for a period of 2 years from date of installation. The video detection supplier shall provide all documentation necessary to maintain and operate the system.

9.14.11 Microwave Vehicle Radar Detector

Where specified on the plans, microwave vehicle radar detection shall be installed. The microwave radar vehicle detector shall be the Wavetronix Smart Sensor Matrix, or approved equal, for all approaches with advance detection for main street approaches on Major-Minor intersections and all approaches for Major-Major intersections.

9.14.12 Pedestrian Detector

Pedestrian push buttons shall be as specified in 9.120b or approved equal as called out in the signal construction plans. They shall be of tamper-proof design, and the housing shall be yellow in color.

A two-wire Polara iNavigator (iN2) Bluetooth-enabled Audible-Tactile Pedestrian system composed of a pedestrian Head Controller Unit and Push Button Stations with integral pedestrian signs meeting the functionality requirements of MUTCD 11th Edition – 4I and 4K. The Contractor shall coordinate with the City and the vendor to provide audio messaging files meeting MUTCD 11th Edition 4K.03 guidelines and approved by the City with the equipment and to the City for backup purposes at no additional cost to the City.

9.14.13 Pedestrian Push Button Sign

Pedestrian push button signs shall be integral to Polara iNavigator (iN2) or approved equal, APS push button station, or as indicated in the plans. Pedestrian signage shall be a MUTCD R10-3e 9-inch-by-15-inch sign.

9.14.14 Mast Arm and Pole

Mast arms and poles shall meet the requirements of the standard details, which indicate the critical dimensions that must be met exactly or within stated tolerances. The intent is to provide mast arms and poles that match the overall appearance as illustrated in the standard details and meet the performance requirements of the details and these specifications. Pole supplier submittals shall demonstrate conformity with this intent.

Mast arms and poles shall be wrapped for shipping from the factory in heavy-duty paper or plastic, to protect them from scratches and abrasions in transit.

Mast arms and poles shall be factory-coated conforming to standard detail requirements.

Specialty signal poles, such as modular or nostalgia designs, may only be installed with approval from the City. The entity paying for the signal will be required to have spare components available and stored near the City in case of pole failure, required replacement, or other emergency.

Mast arms shall not be installed and left unloaded for an extended period of time. If, at the discretion of the City, the mast arms are installed, and loading cannot occur by installing signal heads or mast arm signing, the mast arms shall be loaded with a minimum of two sign panels on each mast arm. These sign panels shall be mounted with Astro brackets so a gap is maintained between the mast arm and the sign

panel. These sign panels shall be spaced at one-third intervals on the mast arm. The sign panels shall be mounted parallel with the roadway on the top of the mast arm. The Contractor shall then contact the City so the mast arm and signal pole can be inspected for excessive vibration. Additional sign panels or adjustments in sign-panel spacing may be required at the discretion of the City.

9.14.15 Span Wire Pole

Unless otherwise specified in the plans and specifications, span wire poles are intended for temporary use only, prior to installation of permanent mast arm signals or for emergency use. In all cases, span wire signals will be allowed only with written authorization of the City.

Span wire poles and cable shall be designed to meet the structural requirements given in the latest edition of AASHTO's "Standard Specifications for Structural Support for Highway Signs, Luminaires and Traffic Signals" for a wind velocity of 90 mph. The minimum pole weights and span wire cable rating given in the standard details shall be increased as necessary in accordance with the AASHTO requirements.

Span wire pole may be seamless or may be fabricated as one piece without transverse joints or welds and with only one longitudinal seam, which shall be either continuously welded and ground or rolled flush.

Span wire cable shall be seven-wire stranded, common galvanized, and utilities grade. The cable shall have a minimum wire diameter of three-eighths of an inch and shall be rated at 13,000 pounds minimum. Tether cable shall have a maximum diameter of one-quarter inch and shall be stranded, galvanized steel. Both span wire cable and tether cable shall be incidental to the span wire pole pay item.

9.14.16 Pedestal Pole

Pedestal poles shall be designed to meet the structural requirements given in the latest edition of AASHTO's "Standard Specifications for Structural Support for Highway Signs, Luminaires and Traffic Signals" for a wind velocity of 100 mph. The pole base shall be frangible. All ped poles shall include Pelco pole and base collar assembly #PB-5334.

The pedestal pole shall also meet the requirements as stated in Section 9.14.14 of these specifications.

9.14.17 Pedestrian Push Button Pole

Pedestrian push button pole shall be as illustrated in the standard details and installed at locations shown on the plans. When indicated on the plans, push buttons, pedestrian signs, and instructional signs shall be mounted on the pedestrian push button pole.

9.14.18 Controller and Cabinet (Local/Master)

Each controller and cabinet assembly shall be in conformance with the latest edition of the City of Castle Pines Traffic Signal Specifications, as clarified by the following.

Each controller and cabinet assembly shall include:

- 1) Q-Free Intelight model or approved equal.
- 2) 210ECLip or approved equal.
- 3) A cabinet with an exterior painted CDOT silver with an anti-graffiti coating; interior shall be painted white. Cabinet shall be furnished with a "BEST" door lock kit. Lock and core is "BEST" 5L6R left and right.

The cabinet shall contain the CalTrans PDA #2 power distribution assembly or approved equal. Hinged covers shall protect all circuit breaker switches. The assembly shall contain a quick-release locking latch in front of the 206-power supply. Other specific items shall be as follows:

- Quad fans with two thermostats for 332D cabinets: fans shall be wired on independent circuits.
- Dual input files
- Output File. It shall contain a hot swappable red monitor board with a protective cover mounted on the outside rear of output file. An 8-position load resistor termination panel shall also be included and mounted on the assembly
- Auxiliary Output File
- Six Model 430 transfer relays
- Model 204 2-circuit flashers
- Eighteen Model 200 input/output load switches
- Model 242 D.C. isolators
- Model 2018E Reno conflict monitor or approved equivalent
- CalTrans/CDOT pullout drawer assembly
- Interior shelf
- Internal (front/back) LED lamp assemblies. No more than two light strips per power supply
- Service panel assembly with main breaker, including terminal blocks for service and battery back-up system. Transient voltage surge suppression shall be a removable/plug-in type, Hesco/RLS HE 1750 TEES or approved equal
- Polymer concrete cabinet base pad
- 72000 EtherWAN hardened managed network switch
- Gator Patch 12 Port pre-terminated patch panel SC connector or approved equal as specified on plans
- Electronic copy of all cabinet documentation, including the cabinet manual and cabinet prints, shall be provided on a flash drive
- 332/332D Cabinet Equipment Layout – Top to Bottom
- Front Right (facing cabinet):
 - Ethernet switch
 - Controller
 - CalTrans/CDOT pullout drawer
 - "I" File
 - "J" File
 - PDA Assembly
 - Output file
 - Aux Output file
- Front Left (facing cabinet):
 - Gator Patch Panel
 - UPS Head Unit
 - Transfer Switch
 - Wavetronix file or approved equal (as needed)
 - Shelf
 - CalTrans/CDOT pullout drawer
 - Bottom shelf

Notes:

- The cabinet drawings shall be non-fading prints using the xerography method. No blue line drawings will be acceptable.
- The City Public Works Department shall be supplied a computer printout of the complete environmental testing results.
- The cabinet shall have 14 red flash jumper blocks with 10 additional jumpers to accommodate yellow flash.
- The cabinet field terminals shall be silk screened with the appropriate phase/color designations. Field wire attachment point in the cabinet shall be a 12-position terminal block with screw-down plugs.

The controller and cabinet shall be delivered to the City of Castle Pines Traffic Signal Shop for testing, programming, and operational checking. No testing shall commence until cabinet is completely assembled by the Contractor (for example, UPS and communication equipment). City Public Works Department staff will have the complete cabinet available for pickup no more than 10 working days after final testing. Contractor is responsible for delivery and pick-up. Any malfunctions or problems with the testing and programming will be reported to the Contractor for immediate repair. Any malfunctions or problems will not count against the 10 working days.

9.14.18.1 Uninterruptible Power Source

Unless otherwise indicated, UPS shall be installed. The UPS shall be Alpha FXM1100 with Ethernet SNMP card or approved equal, transfer switch (U-ATS and U-GTS), battery string monitor (Alpha Guard), heater mats and equipped with Alpha Cell 195 GXL batteries having a minimum rating of 100 amp hours or approved equal.

Documentation and Warranty The manufacturer shall furnish the owner an instruction manual covering the installation, operation, and maintenance of the UPS and batteries. The UPS shall be covered by a parts and labor warranty in accordance with the manufacturer's Standard Terms and Conditions. The warranty period shall be for 2 years from the in-service date.

9.14.19 Miscellaneous Hardware

All ferrous mounting hardware and weatherheads shall be galvanized, cadmium plated, or made of stainless steel to resist corrosion. Payment for miscellaneous hardware, including pole plates for side-of-pole mounting, shall be incidental to the pay item to which the miscellaneous hardware items are attached.

9.14.20 Instructions and Wiring Diagrams

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

9.14.21 School Flashing Beacon Assembly

A school flashing beacon assembly shall be as shown in the standard details. Payment for this item shall be inclusive of all work to provide an operational flashing assembly, including materials, installation, and

electrical service connection (if not a solar installation). Fluorescent yellow-green signs shall be installed as an integral part of the flashing assembly.

9.14.22 Warning or Regulatory Sign Flashing Beacon Assembly

A warning or regulatory sign flashing beacon assembly shall be as shown in the standard details. Payment for this item shall be inclusive of all work to provide an operational flashing assembly, including materials, installation, and electrical service connection (if not a solar installation). Signs shall be installed as an integral part of the flashing assembly.

9.14.23 Fiber-Optic Cable

9.14.23.1 Industry Standards

Fiber-optic cable shall conform to the industry standards listed as follows to assure the cable's performance and durability in the field environment:

- Electronic Industries Alliance (EIA)
- Insulated Cable Engineers Association (ICEA)
- International Electrotechnical Commission (IEC)
- International Organization of Standardization (ISO)
- International Telecommunication Union – Telecommunication Standardization Sector (ITU-T)
- Telcordia Technologies, Inc. (Telcordia)
- Telecommunications Industry Association (TIA)
- United States Department of Agriculture Rural Utilities Service (RUS)

The industry standards shown in the Table 9-11 shall be referenced throughout this section by its Section Standard Number (SSN). The Contractor shall be responsible for using the most current edition or version of the standards listed in Table 9-11 or the replacement standard if the standard has been superseded.

Table 9-11. Industry Standards

SSN	Standard	Edition	Fiber-Optic Test Procedure	Standard Title
10-1	TIA-526-7	A	7	Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant
10-2	TIA-455-78	B	78	Optical Fibers Attenuation Measurement Methods and Test Procedures
10-3	ITU-T G.652D	2009	N/A	Characteristics of a Single-Mode Optical Fiber and Cable
10-4	TIA-455-3	B	3	Procedure to Measure Temperature Cycling Effects on Optical Fiber Units, Optical Cable and Other Passive Components
10-5	EIA-359	A	N/A	Color for Color Identification and Coding
10-6	TIA-598	D	82-B	Optical Fiber Cable Coding
10-7	TIA-455-82	B	81	Fluid Penetration Test for Fluid Blocked Fiber Optic Cable
10-8	TIA/EIA-455-81	B	41	Compressive Loading Resistance of Fiber Optic Cables

SSN	Standard	Edition	Fiber-Optic Test Procedure	Standard Title
10-9	TIA/EIA-455-41	A	104	Fiber Optic Cable Cyclic Flexing Test
10-10	TIA-455-104	B	25	Impact Testing of Optical Fiber Cables
10-11	TIA/EIA-455-25	D	33	Optical Fiber Cable Tensile Loading and Bending Test
10-12	TIA-455-33	B	85	Fiber Optic Cable Twist Test
10-13	TIA-455-85	A	226	Calibration of Optical Time-Domain Reflectometers
10-14	TIA/EIA-455-226	2002	231	Calibration of Fiber Optic Power Meters
10-15	TIA-455-231	2015	N/A	General Requirements for the Competence of Testing and Calibration Laboratories
10-16	ISO/IEC 17025	2nd	N/A	General Requirements for the Competence of Testing and Calibration Laboratories
10-17	TIA-455-37	A	37	Low or High Temperature Bend Test for Fiber Optic Cable
10-18	TIA/EIA-455-98	A	98	Fiber Optic Cable External Freezing Test
10-19	Telcordia GR-20 CORE	4	N/A	Generic Requirements for Optical Fiber and Optical Fiber Cable
10-20	ISO 9000	4th	N/A	International Standards for Quality Management
10-21	ICEA S-87-640	6th	N/A	Optical Fiber Outside Plant Communications Cable
10-22	RUS PE-90a	N/A	N/A	Minimum Performance Specifications for Fiber Optic Cables
10-23	IEEE C2	2017	N/A	National Electrical Safety Code (NESC)

9.14.23.2 Fiber-Optic Material Specifications

- 1) Where specified on the plans, interconnect wire connecting traffic signal controller cabinets shall be fiber-optic type.
- 2) Fiber-optic cable runs consist of a backbone cable, which runs the length of the project, and lateral connections to the individual local controller cabinets and material specifications for each are explained in detail in this specification:
 - a) Backbone fiber-optic cable shall be loose tube, non-armored, outdoor cable consisting of (72 single-mode fibers unless otherwise specified on the plans.
 - b) The lateral fiber-optic cable shall be loose tube, non-armored, outdoor cable with fiber count as indicated on the plans and complying with the following specification for fiber-optic cable: Lateral cables shall include a pre-terminated type termination panel, similar to Fiber Connections GatorPatch panel, Corning Zeux Panel, or approved equal, and shall be spliced to the backbone fiber-optic cables in the splice closure as specified in the plans or Project Specifications, or as directed by the City or its designee.
- 3) Fiber-optic cable for installation in conduit shall meet the requirements of SSN 10-3.

9.14.23.3 General Considerations

- 1) The cable shall be new, from an unused reel, and of current design and manufacture.
- 2) Connectors shall be "SC" single-mode type with a UPC finish (nominal reflectance of -50 dB), unless otherwise specified on the plans.
- 3) A No. 14 AWG (minimum), fully annealed, solid conductor tracer wire shall be installed in conduit with fiber. The tracer wire shall use HDPE insulation and the American Public Works Association color code standard for buried communications.

9.14.23.4 Fiber Characteristics

- 1) All fibers in the cable must be usable fibers.
- 2) The cable and jacket shall be sufficiently free of surface imperfections and inclusions to meet the optical, mechanical, and environmental requirements of this specification.
- 3) Each optical fiber shall consist of a doped silica core surrounded by a concentric silica cladding.
- 4) The single-mode fiber used in the cable specified herein shall conform to SSN 10-3 except as noted herein.

9.14.23.5 Fiber Specification Parameters

All fibers in the cable shall meet the following requirements:

- 1) Have attenuation values of 0.35 decibel per kilometer (dB/km) at 1,310 nanometers (nm) and 0.25 dB/km at 1,550 nm.
- 2) Temperature testing shall be in accordance with SSN 10-4.
- 3) The chromatic dispersion for single-mode optical fibers shall be as required by SSN 10-3.
- 4) Specifications for Outdoor Fiber Cables
 - a) Optical fibers shall be placed inside loose buffer tubes.
 - b) All cable shall be dielectric.
 - c) Up to 36 fibers per cable shall have 6 or 12 fibers per buffer tube, and greater than 36 fibers per cable shall have 12 fibers per buffer tube.
 - d) The fibers shall not adhere to the inside of the buffer tube.
 - e) The ultraviolet acrylate-coated fibers shall be color coded with highly distinguishable colors according to the following:
 - i) Blue
 - ii) Orange
 - iii) Green
 - iv) Brown
 - v) Slate
 - vi) White
 - vii) Red
 - viii) Black
 - ix) Yellow

- x) Violet
- xi) Rose
- xii) Aqua
- f) All colors shall meet Munsell standards as specified in SSN 10-5 and 10-6.
- g) Buffer tubes containing fibers shall also be color coded or numbered with distinct and recognizable colors or numbers according to the following:
 - i) Blue
 - ii) Orange
 - iii) Green
 - iv) Brown
 - v) Slate
 - vi) White
 - vii) Red
 - viii) Black
 - ix) Yellow
 - x) Violet
 - xi) Rose
 - xii) Aqua
- h) These colors shall meet SSN 10-5 and 10-6.
 - i) In buffer tubes containing multiple fibers, the colors or numbers shall be stable during temperature cycling and not subject to fading or smearing onto each other. Colors shall not cause fibers to stick together.
 - ii) Buffer tubes shall be of a dual-layer construction with the inner layer made of polycarbonate and the outer layer made of polyester.
 - iii) Fillers may be included in the cable core to lend symmetry to the cable cross-section where needed.
 - iv) The central anti-buckling member shall consist of a fiberglass-reinforced plastic rod. The purpose of the central member is to prevent cable buckling.
 - v) Each buffer tube shall be filled with a swellable yarn (dry water blocking) meeting the requirements of SSN 10-19, 10-21, and 10-22.
 - vi) Buffer tubes shall be stranded around a central member using the reverse oscillation, or "SZ," stranding process.
 - vii) The cable core interstices shall be filled with a swellable glass yarn, and the buffer tubes shall be surrounded by a dry water-blocking tape meeting the requirements of SSN 10-19, 10-21, and 10-22.
 - viii) Binders shall be applied with sufficient tension to secure the buffer tubes to the central member without crushing the buffer tubes. The binders shall be non-hygroscopic and dielectric with low shrinkage.

- ix) The cable shall contain at least one ripcord, unless cable is using fast-access technology, under the sheath for easy sheath removal.
- x) Tensile strength shall be provided by high-tensile-strength aramid yarns, fiberglass yarns, or both.
- xi) The high-tensile-strength aramid yarns and/or fiberglass yarns shall be helically stranded evenly around the cable core.
- xii) All cables shall be sheathed with medium-density polyethylene. The minimum nominal jacket thickness shall be 1.4 mm. Jacketing material shall be applied directly over the tensile strength members and dry water-blocking materials. The polyethylene shall contain carbon black to provide ultraviolet light protection and shall not promote the growth of fungus.
- xiii) The jacket or sheath shall be free of holes, splits, and blisters.
- xiv) The cable jacket shall contain no metal elements and shall be of a consistent thickness.
- xv) Cable jackets shall be marked with the following items:
 - Fiber-optic cable manufacturer's name, logo, or both
 - Month and year of manufacture
 - Fiber-optic cable manufacturer's part number
 - Fiber count
 - Sequential length markings in feet or meters
 - Telecommunication handset symbol, as required by section 350G of SSN 10-23.

All length markings shall be placed at 2-foot, 3-foot, or 1-meter intervals. The actual length of the cable shall be within $\pm 3\%$ of the length markings. All markings shall be indented in permanent white characters. The height of the marking shall be approximately 2.5 mm. If remarking is required, yellow markings shall be used to correct the error in the original markings. All cable markings shall be in English.

i) General Fiber Cable Performance Specifications

- i) The unaged cable shall withstand water penetration when tested with a 1-meter static head or equivalent continuous pressure applied at one end of a 1-meter length of filled cable for 24 hours. No water shall leak through the open cable end. When a 1-meter static head or equivalent continuous pressure is applied at one end of a 1-meter length of aged cable for 1 hour, no water shall leak through the open cable end. Testing shall be done in accordance with SSN 10-7.
- ii) When tested in accordance with SSN 10-8, the cable shall exhibit no flow (drip or leak) of filling or flooding compound at 80°C. If material flow is detected, the weight of any compound that drips from the sample shall be less than 0.05 gram (0.002 ounce).
- iii) The cable shall withstand a minimum compressive load of 220 Newton centimeters (125 pound-force) for non-armored cables applied uniformly over the length of the compression plate. The cable shall be tested in accordance with SSN 10-9, except that the load shall be applied at the rate of 3 mm to 20 mm per minute and maintained for 10 minutes. The magnitude of the attenuation change shall be within the repeatability of the measurement system for 90% of the test fibers. The remaining 10% of the fibers shall not experience an attenuation change greater than 0.1 dB at 1,550 nm (single-mode). The repeatability of the measurement system is typically ± 0.05 dB or less. No fibers shall exhibit a measurable change in attenuation after load removal.

- iv) When tested in accordance with SSN 10-10, the cable shall withstand 25 mechanical flexing cycles at a rate of 30 ± 1 cycles per minute, with a sheave diameter not greater than 20 times the cable diameter. The magnitude of the attenuation change shall be within the repeatability of the measurement system for 90% of the test fibers. The remaining 10% of the fibers shall not experience an attenuation change greater than 0.1 dB at 1,550 nm (single-mode). The repeatability of the measurement system is typically ± 0.05 dB or less. The cable jacket shall exhibit no cracking or splitting when observed under 5 times magnification.
- v) When tested in accordance with SSN 10-11, the cable shall withstand 25 impact cycles. The magnitude of the attenuation change shall be within the repeatability of the measurement system for 90% of the test fibers. The remaining 10% of the fibers shall not experience an attenuation change greater than 0.1 dB at 1,550 nm (single-mode). The repeatability of the measurement system is typically ± 0.05 dB or less. The average increase in attenuation for fibers shall be less than or equal to 0.04 dB at 1,300 nm (multimode). The cable jacket shall not exhibit evidence of cracking or splitting at the completion of the test.
- vi) When tested in accordance with SSN 10-12, using maximum mandrel and sheave diameter of 560 mm, the cable shall withstand a tensile load of 2,700 Newtons (N) (608 lbf) applied for 1 hour (using Test Condition II of the procedure). In addition, the cable sample, while subjected to a minimum load of 2,660 N (600 lbf), shall be able to withstand a twist of 360 degrees in a length of less than 3 meters. The magnitude of the attenuation change shall be within the repeatability of the measurement system of 90% of the test fibers. The remaining 10% of the fibers shall not experience an attenuation change greater than 0.1 dB at 1,550 nm. The repeatability of the measurement system is typically ± 0.05 dB or less. The cable shall not experience a measurable increase in attenuation when subjected to the rated residual tensile load, 890 N (200 lbf).
- vii) When tested in accordance with SSN 10-13, a length of cable no greater than 2 meters will withstand 10 cycles of mechanical twisting. The magnitude of the attenuation change will be within the repeatability of the measurement system for 90% of the test fibers. The remaining 10% of the fibers will not experience an attenuation change greater than 0.1 dB at 1,550 nm. The repeatability of the measurement system is typically ± 0.05 dB or less. The cable jacket will exhibit no cracking or splitting when observed under 5 times magnification after completion of the test.
- viii) Low and high temperature cable bending, maximum bend radius, and cable aging shall be tested in accordance with SSN 10-17.
- ix) Cable freezing shall be tested in accordance with SSN 10-18.
- x) Color-coding permanence shall be tested in accordance with SSN 10-19, 10-21, and 10-22.
- xi) In accordance with SSN 10-4, the fiber-optic cable shall conform to the following temperature requirements:
 - o Operation: -40°C to 70°C (-40°F to 158°F)
 - o Installation: -30°C to 60°C (-22°F to 140°F)
 - o Shipping/Storage: -40°C to 75°C (-40°F to 167°F)

9.14.24 Quality Assurance Provisions

- 1) Optical fiber shall meet SSN 10-20 standards.
- 2) Optical fibers shall be proof tested by the fiber manufacturer at a minimum load of 100 kilopounds (kip) per square inch.
- 3) Optical fibers shall be 100% attenuation tested by the manufacturer. The attenuation of each fiber shall be provided with each cable reel.

9.14.25 Packaging

- 1) The complete cable shall be packaged for shipment on non-returnable wooden reels.
- 2) Text on the reels shall contain the following information:
 - a) Fiber-optic cable manufacturer's name, logo, or both
 - b) Fiber-optic cable type
 - c) Fiber count
 - d) Marking showing side to unreel cable
- 3) Top and bottom ends of the cable shall be available for testing without removing cable from the reel.
- 4) Both ends of the cable shall be sealed to prevent the ingress of moisture.
- 5) Each reel shall have a weatherproof reel tag attached identifying the reel and cable.
- 6) Each cable shall be accompanied by a cable data sheet that contains significant information on the cable.

9.14.26 Miscellaneous

The cable manufacturer shall provide installation procedures and technical support concerning the items contained in this specification.

9.14.27 Fiber-Optic Cable Installation

- 1) Interconnect Cable Installation. The Contractor shall provide the City with two copies of the cable manufacturer's recommended installation instructions for fiber-optic cable in conduit. Installation shall be in accordance with these practices except as directed by the City or its designee. Additional cable costs as a result of damage caused by the Contractor's neglect of recommended procedures shall be the Contractor's responsibility.
- 2) Fiber-optic cable shall be installed in continuous runs except where cable type changes or where maximum pull lengths govern. The manufacturer's recommended limits for cable lengths shall not be exceeded.
- 3) Cable ends shall be stored in splice enclosures immediately adjacent to cabinets or in controller cabinets as directed by the City or its designee. Only fibers called out in plans need to be spliced. All other fibers shall be sealed in a manner recommended by the manufacturer.
- 4) The City or its designee shall provide an interconnect schematic diagram to the Contractor. The diagram shall clearly indicate cable routing, splice points, and fiber connections, including identifying the color-coded fibers and buffer tubes. Cable installation will not be permitted until the schematic diagram has been reviewed by the Contractor in the preconstruction meeting and with the City's or its designee's oversight during installation.
- 5) The fibers and buffer tubes noted on the plans shall be the only ones terminated or spliced, unless otherwise approved by the City or its designee. Under no conditions shall the single-mode fibers be cut or spliced at intermediate points without express written direction from the City or its designee. The Contractor shall place an end cap on any bare cable ends to prevent moisture or dirt intrusion.
- 6) Field terminations of fiber shall not be allowed without express written direction from the City or its designee.
- 7) The Contractor shall leave a minimum of 50 feet coiled in each pull box, a minimum of 10 feet within the controller cabinet, and 100 feet coiled in splice vaults, unless otherwise specified on the plans.

- 8) The maximum pulling tension shall be 2,700 N (600 lbf) during installation (short term) and 890 N (200 lbf) long-term installed as tested in accordance with SSN 10-12.
- 9) The Contractor shall seal all ends of conduit for pulled-fiber cable with approved reusable split-plug products.
- 10) The Contractor shall place fiber tags on the ends of all pulled-fiber cable with the following information:
 - a) Name of manufacturer
 - b) Type of fiber (single mode or multi-mode)
 - c) Number of strands
 - d) Date of installation
 - e) Cable end to end locations
 - f) Lateral run identification (where applicable)

9.14.28 Fiber-Optic Cable Testing

- 1) The Contractor shall demonstrate that all fiber-optic cable testing results in acceptable attenuation values. All fiber-optic cable testing parameters shall be submitted as specified in this section and in Section 9.14.32.
- 2) The Contractor, solely at the Contractor's cost, shall resplice any fusion splices or re-terminate any terminations that have test results exceeding acceptable attenuation values. The Contractor, solely at the Contractor's cost, shall retest any fiber links that have been re-spliced.
- 3) The Contractor, solely at the Contractor's cost, shall bring any link not meeting the requirements of testing specifications into compliance.
- 4) The installed fiber-optic cable test shall consist of the testing of single-mode fiber-optic cable. The testing procedures involve an optical time domain reflectometer (OTDR) test and an optical power meter test. Under no circumstances shall fiber-optic testing begin before cable installation is complete, without the express written consent of the City.
- 5) Guidelines for fiber-optic cable testing are as follows:
 - a) Launch box or test jumpers must be of the same fiber core size and connector type as the cable system: Single-mode fiber 8.3/125 micrometers (μm).
 - b) The optical sources for testing are stabilized and have center within ± 20 nm of the 1,310/1,550 nm single-mode nominal wavelength for testing in accordance with SSN 10-1.
 - c) The power meter and the light source must be set to the same wavelength during testing.
 - d) The OTDR and power meter must be calibrated at each of the nominal test wavelengths and traceable to National Institute for Standards and Technology calibration standards. The calibration of the OTDR and power meter shall conform to the requirements set forth in SSN 10-14 and 10-15, respectively.
 - e) All system connectors, adapters, and jumpers are properly cleaned prior to and during measurements.
- 6) Materials for Testing
 - a) Fiber-Optic Cable Testing Equipment
 - i) Equipment shall be calibrated annually by the manufacturer or by an SSN 10-16 accredited calibration laboratory. A copy of the most recent certificate of calibration and any

out-of-tolerance conditions shall be provided with project submittals prior to the initiation of any testing activities. The following equipment and information is required to perform fiber-optic cable tests:

- OTDR
- Launch box (minimum length – 300 meters, or 984 feet)
- Light source at the appropriate wavelengths (1,310 and 1,550 nm)
- Optical power measurement equipment capable of measuring optical power in decibels per milliwatt (dBm)
- Minimum length for test jumpers shall be as recommended by the manufacturer of the light source and power meter. The connectors on the jumpers shall be compatible with the light source and power meter and have the same fiber construction as the link segment being tested in accordance with SSN 10-1. The Contractor shall also be responsible for providing any adapters, if needed.
- Jacket length measurements for lateral and backbone cable at each cable end, including splice points and termination panels

b) Optical Fiber Cable Testing with OTDR

- i) The Contractor shall perform an OTDR test of all fibers in all tubes on the reel, prior to installing the fiber. The test results shall be supplied to the City prior to cable installation. The preinstallation testing shall be used to evaluate the integrity, overall length, and fiber attenuation in dB/km for fiber-optic cables prior to the installation in conduit. The Contractor shall use a pigtail and mechanical splice to access one cable end to verify the length and attenuation of each fiber. The results of the testing shall be compared with the reel tag. Results indicating that the fiber-optic cable received does not meet the specification, or the discovery of point defects caused by shipping and handling shall be brought to the attention of the City or its designee immediately.
- ii) If the fiber is specified as "Install Only," the Contractor shall test the fiber on the reel and provide the test results to the City prior to the Contractor's accepting the cable. After installation, if there are unused portions of cable remaining on the reel, the City may request the Contractor or other qualified technician to perform a reel test. The Contractor shall provide the City the test results prior to delivering the cable to the City. Any cable damaged while in the Contractor's possession shall be replaced at the Contractor's expense.
- iii) Fiber testing shall be performed on all terminated fibers from patch panel to patch panel and unterminated fibers from end to end. Additionally, mid-entry splices into mainline cables require testing of all strands in the mainline cable, before and after installation. Testing shall consist of a bidirectional end-to-end OTDR trace performed in accordance with SSN 10-2 at both the 1,310- and 1,550-nm wavelengths. The attenuation measurements shall be provided at dual wavelengths 1,310 and 1,550 nm for single-mode fibers.
- iv) OTDR inspection will be used to verify installed cable integrity and length. It will also be used to assess splices and connectors. OTDR signature traces will be used for documentation and maintenance.
- v) Attenuation numbers for the installed link shall be calculated by taking the sum of the bi-directional measurements and dividing that sum by two.
- vi) The Contractor shall use an OTDR that is capable of storing traces electronically and shall save each final trace.

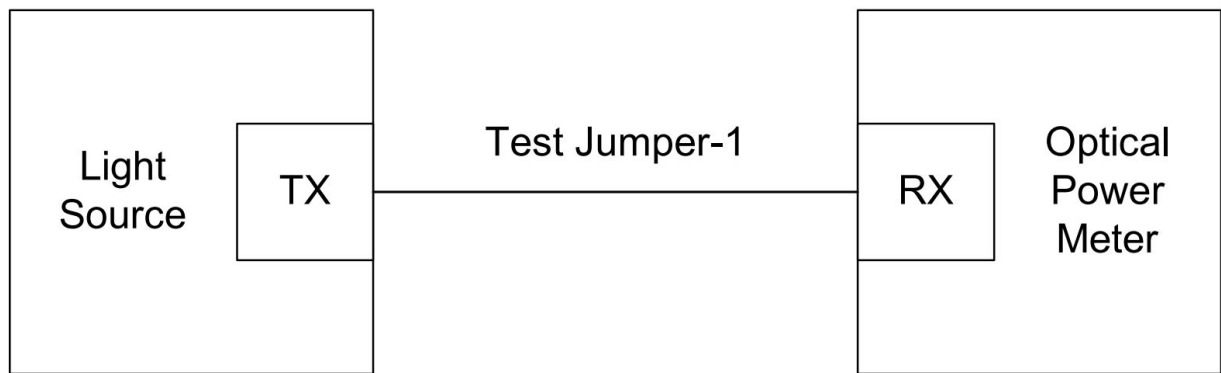
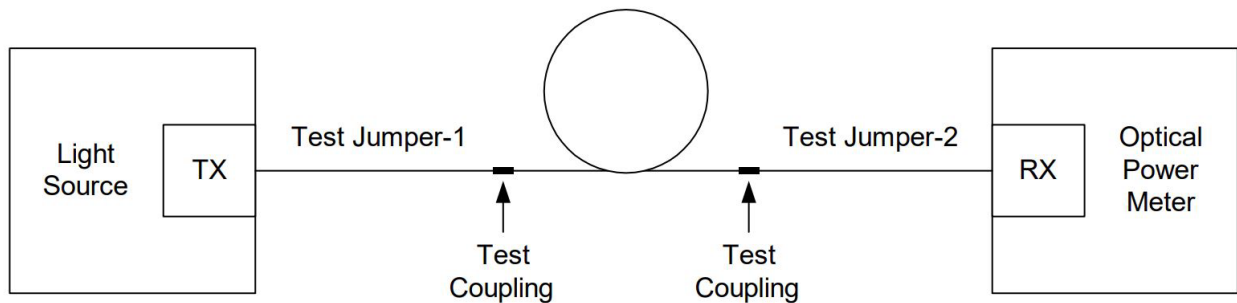
- vii) To ensure the traces identify the end points of the fiber under test and the fiber designation, the Contractor shall use a launch box, if required with the OTDR being used, to eliminate the "dead zone" at the start of the trace so that the start of the fiber under test can be identified on the trace. The length of the launch box shall be indicated for all test results.
- viii) In compliance with SSN 10-2, the Contractor shall record the following information during the test procedure:
 - Name and contact information for individuals responsible for conducting the test
 - Type of test equipment used (manufacturer, model, serial number, calibration date and valid certification of calibration)
 - Date test is being performed
 - Jacket readings in and out of each splice vault and each pull box
 - The index of refraction value used to perform the testing (1.466 for 1,310 nm and 1.467 for 1,550 nm in accordance with SSN 10-3)
 - Optical source wavelength and spectral width
 - Fiber identification
 - Start and end point locations
 - Launch box length
 - Method of calculation for the attenuation or attenuation coefficient
 - Acceptable link attenuation
- c) Optical Fiber Cable Testing with Optical Power Meter
 - i) The Contractor shall conduct an optical power meter test for each fiber installed. Single-mode segments shall be tested in one direction at both the 1,310 nm and 1,550 nm wavelength.
 - ii) In compliance with SSN 10-1, the following information shall be recorded during the test procedure:
 - Names and contact information of personnel conducting the test
 - Type of test equipment used (manufacturer, model, serial number, calibration date, and valid certificate of calibration)
 - Date test is being performed
 - Optical source wavelength and spectral width
 - Fiber identification
 - Start and end point locations
 - Test direction
 - Reference power measurement (when not using a power meter with a Relative Power Measurement Mode)
 - Measured attenuation of the link segment
 - Acceptable link attenuation

d) Acceptable Attenuation Values

- i) Acceptable attenuation values shall be calculated for each fiber tested. These values represent the maximum acceptable test values.
- ii) Single-mode fiber. The general attenuation equation for any single-mode link segment is as follows:
 - Acceptable Link Attenuation (Attn.) = Cable Attn. + Connector Attn. + Splice Attn.
- iii) 8.3 μ m Single-mode Attenuation Coefficients:
 - Cable Attenuation = Cable Length (km) x (0.35 dB/km@1,310 nm and 0.25 dB/km@1,550 nm)
 - Connection Attenuation = Number of Mated Connections x 0.50 dB
 - Splice Attenuation (Fusion) = Splices x 0.10 dB

e) Test Procedures

- i) Fiber testing shall be performed on all fibers in the completed end-to-end system.
- ii) Single-mode fiber. The single-mode optical power meter fiber test shall be conducted as follows:
 - Clean the test jumper connectors and the test coupling according to manufacturer's instructions.
 - Follow the test equipment manufacturer's initial adjustment instructions.
 - Connect Test Jumper-1 between the light source and the power meter. Avoid placing bends in the jumper that are less than 100 mm (4 inches) in diameter (refer to Figure 9-3).
 - If the power meter has a Relative Power Measurement Mode, select it. If it does not, reduce the Reference Power Measurement (preferred). If the meter can display power levels in dBm, select this unit of measurement to simplify subsequent calculations unless attenuation values can be read on the display directly in dB without calculations.
 - Disconnect Test Jumper-1 from the power meter. Do NOT disconnect the test jumper from the light source.
 - Attach Test Jumper-1 to one end of the cable plant to be measured and Test Jumper-2 to the other end (refer to Figure 9-4).
 - Record the Power Measurement. If the power meter is in Relative Power Measurement Mode, the meter reading represents the true value. Record the Relative Power Measurement if the meter does the calculation and provides this information.

Figure 9-3. Test Jumper 1 Connection**Figure 9-4. Test Jumper 1 to Test Jumper 2**

9.14.29 Fiber Acceptance

Once the fiber-optic communication system is in place and passed the fiber testing requirements, it shall be made operational for a burn-in period test. During this time, the system will be exercised and monitored for a period of 30 calendar days to exhibit fault-free operation. During the 30-day burn-in period, the Contractor is responsible for the maintenance or repair of the system or systems. The cost of any maintenance or repair necessary, except electricity, damage by the public, or acts of God, shall be borne by the Contractor and will be considered as included in the price paid for the contract item involved; therefore, no additional compensation will be allowed. The City shall suspend the 30-day burn-in period when a problem is detected and then reset the 30-day clock once the failure has been corrected to ensure 30 days of continuous, problem-free operation.

9.14.30 Emergency and Non-emergency Repairs during Construction and Burn-in Period

The Contractor shall provide emergency maintenance and fiber restoration services on the project corridor(s) where fiber-optic communication systems are installed for the City Public Works Department based on the terms and conditions set forth in the executed Agreement. All unplanned service disruptions of fiber-optic communication systems along project corridors shall be considered an emergency unless otherwise identified by the City or its designee. The terms of this service shall be provided from the initiation of the Agreement through system acceptance at the successful completion of the burn-in period. The Contractor shall have access to the fiber-optic system documentation that it prepares for the City to assist in the emergency maintenance and fiber restoration activities. The City will provide the Contractor with a project contact list to initiate contact about any disruptions in fiber-optic cable service. Project contacts will be responsible for notifying affected users of affected fiber-optic cable of any service

disruptions. The City will also provide access permission for local work Permits, if needed, for restoration activities.

The City or a third party may provide the first response in the event of an emergency and contact the Contractor to repair the problem. The Contractor shall dispatch personnel to undertake each such repair no later than 1 half-hour after the City Public Works Department initially notifies the Contractor of the emergency. Personnel responding shall arrive within 1 hour after notification during regular working hours and within 2 hours during non-working hours after notification.

The Contractor shall conduct the following activities, at a minimum, to support repairs covered under this section:

- Contractor shall provide a single point of contact to initiate restoration service.
- Contractor shall provide qualified employees and a supervisor, including skilled fiber-optic splicers.
- Response time shall be as noted in the previous paragraph.
- Upon starting the restoration services, Contractor technicians shall continue those services as expeditiously as possible until temporary emergency services are completed and the fiber link is again ready for service.
- Contractor crews shall be available 24 hours/day, 7 days/week from the initiation of the project through successful completion of the burn-in period.
- Contractor shall provide all tools, materials, and test equipment needed to perform repairs associated with restoration services.
- Contractor shall update record drawings and project documentation to reflect changes in the fiber-optic communication system caused by restoration activities.
- Where emergency splicing is required, the Contractor may use temporary mechanical splicing until such time that fusion splicing can be performed to replace the temporary mechanical splice. The attenuation for mechanical splices shall not exceed 0.30 dB per splice.
- In instances of repairs that are of a non-emergency nature and determined to be the Contractor's responsibility by the City, such repairs shall be undertaken at the site within 1 working day after the City notifies the Contractor of the needed repair.

Should the Contractor fail to perform any maintenance responsibilities within the prescribed time period(s), the City shall employ the services of the City's traffic signal maintenance contractor to perform said maintenance work. The Contractor shall reimburse the City as specified in Chapter 13 – Public Infrastructure Acceptance Procedures and Warranty Requirements.

9.14.31 Submittals

The Contractor is responsible for submitting all fiber-optic equipment calibration documentation, testing information, and fiber-optic testing results as specified in Section 9.14.29.

Additional Submittals: The following test data, certificates of compliance, and material specifications shall also be included with testing results specified in Section 9.14.29.

- End-to-end attenuation data resulting from the measurement of the optical power loss between cable termination points using a stabilized light source and optical power meter.
- OTDR signature traces resulting from the pre- and post-installation measurements for cable integrity, overall length, fiber attenuation in dB/km, and losses associated with fusion splices and connectors at

patch panels. Electronic copies shall include the required viewing software, if needed, for the City to interactively review, analyze, and print the traces.

- Certificate of compliance for end-to-end, connector, and splice loss to confirm test performance, compliance with stated loss requirements, and applicable warranty coverage for all individual connector and splice losses in the installed cable plant.
- Cable specifications provided by the cable manufacturer that define the minimum optical and mechanical performance guaranteed for the cable.

9.14.31.1 As-Built Submittal

The Contractor shall submit one copy of the complete contract plans, including additional drawings issued as part of any change orders, with any deviations clearly marked in color. Deviations to be noted include, but are not limited to, the following:

- 1) Fiber routing and location information
- 2) Fiber splice location
- 3) Fiber splice configuration
- 4) Patch panel locations
- 5) Installed cable lengths

9.14.31.2 Emergency and Non-emergency Repair Submittal

The Contractor shall submit one copy of the complete plans showing all fiber-optic cable repairs, including additional drawings issued as part of any repair work, with any deviations clearly marked in color. Deviations are to be noted and shall include the following, among others:

- 1) Repaired fiber routing and location information
- 2) Repaired fiber splice locations
- 3) Repaired fiber splice configuration
- 4) Patch panel modifications where applicable
- 5) Installed cable lengths necessary for repairs

The Contractor shall submit all fiber-optic equipment, material, and testing documentation related to any repair work as specified in Sections 9.14.29 and 9.14.32.

9.14.31.3 File Format

The Contractor shall submit fiber-optic interconnect documentation to the City in a pre-approved format.

9.14.32 Paint Equipment

9.14.32.1 Paint Existing Structures

- 1) Previously installed signal poles shall be field painted when indicated on the plans. When so indicated, 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 repainted. Previously painted surfaces, whether finish or prime coated, shall be scuff sanded with particular attention paid to the lower 8 feet of the pole.

- 2) Pole inspection by the City prior to application of the finish coats is required. Two finish coats of paint selected by the City shall be applied over the primer or previously painted surfaces.
- 3) The painting shall be done in a neat and efficient manner and may be applied either by hand brushing or spraying. The City 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) Touch-up painting shall be completed at the direction of the City. Nicks and abrasions shall be cleaned, and the City shall designate the appropriate primer coat, and finish coat, if applicable.
- 5) When indicated on the plans, traffic and pedestrian signal heads shall be painted black.

9.14.33 Pavement Marking

9.14.33.1 Materials

If pavement overlay or reconstruction is programmed within 1 year of marking installation, the City may approve use of alternate marking materials.

9.14.33.2 Surface Preparation

- 1) New concrete pavement shall have all residues removed, such as mud, dirt, and curing compound. Removal shall be by water blasting, sand blasting, or other City-approved method.
- 2) New asphalt pavements shall be dry and free of dirt.
- 3) For all restriping on existing concrete or asphalt pavement, the surface shall be clean and dry. Cleaning shall be by water sweeping, air blasting, or other City-approved method. When directed by the City, the surface shall be ground.
- 4) Surface temperature shall be 50°F and rising for all pavement marking applications except preformed plastic. Surface temperature shall be 60°F and rising for preformed plastic markings.
- 5) When the surface temperature does not reach 50°F, the Contractor may, on approval of City, substitute designated pavement markings with temporary marking materials to be replaced with permanent materials when weather dictates. Temporary pavement markings shall be refurbished by the developer or Contractor, at their own cost, as determined by the City.

9.14.33.3 Installation

All pavement markings shall be applied per the manufacturer's recommendations unless otherwise authorized by the City.

9.14.33.4 Pay Item

Pavement markings shall be measured and paid for on a lineal-foot basis; Arrows and legends shall be paid for on a square-foot basis unless otherwise authorized by the City. Refer to CDOT Standard Specifications for Road and Bridge Construction in accordance with Section 627.

9.14.34 Guarantees and Warranties

9.14.34.1 General

All work completed by the Contractor shall be guaranteed against defects in workmanship or materials for a period of 2 years from the date of Initial Acceptance, excepting ordinary wear and tear, abuse, or neglect. Please refer to the City of Castle Pines Roadway Design and Construction Standards, Chapter 13 –

Acceptance Procedures and Requirements, for explanation of the required 2-year warranty period and for Final Acceptance requirements.

9.14.34.2 Pavement Marking Warranty

The following warranty is required for pavement marking installations: One year with normal traffic wear. Material will not peel or lift in this time period. Approval of all work must be obtained from the City or its designee prior to the start of this warranty period.

9.14.34.3 Materials and Parts

The Contractor shall supply the City with all manufacturer warranties and guarantees covering materials and parts.

9.14.35 General Signal Design Requirements

9.14.35.1 Scope

This section describes general signal design requirements for use in City of Castle Pines. Variances from these requirements require written approval of the City..

9.14.35.2 Signal Head Placement and Sizes

- 1) For all installations, one signal head shall be provided centered over each exclusive left turn and through lane. If mast arms do not reach the left turn lane(s), the number and configuration of signal heads should be adjusted in consultation with the City. Far left and far right pole-mounted signal heads shall also be provided. The need for one signal head per right turn lane should be determined on a site-specific basis. The traffic signal design engineer (Engineer of Record) shall coordinate with the pole manufacturer to verify that the structure is adequate to accommodate the proposed loading.
- 2) Where left-turn arrows are included, at least two signal heads with left arrow sections shall be provided, with one of these located on the far left pole.
- 3) Pedestrian signal heads shall be provided for all marked crosswalks. Where pedestrian signal heads are provided, corresponding pedestrian push buttons shall be provided.
- 4) All mast arm and span wire-mounted signal heads shall have aluminum louvered backplates, black in color with a 2-inch, diamond-grade, fluorescent-yellow retroreflective border.
- 5) All vehicle signal sections shall be 12-inch LED. Pedestrian indications shall be LED (refer to Section 9.14).
- 6) Where mast arms extend over the left turn lane(s), left-turn-only sign(s) (R3-5) shall be provided. Double lefts may be covered with one left-turn-only sign (R3-5) per lane, or one double left-turn-only sign located over the lane line between the double lefts as directed per plan.
- 7) Where flashing yellow arrow left turn control is recommended for left turn operations, a custom 30-inch-by-36-inch "left-turn yield on flashing yellow arrow" pictorial (for the arrow – no starburst) sign shall be installed to the right of the left-turn signal indication.

9.14.36 Pole and Cabinet Placement

All signal poles, pedestals, and cabinets shall be placed a minimum of 3 feet from the face of a traffic signal item to the face of the curb where curbing is present, with a desired separation of 5 feet. The traffic control cabinet and base shall be placed on level ground with adequate room to access and maneuver around the cabinet. The cabinet location shall be such that it guarantees adequate visibility of intersection

and approaching traffic from all directions. The same separations apply from the face of a traffic signal item to the outside edge of the shoulder where pavement and shoulder exist with no curbing. Where only pavement exists without shoulder and curbing, a minimum of 5 feet from the face of the traffic signal item to the edge of pavement shall be maintained, with a desired separation of 7 feet. Refer to Section 9.14.43.3.

9.14.37 Street Name Signs

Rigidly affixed street name signs shall be provided for all approaches. They shall be on 0.100 aluminum sign and shall consist of Diamond Grade LDP reflective material or equivalent. The ElectroCut film shall be 3M 1170 Green or equivalent. The font type is FHWA Hwy. Series C unless otherwise specified. The street name shall be 12-inch initial upper case and combination of lower case, and the designator shall be 8-inch initial upper case and combination of lower case.

9.14.38 Signal Conduit

Refer to Section 9.12 for requirements.

9.14.39 Interconnect

Requirements for traffic signal interconnect shall be determined on a site-specific basis. The traffic signal designer shall coordinate with the City or its designee to determine the need for interconnect.

9.14.40 Luminaires

Unless otherwise indicated in the plans, the Contractor shall provide a luminaire extension and luminaire wiring. The final power hook-up and the actual luminaire shall be provided and installed by the Contractor. Luminaire heads shall be General Electric Evolve ERLH or approved equal.

9.14.41 Vehicle Detectors and Bluetooth Readers

Stopbar detection for designated phases shall be provided. The locations and type of detection shall be indicated in the plans.

Counting detectors, when explicitly called out in the plans, shall be provided for each approach lane of traffic according to the City's direction. When imbedded in the roadway, detectors shall be located 20 feet or more upstream of stopbar detectors, or 10 feet or more upstream of the closest water type pull box where no stopbar detector exists. Refer to City of Castle Pines Standard Signal Details.

On all approaches with free-flow speeds of 40 to 45 mph and greater, advance detection for dilemma zone protection shall be provided. Site-specific conditions, such as grades or sight-distance obstructions, may also justify use of advance detection. The potential need for advance detection in these cases should be reviewed with the City.

Advance Detection Zones placement shall be in accordance with Table 9-12.

Table 9-12. Advance Detection Zone Placement

Posted Speed (mph)	Zone Placement (measured from back edge of crosswalk or stop bar) (feet)
25	100
30	150
35	205
40	235
45	270
50	300

When microwave or video detection is specified, a note shall be included on the signal plans that requires the Contractor to coordinate with the device manufacturer to determine placement and orientation of detection. Detection supplier's representative must be present for detection setup and initial operation.

9.14.42 Signal Power

- 1) The traffic signal design engineer (Engineer of Record) or the Contractor responsible for signal construction shall coordinate power source and meter location and requirements as part of the signal design. Coordination shall include determination of, and initial contact with, the appropriate power company, indication of the power source and meter location on the signal plans, and the power company's contact name and number. Meter location shall be within 75 feet of the vault or cabinet or home run pull box and on the cabinet corner unless otherwise approved.
- 2) In general, circuit breakers and power disconnects should be located internal to service meter assemblies and signal controller cabinets, and should not be readily accessible to the public.
- 3) Typically, the City inspector will be responsible for inspecting service installations and certifying acceptability to the utility company for hook-up. The City Public Works Department shall be responsible for all inspections from the point of connection of power to the inside of the cabinet out through the intersection.

9.14.43 Construction Requirements

9.14.43.1 Scope

This section describes general signal construction requirements for use in the City. Variances from these requirements require the City's written approval.

9.14.43.2 Inspections

- 1) For all City field inspections, the Contractor shall give at least 48 hours' prior notice to the City Public Works Department and the City Building Division for electrical inspections on the City's website. Inspections will normally be completed by City staff or the Contract Administrator.
- 2) The Contractor shall contact the City at least 48 hours prior to placing the pole foundations.
- 3) The Contractor shall notify the City at least 48 hours prior to standing the traffic signal poles.

9.14.43.3 Field Location

- 1) Prior to initiating the traffic signal design, the Contractor's Engineer of Record (or authorized representative) shall schedule and attend a field meeting with the City, or the authorized City personnel and the utility location company, to field locate the signal pole foundation locations and determine the appropriate mast arm lengths.
- 2) All poles, power meters, control cabinets, and pull boxes shall be field located by the City or its designee(s). The Contractor shall contact the City 2 days prior to field location.

9.14.43.4 Signal Turn-on

- 1) Signal heads installed on mast arms, span wires, or poles at new signal locations that are not ready for actual electrical operation shall be bagged with orange plastic.
- 2) Traffic signal construction and all associated work, including operational luminaries, shall be 100% complete prior to flashing operation.
- 3) Immediately prior to signal turn-on, signals shall be flashed from 2 to 5 days, with the exact duration of flashing determined by the City. Mondays, Fridays, and holidays are excluded for start of flash days.
- 4) The Contractor's Project Manager, IMSA Level II Traffic Signal Bench Technician/Signal Technician (BB Certification), Opticom emitter, Foreman (BE Certification), and a bucket truck are required at all signal turn-ons.
- 5) The Contractor must contact the City or the City's authorized personnel 48 hours prior to signal flash. At the scheduled signal flash, the date and time for full operation will be determined. Failure to contact these parties will result in the forfeiture of retainage or liquidated damages equal to retainage.

9.14.43.5 Equipment Condition

- 1) The Contractor shall verify that the traffic signal cabinet is in good condition upon delivery. Any surface areas damaged during the handling and installation shall be repaired immediately per the manufacturer's specifications.
- 2) Prior to the installation of the mast arms and poles, the Contractor shall wipe them clean. Following installation of the poles, the Contractor, shall use factory-supplied paint to touch up nicks and abrasions (refer to Section 9.14.33).

9.14.43.6 Cabinet Base Installation

At the cabinet base location, the Contractor shall install gravel in the excavation for the conduit, set the cabinet base, and fill the riser portion of the base with gravel.

9.14.44 Payment Basis

The accepted quantities will be paid for at the contract unit price for each of the pay items listed in Table 9-13 that appear in the bid schedule.

Table 9-13. Payment Schedule

Pay Item	Unit
Removal of Traffic Signal Equipment	LS
Reset Traffic Signal Equipment	LS
PVC Conduit 2-inch Trenched	LF

Pay Item	Unit
PVC Conduit 2-inch Bored	LF
PVC Conduit 3-inch Bored	LF
Common Trench	LF
Common Boring	LF
PVC Conduit 2-inch (within common boring, trench, or sleeve)	LF
PVC Conduit 3-inch (within common boring, trench, or sleeve)	LF
Traffic Signal Light Pole, xx-foot mast arm without luminaire (Install Only)	EA
Traffic Signal Pole, xx-foot mast arm (Install Only)	EA
Traffic Signal Pedestal Pole (Install Only)	EA
Street Name Signs (Aluminum) or (Illuminated)	EA
Sign Panel (Class I)	EA
Sign Panel (Class II)	EA
Traffic Signal Head, 3-section, 12-inch lenses	EA
Traffic Signal Head, 3-section, 12-inch lenses "Arrow"	EA
Traffic Signal Head, 4-section, 12-inch lenses "Vertical"	EA
Traffic Signal Head, 5-section, 12-inch lenses "Vertical" or "Doghouse"	EA
Pedestrian Head (16-inch) (Countdown)	EA
Pedestrian Push Buttons	EA
Intersection Detection System (Camera)	LS
Microwave Radar Vehicle Detection System	LS
Traffic Signal Controller Cabinet (332D)(with Dual Input File and AUX output file)	EA
Traffic Signal Controller	EA
Uninterrupted Power Source	EA
Fiber-Optic Cable	LF
Fiber Termination	EA
Network switch, power supply and rack mount kit	EA
Test Fiber-Optic Cable	LS
Pull Box (Type I)	EA
Pull Box (Type II)	EA
Pull Box (Type III)	EA
Pull Box (Special)	EA
Emergency Preemption Card	EA

Pay Item	Unit
Emergency Preemption Detector	EA
Radio Communications System	LS
Furnish and Install Electrical Service Connection	LS
Traffic Control, Mobilization, and Start-up	LS
City of Castle Pines Permit	LS
Concrete Sidewalk	SY
Remove Striping and/or surface preparation	LF
10-foot-by-2-foot Crosswalks	LF
Arrows	EA
Onlys	EA
Striping (Double Yellow)	LF
Striping (White)	LF

Notes:

EA = each

LF = linear foot

LS = lump sum

SY = square yard

9.14.45 Pay Item Notes and Clarifications

- 1) Removal pay items shall consist of items in the pay item list or items specifically identified on the plans or in writing by the City. It shall be the Contractor's responsibility to assure that it has a full and complete understanding of included items prior to bidding.
- 2) Removal of traffic signal equipment items shall consist of items in the pay item list or as specifically identified in the plans or in the project special provisions or at a minimum as identified in Section 9.11. It shall be the Contractor's responsibility to assure that it has a full and complete understanding of included items prior to bidding.
- 3) Reset pay items shall consist of items in the pay item list or items specifically identified on the plans or in writing by the City. It shall be the Contractor's responsibility to assure that it has a full and complete understanding of included items prior to bidding.
- 4) Reset of traffic signal equipment items shall consist of items in the pay item list or as specifically identified in the plans or in the project special provisions or at a minimum as specified in Section 9.11. It shall be the Contractor's responsibility to assure that it has a full and complete understanding of included items prior to bidding.
- 5) Common trench is the trench itself not including conduit.
- 6) Common boring is the boring itself not including conduit.
- 7) Conduit shall include signal cable, elbows, pull wire, weatherheads, adaptors, condulets, saw cutting, excavation, backfill, jacking and drilling pits, removal of pavement, sidewalks, gutters, curbs and their replacement in kind to match existing grade and all work necessary to complete the item.

- 8) The cost of the traffic signal light pole/mast arm, traffic signal pole/mast arm, and the traffic signal pedestal pole shall include the cost of the concrete foundations and all items associated with the installation and construction of the foundations, unless the foundations are existing. Refer to the standard details for concrete foundation size requirements.
- 9) Vehicle detection systems, Intersection Detection System (Camera), and Microwave Radar Vehicle Detection System, shall be paid for based on the detector system required to complete the item.
- 10) Fiber-optic cable installation shall include all labor and materials required to install the cable, including, but not limited to, the following items:
 - a) Required splice kits, splicing tools, ancillary hardware and labor to accomplish the splices
 - b) Required patch cords
 - c) Required fan-out kit tools, ancillary hardware, and labor to accomplish the fan-out
- 11) Fiber-optic termination shall include all labor and materials required to terminate the interconnect cable and make a complete and operational system, including, but not limited to, the following:
 - a) Required termination enclosures (including specified features), connectors, adaptors, jumpers, pigtails, ancillary hardware, and labor required to accomplish the termination
 - b) Other work necessary to complete the item
- 12) Test Fiber-Optic Cable – Lump sum includes the complete end-to-end OTDR test on all fiber strands (before and after installation), including document submission and the complete end-to-end optical power meter test on all fiber strands, including document submission.
- 13) Furnish and Install Electrical Service Connection – Lump sum. This information shall be clarified on the plans.
- 14) Striping Material (Crosswalks, Arrows, Onlys, Lines) – Striping materials shall be as determined by City Public Works Department and indicated on the plans.