

Chapter 12. TRAFFIC OPERATION DEVICES

12.1 Introduction

12.1.1 General

The standards contained in this chapter regulate all improvements and private work to be dedicated to the public and accepted by the City and all work within the public Right of Way. They are intended to provide for policies to ensure consistent and proper traffic planning and engineering with required facilities to serve and protect the potential users of the various areas of the community.

The standards in this chapter apply to new developments and capital projects which are not constrained by already existing improvements. This chapter will address in-fill development and projects with some existing infrastructure. Improvements may be required to the existing infrastructure dependent on the change in uses for each development.

12.2 Design Standards

12.2.1 Access Requirements & Criteria

General

New access may occur as one of two types: direct access to individual property (driveway) and new public street access as new intersections:

- For new developments, access is granted through the Planning Commission approval of the Final Development Plan; Planned Development (PD) or subdivision plat.
- New access to City streets from existing developed property is dependent upon zoning.
 - For property classified as a standard zoning district, the application should be made to the Planning and Development Department and accompanied by plans of the proposed access and technical justification for the access and associated public improvements.
 - For Planned Developments, new or altered access shall be obtained through the Planned Development (PD) amendment process. This involves applying through the Planning and Development Department for an amendment to the appropriate PD. The application should be accompanied by appropriate plans for the proposed access and technical justification, including justification for the extent of the improvements proposed at the access point.

12.2.2 Designing Placement of Accesses

Direct Access Restricted

New direct access to individual lots from Arterials is restricted. The City may implement Access Management Plans for Arterials and State Highways to ensure that Arterials are not overly burdened with too many accesses that substantially slow speeds of the Arterials.

Avoiding Conflicts in Center Left Turn Lane

When establishing the placement of offset accesses (either driveways or intersections), ensure that the traffic making left-hand turns into the accesses does not conflict or compete for the simultaneous use of a center left turn lane.

Setbacks from Intersections

When establishing the placement of accesses near intersections, ensure that the distance is sufficient to provide adequate site distance in accordance with these STANDARDS AND SPECIFICATIONS.

Separation Distances

The specific separation distances between accesses shall be as shown in **Chapter 11 – Roadways and Pavement**.

Access Control Plan

For a street controlled by an adopted Access Control Plan, the proposed access shall conform with the applicable Access Control Plan.

12.2.3 Review and Approval

Review Procedure

- **Pre-Application Meeting.** The Planning and Development Staff is available to provide advice on the extent of technical justification required for any access request. It is recommended that this advice be sought prior to submitting any application.
- **Access Approval.** All new access shall be reviewed and approved through the City. Access is granted through the acceptance of the final plat, final construction plans or final site plan. The number and location of access points shall conform to the criteria in this chapter.
- **CDOT Approval for State Highway Access.** The Colorado Department of Transportation shall review and approve all State Highway access. These accesses will be governed by the State Highway Access Code. CDOT will issue the access permits for any approved State Highway approved access.
- **Permit Required.** This approval is finalized through City accepted plans and an approved Right of Way permit. All new accesses can only be constructed after approval of Right of Way permit from the Engineering Division (or CDOT, if required).

12.2.4 Criteria for Access onto Roadways

Access to State Highways

Access to State Highways is governed by the State Highway Access Code, State highway access plans and these Standards. All access issues on state highways within the City of Northglenn shall be submitted to the Colorado Department of Transportation and approved before access permits will be issued by CDOT.

Access to Existing Frontage Roads

Proposed access to all frontage roads shall comply with the requirements of the Colorado Department of Transportation State Highway Access Code, any applicable access control plan and the requirements of these Standards. All access issues on State Frontage Roads within the City of Northglenn shall be submitted to the Colorado Department of Transportation and approved before access permits will be issued by CDOT.

Freeways

Any new freeway access in the City of Northglenn shall meet the requirements of the Colorado Department of Transportation. All design issues shall meet CDOT Standard Specifications.

Arterials

- Private, direct access to arterials shall be permitted only:
 - When the property in question has no other reasonable access to the general street system; or
 - When denial of direct access to the arterial and alternative direct access to another roadway would cause unacceptable traffic operation and safety problems to the overall traffic flow of the general street system.
- When direct private access must be provided, the following shall be considered:
- **Temporary Approval.** Such access shall continue only until such time that some other reasonable access to a lower function category street is available and permitted. The Right of Way permit should specify the future reasonable access location(s), if known, and under what circumstances what changes will be required.
- **Limited Accesses.** No more than one (1) access shall be provided to an individual parcel or to contiguous parcels under the same ownership unless it can be shown that allowing only one access conflicts with safety regulations (i.e., fire access) or if additional access would significantly benefit safety and operation of the Arterial and is necessary to the safe and efficient use of the property.
- **Right Turns Only.** An access shall be limited to right turns only unless it has the potential for signalization, left turns would not create unreasonable congestion or safety problems and lower the level of service, or if alternatives to the left turns would not cause unacceptable traffic operation and safety problems to the general street system.
- **Spacing and Signalization.** Public direct access to arterial where left turns are to be permitted shall meet the signal-spacing criteria of this chapter. Those that do not meet these requirements shall be limited to right turns only, unless they meet the requirements mentioned above. No local streets shall be permitted to intersect arterials.
- In general terms, full access to Arterials shall be limited to one-half (1/2) mile intervals, plus or minus approximately two hundred feet (200'), to achieve good speed, capacity, and optional signal progression.
- To provide flexibility for both existing and future conditions, an approved engineering analysis of signal progression shall be made to properly locate any proposed access that may require signalization.
- **Local Street Access.** No local streets may intersect Arterials.

Collectors

- Private access to collectors shall be governed by the curb opening and driveway criteria.
- Single-family residence access to collectors is not permitted.
- Public streets shall intersect collectors not closer than three hundred and thirty feet (330') from each other (centerline to centerline).

Local

- Private access to local streets shall be governed by the following curb opening and driveway criteria.

- Public streets should not intersect local roadways closer than one hundred and fifty feet (150') from each other (centerline to centerline).

12.2.5 Basic Principles for Curb Openings, & Driveways

General

- **Purpose.** The design of curb openings and driveways within the range of minimum and maximum dimensions will provide for good service on the part of the motorist using the driveway while at the same time minimizing the interference to the traffic using the street.
- By controlling the location and width of openings of driveways along the street, it will be possible to avoid or eliminate long, open stretches where motorists can indiscriminately drive onto the street. The width of opening established in these STANDARDS AND SPECIFICATIONS are based on studies which indicate that the various width openings will accommodate vehicles of maximum size authorized on City streets.
- **Layout Criteria.** The opening or driveway width should be adequate to properly handle the anticipated traffic volume and character of traffic, as well as being within the limits specified for the type of property development. The controls established for curb openings and driveways shall apply to existing streets as well as new streets that may be developed in the future.
- **Site Distance.** All openings for driveways shall be located at the point of optimum sight distance along the street. For openings and driveways to commercial establishments and service stations, there shall be sufficient space reasonably cleared of any obstructions such that drivers entering the property will have sufficient sight distance to enable them to make proper and safe movements. The profile of a driveway approach and the grading of the adjacent area shall be such that when a vehicle is located on the driveway outside the traveled portion of street the driver can see a sufficient distance in both directions to enable him to enter the street without creating a hazardous traffic situation.
- **Adjustments.** Any adjustments which must be made to utility poles, street light standards, fire hydrants, catch basins or intakes, traffic signs and signals or other public improvements or installations which are necessary as the result of the curb openings or driveways shall be accomplished without any cost to the City of Northglenn. Also, any curb opening or driveway which has been abandoned shall be restored by the property owner except where such abandonment has been made at the request of or for the convenience of the City.
- **Signage for Exit and Entrance.** Driveway approaches, whereby the driveway is to serve as an entrance only or as an exit only, shall be appropriately signed by and at the expense of the property owner. The property owner will be required to provide some means of ensuring that the motorists will use the driveway either as an entrance only or an exit only, but not both.

Number of Openings

Single-Family Residential - In general, each single-family residential property shall be limited to one (1) access point.

Multi-Family Residential - In general, access shall be determined by information provided by the Owner/Developer in the traffic impact study and by comments generated during the Engineering Division's review and acceptance of that study.

Commercial - In general, commercial property having less than one hundred and fifty feet (150') of frontage and located mid-block shall be limited to one (1) access point to the street. An exception to this rule may be where a building is constructed in the middle of a lot and parking is provided for on each side of the building. A second access point may

be allowed for commercial property having more than one hundred fifty feet (150') of frontage. For commercial property located on a corner, one (1) access to each street may be permitted.

Service Stations - Where there is sufficient frontage to provide for minimum and maximum requirements, two (2) access points to a street may be permitted.

Industrial - Access shall be determined on a case-by-case basis. The City shall consider good traffic engineering practice and the information provided by the Applicant in the traffic impact study accompanying the submittal. Refer to **Chapter 5- Design Report Requirements**.

Amount of Curb Opening Permitted

The total length of curb opening on a street for access to a commercial property or service station shall not exceed thirty-five feet (35'). This requirement does not apply to residential-type drive cuts.

Entrance Angle

In general, the entrance angle for all driveway approaches shall be as near ninety degrees (90o) to the centerline of the street as possible. The minimum angle which will be permitted is sixty degrees (60o).

Minimum Space Between Openings

The minimum spacing between curb openings shall be thirty-five feet (35') measured at the curb line. This spacing shall apply to double drives that serve a single property, as well as the distance between drives serving adjoining properties. A fifty-foot (50') spacing applies to commercial openings.

Joint Entrances

Whenever possible and feasible, joint entrances shall be provided to serve two adjacent properties. Joint entrances are to be centered on the common property line.

12.2.6 Control Dimensions

To accomplish the objectives of the basic principles stated earlier, certain control dimensions are necessary. There are many variables which affect these control dimensions. Some of the variables are as follows: type of street classification, type of private property development, volume and type of traffic and width of Right of Way.

Width of Curb Opening (W)

The total width of curb opening for properties on various function street classifications shall be in conformance with the Standard Drawings in **Appendix G.4** of these STANDARDS AND SPECIFICATIONS.

Curb openings of thirty-five feet (35') or more shall be constructed as radius curb returns.

- **Residential.** No edge clearance is required for residential access. However, the drive shall not extend beyond the property line extended.
- **Commercial.** Access onto an Arterial -- 75 Feet Minimum. NOTE: Joint access with adjoining property is encouraged. Joint access shall be the only justification for reducing the minimum edge clearance dimension.
- **Corner Clearance.** It is important to locate driveways away from major intersections. This constraint is as much for the ability to enter and leave the property as for the benefit of intersection safety and

operations. Exiting a driveway during peak-hour conditions at traffic signals is difficult where the queue of standing or slow-moving vehicles never allows a sufficient gap for entry from the driveway.

- **Sight Distance.** Sight distance for curb openings to private property shall be in accordance with CDOT Requirements and **Chapter 11 – Roadways and Pavements** of these STANDARDS AND SPECIFICATIONS.

12.2.7 Street Lighting & Street Lighting Procedure

The Developer/Designer shall submit a written request for street light design to the relevant power authority. The relevant power authority will submit the final design and cost estimates to the Engineering Division for review and approval. Developer will pay the relevant power authority the total costs of installation for all street lighting within the prescribed time period. Developer will be responsible for street lighting within the development as well as on side streets surrounding the development site.

12.3 Traffic Signal Specifications

12.3.1 General Requirements

Scope and Intent

These specifications describe the installation of necessary material, equipment, and work procedures to complete traffic signals and/or other electrical systems, for projects in the City of Northglenn. These specifications provide minimum functional requirements that must be satisfied for all such work. Contractor as specified herein shall be defined as the individual, firm, or corporation who undertakes responsibility for the execution of the work, including the provision of labor and materials, in accordance with the terms of the contract specifying cost and schedule for completion of the work.

Permits

For all work within the City of Northglenn Right of Way, the Contractor shall obtain a Right of Way Use Permit from the Engineering Division. For new installations, the Contractor shall also obtain an electrical permit through the Building Department.

Inspections

For all required inspections, the Contractor shall give at least 48 hours' prior notice to the Engineering Division. Inspections will be completed by the Engineering Division except the electrical permit that is inspected through the Building Department.

Access

The Contractor will be required to maintain access to all roads and driveways throughout the period of construction.

Testing

The Contractor shall retain the services of an independent testing lab to perform all material testing, including but not limited to concrete, asphalt, and soils.

Field Location

The Contractor shall field survey all proposed poles, control cabinets, pull boxes, and pole foundations. The Engineering Division will field verify the proposed equipment locations before final placement.



Equipment Salvage

Unless otherwise specified, all traffic signal equipment which is removed shall remain the property of the City. Such property is to be removed from the work site and returned by the Contractor to the City of Northglenn at a City specified location.

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. At all times, the Contractor shall maintain a minimum of two three section (red, yellow, and green) traffic signal heads for each roadway approach. These displays, and all other signal elements, shall be in conformance with the MUTCD.

Intersection Power

Unless otherwise directed in the plans, the Contractor shall be responsible for coordinating with the local electric company to obtain power hook-up to the intersection in a timely fashion. The City's Building Division shall inspect all installations prior to meter installations.

Utilities

Utilities will be shown on the plans to the extent that they can be identified, based upon 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, etc., and ensure that they are properly protected and that signal equipment locations are adjusted accordingly.

Job Site Supervision

At all times, all workers shall wear appropriate clothing and safety equipment and conduct themselves in a safe manner. An International Municipal Signal Association (IMSA) Level II supervisor shall be on-site when any work is performed in the controller cabinet.

12.3.2 Regulations & Codes

Reference Documents

All equipment and material shall conform to these standards: Colorado Department of Transportation (CDOT), the Institute of Transportation Engineers (ITE) or IMSA, whichever is applicable. In addition to requirements of all these specifications, the plans, standard details, and the special contract provisions, all material and work shall conform to the requirements of the MUTCD, the Rules for Overhead Electrical Line Construction of the Colorado Public Utilities Commission (Rules), the standards of the American Society for Testing and Materials (ASTM) and of the American National Standards Institute (ANSI), and local ordinances which may apply. The City shall have final authority on specifications.

12.3.3 Underground Facilities

Foundations

Concrete foundations shall be Class BZ per the Colorado Department of Transportation, Supplemental Specifications to Standard Specifications for Road and Bridge Construction, most recent edition. The bottom of concrete foundations shall rest on firm ground. Cast-in-place foundations shall be poured monolithically where practicable. The exposed portions shall be formed to present a neat appearance. Forms shall be true to line and grade. Tops of foundations, except as noted on plans, shall be finished to curb or sidewalk grade or as shown on the accepted construction plans or as directed by the Engineering Division. Forms shall be rigid and securely braced in place and inspected prior to the pouring of concrete. Conduit ends and anchor bolts shall be placed in proper position and in a template until the concrete sets. Forms shall be completely removed prior to signal turn on. 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. 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 90-150 psi flow fill concrete, and then backfilled to ground level with native material compacted per the Engineering Division. Any abandoned foundation shall be fully or partially removed and disposed of by the Contractor per the Engineering Division direction. Any conduit runs associated with an abandoned foundation shall be extended or abandoned as called for on the accepted construction plans.

Conduit

All cables and conductors not shown on the plans as aerial cable shall be installed in conduit unless installed in poles, pedestals, cabinets, or mast arms. All buried conduit shall be PVC Schedule 80 or heavier. All exposed conduit shall be galvanized, rigid, ductile steel. The conduit schedule as shown below (Table 12.1) shall be in effect unless otherwise specified in the plans:

Table 12.1: Conduit Schedule

Run Type	Quantity	Size	Use
Street Crossings	1	3"	120 voltage load wiring
	1	3"	Low voltage detection & communications
	1	2"	Luminaire load
Signal Pole	1	3"	All signal cables
	1	2"	Luminaire load
Controller Cabinet	2	3"	120 voltage load wiring
	3	2"	Low voltage detection & communications
Interconnect	1	2"	Interconnect run & communications
Service Points – Signal & Luminaire Power	1	2"	Utility company service run

The Contractor, at its sole expense, may use larger conduit if desired. Where larger conduit is used, it shall be for the entire length of the run. No reducing couplings will be permitted underground.

The ends of all metal conduit, existing or new, shall be well reamed to remove burrs and rough edges. Field cuts of existing or new conduit shall be made square and true, and the ends shall butt together for the full circumference. 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 up tight until the ends of the metal conduits are brought together.

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.

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

All conduit shall terminate in a pull box or pedestal and extend approximately two inches above the rock bedding vertically.

All conduit runs shall have a continuous 3/8-inch nylon mule tape pulled into the conduit along with the specified electrical cables. The line shall be firmly secured at each end of the conduit run with a minimum slack of three feet.

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

Any spare or unused conduits shall be sealed with duct seal and shall include continuous 3/8-inch nylon mule tape.

Pull Boxes

Pull boxes shall be 20k polymer concrete Quazite® pull boxes (with open bottoms), or approved equivalent (ANSI Tier 15).

Pull boxes shall be installed at all locations shown on the accepted construction plans and at such additional points as directed by the Engineering Division.

Pull boxes shall be installed so that the covers are level with curb or sidewalk grade or level with the surrounding ground (as applicable). The bottoms of all pull boxes shall be bedded in crushed rock or squeegee – 6” thick minimum.

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 eighteen inches (18”) below the pull box bottom and enter from the direction of the run.

Stop Line Detection

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.

Vehicle Loop Detectors

Each individual loop detector is to be terminated and spliced within a side-of-road pull box. Each loop detector shall consist of one continuous wire, without splicing, to this termination point. Any required series or parallel connections are to be completed at the termination point. Detector lead-in wire shall be continuous from the controller cabinet 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. Loop sealant is required in all saw cuts whether or not the roadway is to be overlaid. The use of preformed loop detectors shall not be allowed.

Grounding and Bonding

Bonding and Grounding. Metallic cable sheaths, conduit, metal poles and pedestals shall be made mechanically and electrically secure to form a continuous system and shall be effectively grounded.

Bonding and grounding jumpers shall be a #6 AWG bare copper wire or copper strap of the same cross-sectional area.

Sheath for detectors shall be grounded in control cabinet only. The other end of the sheath shall be taped and left ungrounded.

A ground electrode shall be installed at each pole, pedestal, and control box. Each ground electrode shall be one-piece copper-weld rod of 5/8 inch diameter and 8 feet in length, driven to a depth of at least 8 feet below the surface of the ground.

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.

12.3.4 Conductor & Cable

General

Signal cables shall conform to the appropriate IMSA specifications. Wiring within cabinets, junction boxes, etc., shall be neatly arranged and tagged.

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

At least five feet (5') of slack shall be left for each conductor at each support pole.

Splices will not be allowed in pull boxes except for luminaires. Splices shall be kept to a minimum and will only be allowed in handholes 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 utilize copper crimp sleeves that compress from four directions; for example, those manufactured by the Buchanan Company. The crimped sleeve shall then be protected within a flexible rubber insulating cover (Ideal Wrap Cap)

When conductors and cables are pulled into the conduit, all ends of the conductors and cables shall use duct seal 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.

A small permanent tag on which the direction and phase is printed, using the codes given in section 12.3.4.2 Conductor Schedule below, shall be securely attached near the end of each conductor at each controller and signal pole.

Conductor Schedule

Detector conductors shall be tagged at their ends with color-coded electrical tape following the below schedule, including the movement “Codes” (e.g., “1-NBLT”).

Table 12.2: 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”

Note: x = phase number. This is a typical conductor schedule and shall be used for the wiring of all signal installations. A new conductor schedule will be noted on the plans at each intersection where different phasing and/or special equipment is required. It should be noted that a band of white is used to indicate a left turn, and yellow is used for pedestrian movement.

Each pedestrian push button shall have a dedicated wire pair lead-in to the controller cabinet. Where included in the plans. Separate luminaire wire shall be two conductors, black and white in color with ground.

Signal heads mounted on mast arms are to be wired individually from the head to the handhole splice. At least three (3) spare conductors shall be provided from the controller cabinet to the handhole of each signal pole.

12.3.5 Signal Start-Up Procedures

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

Immediately prior to signal turn-on, signals shall be flashed from two to five days, with the exact duration of flashing determined by the Engineering Division.

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 twenty days of continuous, satisfactory operation commencing with full operation of all electrical facilities.

During the twenty-day period, the Contractor shall maintain the system or systems. The cost of any maintenance necessary, except electrical energy and maintenance due to damage by public traffic, shall be borne by the Contractor and will be considered as included in the price paid for the contract item involved, and no additional compensation will be allowed.

12.3.6 Maintenance

Maintenance During Construction

The Contractor shall have full maintenance responsibility of the traffic signal from the time of the Notice to Proceed (or Pre-Construction Meeting) to the date of written acceptance of the work performed. Continuous maintenance and emergency service shall be provided by the Contractor twenty-four (24) hours each day during the time-period defined above. The Contractor shall provide and maintain a 24-hour continuous telephone answering service with one number.

Emergency and Non-Emergency Repairs

During the period of full maintenance responsibility, 1) all hazardous conditions or 2) all malfunctions of a controller and its accessory equipment following turn-on shall be considered an emergency unless otherwise identified by the Engineering Division. Site conditions, equipment malfunctions and/or damage, which in the opinion of the Engineering Division constitutes a serious hazard or inconvenience to the public, shall be considered an emergency. Such malfunctions or damage may include, but not necessarily be limited to, situations such as:

- all indications are out, including bulbs and lenses, for any one traffic movement
- signal heads give conflicting indications to any intersection approach or approaches
- a signal has been knocked down

The Contractor shall dispatch personnel to ensure each such repair is underway no later than two hours after the City notifies the Contractor of the emergency. In instances of repairs that are of a non-emergency nature, such repairs shall be undertaken at the site within two working days after the City notifies the Contractor of the needed repair.

Should the Contractor fail to perform any maintenance responsibilities within the prescribed time periods, the Engineering Division shall perform said maintenance work. The Contractor shall reimburse the City for labor and equipment charges associated with the repair plus the City's administration fee.

12.3.7 Traffic Signal Material Specifications

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 Vehicle Traffic Control Signal Heads standard.

Mounting hardware shall be Sky Bracket type. Visors shall be the detachable tunnel type, polycarbonate, black in color, and twelve (12") inches in length. All faces shall be LED inserts.

Doors on the signal heads for the installation of lamps and lens replacement or other maintenance shall not require use of any tool to be opened. Doors and lenses shall be equipped with neoprene weatherproof gaskets to insure against infiltration of moisture, road film, and dust. Each three-color signal unit shall have the socket leads from all signal sections connected to a terminal board stamped with identifiable terminals. There shall be a terminal for color indication plus a common terminal where one lead from each socket shall terminate. The terminal board shall be mounted in the middle section and be fully insulated. Gaskets shall be supplied for top and bottom openings.

Backplates shall be required for all mast arm signal faces. Backplates shall be yellow in color, louvered aluminum, and five inches (5") in width and have a one inch (1") yellow reflective strip around the outside perimeter.

Pedestrian Signal Head

Pedestrian signal heads shall be sixteen (16") inch, aluminum and shall be adjustable with respect to positioning. Heads shall be provided without egg crate visors. Heads shall be black in color and shall meet the requirements of the latest version of the ITE Pedestrian Traffic Control Signal Indications standard. Pedestrian inserts shall be LED, filled "countdown" style GE Model GT1 or approved equivalent. "Walk/Don't Walk" indications shall be the symbol type, with a minimum height of eleven inches (11"). "Countdown" numerals shall have a minimum height of nine inches (9"). Doors and lenses shall be installed with weatherproof gaskets.

Traffic Signal Lamp

All permanent and temporary traffic signal applications will require LED lamps. Red, yellow, and green signal sections shall be twelve inches (12") in diameter in all cases. All circular and arrow red, yellow, and green signals and pedestrian ("hand" and "walkman") indications shall use LEDs. Traffic signal section optical units shall meet or exceed ITE Adjustable Face Vehicular Traffic Control and Pedestrian Signal Head standards. In addition to this, LED optical units shall conform to CDOT Standard Specifications for Road and Bridge Construction, latest edition, Section 713.

Electrical Cable

All electrical cable shall be in conformance with the CDOT Standard Specifications for Road and Bridge Construction, latest edition, Sections 614 and 713.

Signal cable shall be multi-conductor, stranded, copper wire manufactured to meet IMSA Specification 19-1 or 19-2. Each conductor in the cable shall be individually insulated and rated at 600 volts.

Traffic Signal Communication

The Traffic Signal may be connected to the Engineering Division's traffic signal communications system as specified in the project plans. The traffic signal communication system shall be easily maintained and compatible with the City's current traffic signal management software system.

The traffic signal communication system shall be approved by the City of Northglenn prior to showing in the project plans and shall consist of one of the following communication types:

- Fiber optic communication
- Cellular communication
- Ethernet communication
- Radio communication

The Contractor will be responsible for verifying that the traffic signal communication properly connected, terminated and integrated with the City's Traffic Signal Management Software in the City's Engineering Division.

Fiber Optic Cable

Fiber optic cable shall be loose-tube all-dielectric outdoor cable consisting of twelve single-mode fibers and complying with the following specification for fiber optic cable. Fiber optic cable installation in conduit shall meet applicable portions of IMSA Specification 60.2 or approved equal and include a 14-gauge (min) copper tracer wire. All fiber optic cable runs shall include nylon mule tape. Extra length of fiber optic cable shall be provided with fifty feet (50') of slack in the controller cabinet and twenty-five feet (25') of slack in each pull box.

General Considerations

- The fiber optic cable shall meet all requirements stated in the specification. The cable shall be an accepted product of the United States Department of Agriculture Rural Electrification Administration (REA) as meeting requirements of 7CFR1755.900.
- The cable shall be new, unused, and of current design and manufacture.

Fiber Characteristics

- All fibers in the cable must be usable fibers and meet this specification.
- All optical fibers shall be sufficiently free of surface imperfections and inclusions to meet the optical, mechanical, and environmental requirements of this specification.
- Each optical fiber shall consist of a doped silica core surrounded by a concentric silica cladding.
- The single-mode fiber utilized in the cable specified herein shall conform to the following specifications:
 - Typical Core Diameter: 8.3 μm
 - Cladding Diameter: 125 +/- 1.0 μm
 - Core to Cladding Offset: $\leq 0.8 \mu\text{m}$
 - Cladding Non-Circularity: 1.0%. Defined as: $[1 - (\text{min. Cladding dia.} + \text{max. Cladding dia.})] \times 100$
 - Coating Diameter: 245 $\pm 10 \mu\text{m}$
 - Attenuation Uniformity: No point discontinuity greater than 0.10 dB at either 1310 nm or 1550 nm
 - Attenuation at the Water Peak: The attenuation at 1883 $\pm 3 \text{ nm}$ shall not exceed 2.1 dB/km

- Cutoff Wavelength: The cabled fiber cutoff wavelength shall be ≤ 1250 nm.
- Mode-Field Diameter (Petermann II):
 - 12.30 ± 0.50 μm at 1310nm
 - 10.50 ± 1.00 μm at 1550nm
- Zero Dispersion Wavelength (λ_0): $1301.5 \text{ nm} \leq (\lambda_0) \leq 1321.5 \text{ nm}$
- Zero Dispersion Slope (S_0): $\leq 0.092 \text{ ps}/(\text{nm}^2 / \text{km})$
- The coating shall be a dual layered, UV cured acrylate applied by the fiber manufacturer.
- Coating shall be mechanically strippable without damaging the fiber.

Fiber Specifications Parameters

All fibers in the cable shall meet the following requirements:

- When tested in accordance with FOTP-3, Procedure to Measure Temperature Cycling Effects on Optical Fiber, Optical Cable, and Other Passive Fiber Optic Components, (single-mode only), the average change in attenuation at extreme operational temperatures (-40°C to $+70^\circ\text{C}$) shall not exceed 0.05 dB/km at 1550 nm. The magnitude of maximum attenuation change of each individual fiber shall not be greater than 0.15 dB/km at 1550 nm.
- Required fiber grade = Maximum Individual Fiber Attenuation.
- The maximum dispersion for single-mode optical fibers shall be $\leq 3.3 \text{ ps}/(\text{nm km})$ for 1285 nm through 1330 nm and $\leq 18 \text{ ps}/(\text{nm km})$ at 1550 nm.

Specifications for Outdoor Cables

- Optical fibers shall be placed inside a loose buffer tube.
- Each buffer tube shall contain up to 6 fibers.
- The fibers shall not adhere to the inside of the buffer hole.
- Each fiber shall be distinguishable from the others by means of color coding according to the following:
 - Blue
 - Orange
 - Green
 - Brown
 - Slate

- White

These colors shall meet EIA/TIA-598, Color Coding of Fiber Optic Cables.

- Buffer tubes containing fibers shall also be color-coded with distinct and recognizable colors according to the following:
 - Blue
 - Orange
 - Green
 - Brown
 - Slate
 - White
 - Red
 - Black
 - Yellow
 - Violet
 - Rose
 - Aqua

These colors shall meet EIA/TIA-598, Color Coding of Fiber Optic Cables.

- Buffer tubes containing multiple fibers, the colors shall be stable during temperature cycling and not subject to fading or smearing onto each other or the gel filling material. Colors shall not cause fibers to stick together.
- Buffer tubes shall be of a dual-layer construction with the inner layer made of polycarbonate and the outer layer made of polyester.
- Fillers may be included in the cable core to lend symmetry to the cable cross section.
- The central anti-buckling member shall consist of a glass reinforced plastic rod. The purpose of the central member is to prevent buckling of the cable.
- Each buffer tube shall be filled with a non-hygroscopic, non-nutritive to fungus, electrically non-conductive, homogeneous gel. The gel shall be free from dirt and foreign matter. The gel shall be readily removable with conventional nontoxic solvents.
- Buffer tubes shall be stranded around a central member using the reverse oscillation, or “SZ” stranding process.

- The cable core interstices shall be filled with a water-blocking compound. The compound shall be a thixotropic gel containing a Super Absorbent Polymer (SAP) material. The gel shall be non-nutritive to fungus, electrically non-conductive and homogeneous. The gel shall be free from dirt and foreign matter and shall be readily removable using nontoxic solvents.
- Binders shall be applied with sufficient tension to secure buffer tubes to central member without crushing the buffer tubes. Binders shall be non-hygroscopic, non-wicking (or rendered so by the flooding compound), and dielectric with low shrinkage.
- The cable shall contain at least one ripcord under the sheath for easy sheath removal.
- Tensile strength shall be provided by high tensile strength aramid yarns and/or fiberglass yarns.
- The high tensile strength aramid and/or fiberglass yarns shall be helically stranded evenly around the cable core.
- All dielectric cables (with no armoring) 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 flooding compound. The polyethylene shall contain carbon black to provide ultraviolet light protection and shall not promote the growth of fungus.
- The jacket or sheath shall be free of holes, splits and blisters.
- The cable jacket shall contain no metal elements and shall be of a consistent thickness.
- Cable jackets shall be marked with sequential meter or foot markings, year of manufacture and a telecommunications handset symbol, as required by section 350G of the National Electric Safety Code. The actual length of the cable shall be within 0 to 1% of the length markings. The marking shall be in contrasting color to the cable jacket. The height of the marking shall be approximately 2.5 mm. The maximum pulling tension shall be 2,700 N (608 lbf) during installation (short term) and 890 N (200 lbf) long term installed.
- The shipping, storage, and operating temperature range of the cable shall be -40°C to +70°C. The installation temperature range of the cable shall be -30°C to 70°C.

General Cable Performance Specifications

- The unaged cable shall withstand water penetration when tested with a one-meter static head or equivalent continuous pressure applied at one end of a one-meter length of filled cable for 24 hours. No water shall leak through the open cable end. When a one-meter static head or equivalent continuous pressure is applied at one end of a one-meter length of aged cable for one hour, no water shall leak through the open cable end. Testing shall be done in accordance with FOTP-82, "Fluid Penetration Test for Filled Fiber Optic Cable."
- When tested in accordance with FOTP-81, Compound Flow (Drip) Test for Filled Fiber Optic Cable, Method A; 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 g (0.002 ounce).
- The cable shall withstand a minimum compressive load of 220 N/cm for non-armored cables applied uniformly over the length of the compression plate. The cable shall be tested in accordance with FOTP-41, Compressive Loading Resistance of Fiber Optic Cables, 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 attenuation greater than 0.1 dB at 1500 nm (single mode). The average increase in attenuation for the fibers shall be < 0.20 dB at 1300 nm (multimode). 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.

- When tested in accordance with FOTP-104, Fiber Optic Cable Cyclic Flexing Test, 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 1550 nm. The repeatability of the measurement system is typically ± 0.05 dB or less. The cable jacket shall not exhibit evidence of cracking or splitting when observed under 5x magnification.
- When tested in accordance with FOTP-25, Repeated Impact Testing of Fiber Optic Cables and Cable Assemblies, cable shall withstand 25 impact cycles. Magnitude of the attenuation change shall be within repeatability of measurement system for 90% of test fibers. The remaining 10% of the fibers shall not experience attenuation change greater than 0.1 dB at 1550 nm. The repeatability of measurement system is typically ± 0.05 dB or less. The cable jacket shall not exhibit evidence of cracking or splitting at the completion of the test.
- When tested in accordance with FOTP-33, Fiber Optic Cable Tensile Loading and Bending Test, using a maximum mandrel and sheave diameter of 560 mm, the cable shall withstand a tensile load of 2700 N (608 lbf) applied for one hour (using Test Condition II of the procedure). In addition, cable sample, while subjected to a minimum load of 2660 N (600 lbf), shall be able to withstand twist of 360 degrees in a length of 115 inches. Magnitude of attenuation change shall be within repeatability of the measurement system for 90% of the test fibers. Remaining 10% of the fibers shall not experience an attenuation change greater than 0.1 dB at 1550 nm. 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 of 890 N (200 lbf).
- When tested in accordance with FOTP-85, Fiber Optic Cable Twist Test, a length of cable no greater than 2 m will withstand 10 cycles of mechanical twisting. The magnitude of the attenuation change will be within the limit of 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 1550 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 5x magnification following completion of the test.
- When tested in accordance with the proposed FOTP-181, Lightning Damage Susceptibility Test for Optic Cables with Metallic Components, the cable shall withstand a simulated lightning strike with a peak value of the current pulse ≤ 105 kA. The test current used shall be damped oscillatory with a maximum time-to-peak value of 15 μ s (which corresponds to a minimum frequency of 16.7 kHz and a maximum frequency of 30 kHz). The time to half-value of the waveform envelope (t_2) shall be 40-70 μ s. In addition to the analysis criterion set forth on FOTP-181, the integrity of the buffer tubes (or analogous loose tube, i.e. core tube) and strength members must be intact after removal of the cable specimens from the test box.

Quality Assurance Provisions

- All optical fibers shall be proof tested by the fiber manufacture at a minimum load of 100 ksi.
- All optical fibers shall be 100% attenuation tested. The attenuation of each fiber shall be provided with each cable reel.



Packaging

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

Miscellaneous

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

The Contractor shall provide the Engineering Division with two copies of the cable manufacturer's installation instructions for fiber optic cable in conduit or provided electronically in a PDF file. The bend radius shall be maintained at a minimum of twenty times the outside diameter of the cable during installation. After installation, the bend radius shall be maintained a minimum of ten times the outside diameter of the cable. Additional cable costs due to damage caused by the Contractor's neglect of recommended procedures shall be the responsibility of the Contractor.

Single-mode fiber optic cable shall be installed in continuous runs between controllers. The manufacturer's recommended limits for cable lengths shall not be exceeded. Cable ends shall be stored in controller cabinets or pull boxes immediately adjacent to cabinets or as directed by the Engineering Division. All fibers shall terminate to a rack mounted patch panel.

Under no conditions shall single mode fibers be cut out or spliced at intermediate points without express written direction from the Engineering Division.

Prior to installation of interconnect cable, the Contractor shall submit an interconnect schematic diagram to the City for approval. The diagram shall clearly indicate cable routing, splice points, and fiber connections including identifying the color-coded fibers and buffer tubes. Installation of the cable will not be permitted until the schematic diagram has been approved by the Engineering Division.

The same color-coded pairs of fibers and/or wires shall be used throughout the entire project. At the terminal points the jackets shall be stripped and the ends taped. Gel filling compound shall be removed using filled cable cleaner.

For all fiber optic cables, each fiber shall be checked with an Optical Time Domain Reflectometer (OTDR) and full traces documenting fiber performance shall be provided to the City within thirty (30) days of test. All optical fibers shall be within the manufacturer's recommended tolerances. In addition, any other acceptance testing recommended by manufacturer shall be provided. Data shall be supplied to the Engineering Division prior to completion of the project.

If the fiber cable reel is left outside overnight during installation, the Contractor shall provide security for the cable.

The Contractor shall keep a log that notes the meter (foot) marking on the cable at every pull box to facilitate determining the exact location along the cable run of problems during the OTDR testing.

Fiber Optic Cable

Fiber Optic Cable Testing of single-mode (SM) fiber optic cable shall include both new cable and existing cable. The test procedures involve an OTDR test and an Optical Power Meter Test.

The guidelines for fiber optic cable testing include:

- Test jumpers and patch cords must be of the same fiber core size and connector type as the cable system (SM fiber 8.3/125 μm)
- The light source and OTDR must operate within the range of 1310 \pm 10 nm or 1550 \pm 10 nm for SM testing in accordance with ANSI/EIA/TIA-526-7.
- The power meter and the light source must be set to the same wavelength during testing.
- The power meter must be calibrated and traceable to the National Institute of Standards and Technology (NIST).
- All system connectors, adapters, and jumpers must be cleaned as per the manufacturer's instructions before measurements are taken.

Materials

The following items are required to perform fiber optic cable tests:

- An OTDR
- A test reel, if necessary
- A light source at the appropriate wavelength
- Optical power measurement equipment
- Test jumpers as specified below:
 - CPR Test Jumper-1 and Jumper-2 shall be 1-5 meters long with connectors compatible with the light source and power meter and have the same fiber construction as the link segment being measured.

Fiber Optic Cable Testing with Optical Time Domain Reflectometer

- The Contractor shall perform an OTDR test of all fibers in all tubes on the reel prior to installation of the fiber. The Test results shall be supplied to the City prior to installation of the cable.
- If the fiber is specified as "Install Only," the Contractor shall test the fiber on the reel and provide the test results to the City prior to accepting the cable. After installation, if there are unused portions of cable remaining on the reel, the Engineering Division may request the Contractor or other qualified technician to perform a reel test. The Contractor shall provide the Engineering Division the test results prior to delivering the cable to the Engineering Division. Any cable damaged while in the Contractor's possession shall be replaced at the Contractor's expense.
- All fiber testing shall be performed on all fibers in the completed end-to-end system. Testing shall consist of a bi-directional, end-to-end OTDR trace performed per TIA/EIA-455-61. The system margin loss measurements shall be provided at 1310 nm and 1550 nm. If the plans require installation of a fiber optic patch panel, the Contractor shall supply patch cords to patch all terminated fibers through the panel for all fiber testing. If patch cords are specified in the plans for final equipment installation, these patch cords shall be connected using a test coupling for the end-to-end test.

- OTDR readings will be used to ensure proper installation and to troubleshoot faults. OTDR signature traces will be used for documentation and maintenance. An OTDR provides an indirect estimate of the loss of the cable plant, generally, more accurate or reliable values will be obtained by using an Optical Power Meter. For fibers that are identified in the plans to be left non-terminated, an OTDR shall be used to test end-to-end attenuation.
- Loss numbers for the installed link shall be calculated by taking the sum of the bi-directional measurements and dividing that sum by two.
- The Contractor shall use an OTDR that is capable of storing traces electronically and shall save each final trace.
- To ensure the traces identify the end points of the fiber under test and the fiber designation, the Contractor shall use a test reel, if required, to eliminate the “dead zone” at the start of the trace so that the start of the fiber under test can be identified on the trace. Indicate the length of the test reel for all test results.
- If the fiber designation is not indicated on the trace itself, the Contractor shall provide a cross-reference table between the stored trace file name and the fiber designation.
- In compliance with EIA/TIA-455-61 “Measurement of Fiber or Cable Attenuation Using an OTDR”, the Contractor shall record the following information during the test procedure:
 - Names of personnel conducting the test
 - Type of test equipment used (manufacturer, model, serial number, calibration date)
 - Date test is being performed
 - Optical source wavelength and spectral width
 - Fiber identification
 - End point locations
 - Launch conditions
 - Method of calculation for the attenuation or attenuation coefficient
 - Acceptable link attenuation

The complete end-to-end OTDR test on one fiber, including document submission, represents one OTDR test.

Fiber Optic Cable Testing with Optical Power Meter

- 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 1310 nm and 1550 nm wavelength.
- In compliance with TIA/EIA-526-7, Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant, the following information shall be recorded during the test procedure:
 - Names of personnel conducting the test

- Type of test equipment used (manufacturer, model, serial number, calibration date)
 - Date test is being performed
 - Optical source wavelength and spectral width
 - Fiber identification
 - 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
- The minor attenuation differences due to test direction are on par with the accuracy and repeatability of the test method. Lateral segments within a building are limited to 90 meters. Therefore, the attenuation differences caused by wavelength are insignificant, and as a result, single wavelength testing is sufficient.
 - The complete end-to-end optical power meter test on one fiber, including document submission, represents one optical power meter test.

Acceptable Attenuation Values

- Acceptable attenuation values shall be calculated for each fiber tested. These values represent the maximum acceptable test values.
- The general attenuation equation for any SM link is as follows:

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

- 8.3 μm Single-mode Attenuation Coefficients:
 - Cable Attn. = Cable Length (km) x (0.34 dB/km@1310 nm or 0.25 dB/km@1550 nm)
 - Connection Attn. (ST or SC connectors) = (No. of Connections x 0.39 dB) + (0.42 dB)
 - Connection Attn. (LC connectors) = (No. of Connections x 0.14 dB) + (0.24 dB)
 - Splice Attn. (Mechanical or Fusion) = Splices x 0.30 dB

Test Procedures

- All fiber testing shall be performed on all fibers in the completed end-to-end system.
- The SM Optical Power Meter fiber test shall be conducted as follows:
 - Clean the test jumper connections and the test coupling per manufacturer's instructions.

- Follow the test equipment manufacturer's initial adjustment instructions.
- Connect Test Jumper-1 between the light source and the power meter. Avoid placing bends in the jumper that are less than 100 mm (4inches) in diameter.
- If the power meter has a Relative Measurement Mode, select it. If it does not, reduce the Power Meter Measurement (Pref). If the meter can display power levels in dBm, select this unit of measurement to simplify subsequent calculations.
- Disconnect Test Jumper-1 from the power meter. Do NOT disconnect the test jumper from the light source.
- Attach Test Jumper-1 to one end of the cable plant to be measured and Test Jumper-2 to the other end.
- Record the Power Measurement (Psum). If the power meter is in Relative Power Measurement Mode, the meter reading represents the true value. If the meter does not have a Relative Power Measurement Mode, perform the following calculation:
 - If Psum and Pref are in the same logarithmic units (dBm, dBu, etc.): $CPR (dB) = Psum - Pref$
 - If Psum and Pref are in watts: $CPR (dB) = 10 \times \log_{10}[Psum / Pref]$

Test Acceptance

- The Contractor shall demonstrate that each Optical Power Test results in acceptable attenuation values.
- The Contractor, solely at the Contractor's cost, shall remake any fusion splices that have test results exceeding acceptable attenuation values.
- The Contractor, solely at the Contractor's cost, shall retest any fiber links that have been re-spliced.
- The Contractor, solely at the Contractor's cost, shall bring any link not meeting the requirements of this specification into compliance.

Submittals

- The Contractor shall submit test results documentation as both a hard copy and an electronic copy (PDF file format) to the Engineering Division.
- After each test reel, the Contractor shall submit one hard copy of the OTDR trace for every fiber on the reel. After installation, the Contractor shall submit one hard copy of the OTDR trace for every spliced fiber. Hard copy traces shall be organized and bound in logical order in an 8.5" x 11" hard cover binder.
- The Contractor shall submit, after approval of the hard copy traces, electronic copies of all traces and appropriate software to allow reading the traces.

Fiber Optic Cable Termination

- Color-coded pairs of fibers shall be used for all installations. At the terminal points, the jackets shall be stripped and the ends taped. Gel-filled compound shall be removed using the filled cable cleaner.

- At every cabinet or closure, only fibers shown to be spliced and/or connectorized and connected to a patch panel or other internal device are required to be landed. All cut or unconnectorized fibers shall be sealed in a manner recommended by the cable manufacturer.
- The same color-coded pairs of fibers and/or wires shall be used throughout the entire project. At the lateral cable terminal points, the jackets shall be stripped and the ends shrink-tubed. Gel filling compound shall be removed using the filled cable cleaner.
- The Contractor shall terminate the loose-tube lateral cable at the controller using a buffer tube fan-out kit, Siecor Catalog FAN-BT or approved equal. Fanned-out cables shall be terminated in the contractor furnished termination enclosure as shown in the plans.
- The fiber optic patch cord cables shall consist of SM fibers housed individually in protective jackets. Both ends of the cable shall be connected. Fiber optic patch cord cable shall be suitable for operation over a temperature range of -30°C to +60°C. Fiber optic patch cord cables shall be of sufficient length to be connected between the interconnect panel and the communications equipment (i.e., modems). Appropriate strain relief in the cabinet (through cable ties) shall be installed at a minimum of three locations. Sufficient slack shall be left to allow relocation of the equipment anywhere in the cabinet. The attenuation of a fiber optic patch cord cable after installation, not including the connector loss, shall not exceed 0.1 dB measured at 1310 nm and 1550 nm.
- The connector shall have a ceramic ferrule with a nickel-plated nut and body. The connector shall be an AT&T ST-style compatible field mounted connector. The connector shall be compatible with a physical contact (PC) finish. All connectors shall be polished to a PC finish such that the return loss per mated pair of connectors is at least 25 dB. The return loss when the connector is mated with previously installed connectors shall be at least 18 dB. The connector mean loss shall not be greater than 0.3 dB with a standard deviation of not greater than 0.2 dB. The connector loss shall not vary more than 0.2 dB after 1000 repeated matings and shall withstand an axial load of 135 N.
- Index matching fluids or gels shall not be used. The connectors shall be compatible with the optical fiber surrounding the jacket and shall be installed on one end of the optical fiber in accordance with the manufacturer's recommended materials, equipment, and practices. The connector shall be suitable for the intended environment and shall meet the following environmental conditions:
 - Operating Temperature: -20° to +50°C
 - Storage Temperature: -30° to +60°C
- The connector loss shall not vary more than 0.2 dB over the operating temperature range. Connectors shall be protected by a suitably installed waterproof protection cap.
- Each cabinet to be interconnected shall include slot-mountable interconnect center(s). They are to be complete with connector panels of suitable capacity for all lateral cables. Each interconnect panel shall be compatible for connection to the AT&T ST-style connectors of the lateral and fiber optic patch cord cables. A panel of sufficient size to provide all requisite connections shall be provided.
- Installation shall be in accordance with the cable manufacturer's recommendation.

Emergency Vehicle Detector

All approaches to the signal shall have emergency vehicle pre-emption detection.



Optical detectors for emergency vehicle pre-emption shall be the Global Traffic Technologies (GTT) Model 752 Optical Detector, as needed. Placement of the detectors shall be determined by the City. Two GTT Model 752 Phase Selectors shall be provided in every cabinet.

Pedestrian Detector

Pedestrian push buttons shall be Polara Engineering BullDog III series with LED momentary pedestrian buttons (Part Number BDL3) or approved equivalent. The pedestrian push buttons shall be equipped with a push button instruction sign and shall provide directional arrows on the push button.

The assembly shall be weatherproof and constructed to prevent electrical shock under any weather conditions. The housing shall be shaped to fit the curvature of the pole to which it is attached to provide a rigid installation. Saddles shall be provided to make a neat fit as required. Pedestrian push button housing shall be black in color.

Pedestrian Push Button Sign

Pedestrian push button signs shall normally be an aluminum sign panel. Payment for pedestrian push button signs shall be incidental to the pedestrian push button pay item.

Signs shall be a minimum of 5"x 9" and conform to the 2009 MUTCD R10-3e signage.

Mast Arm and Pole

Mast arm and pole shall consist of a pole with four anchor bolts, a mast arm for support of signs and traffic signals, and, if specified, a luminaire arm and extension for roadway lighting.

Fabricator shall be certified under Category 1, "Conventional Steel Structures," as set forth by the American Institute of Steel Construction Quality Certification Program. Proof of this certification will be required prior to bid opening to assure that the fabricator has the personnel, organization, experience, procedures, knowledge, equipment, capability and commitment to fabricate quality structures.

Pole shaft, base plate, anchor bolts, mast arm, luminaire arm, and structural connecting hardware shall be designed in accordance with loading and allowable stress requirements of the latest edition of the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signals. Loading shall be based on 2001 AASHTO Category II with group consideration. If requested, calculations and detail drawings shall be submitted for verification of compliance to these specifications.

The tubular member's cross section shall be round and shall have a constant linear taper of 0.14 in./ft. It shall be fabricated from United States-produced coil or plate steel conforming to the requirements of ASTM A595 Grade A or ASTM A 572 Grade 65.

The mast arms shall have a horizontal length as called for on the plans. All mast arms that are 45 feet or less shall be manufactured and shipped in one piece with no circumferential splices. Each arm shall be provided with a painted end cap secured in place with setscrews.

For pole shafts, a 6" x 10" handhole reinforcing rim shall be welded into the shaft at eighteen inches from the base of the pole and supplied with a cover attached by bolts. Each pole shall be provided with a pole cap secured in place with setscrews or other suitable fasteners. A J-hook wire support and grounding attachment shall be provided in each pole shaft.

The base plate shall be of steel meeting or exceeding the requirements of ASTM A36 or ASTM A 572 Grade 42. It shall be integrally welded to the pole shaft with either a telescopic welded joint or a full penetration butt weld with a backup bar.

Anchor bolt material shall have a minimum yield strength of 55,000 psi and a minimum tensile strength of 75,000 psi. The bolts shall be galvanized to ASTM A153 for a minimum of eight to ten inches on the threaded end. Each anchor bolt shall be supplied with two hex nuts and two flat washers. The strength of the nuts shall be equal or exceed the proof load of the bolts.

Welding shall be in accordance with AWS (American Welding Society) Structural Welding Code D1.1, sections 1 through 8, and shall be performed by welders certified in accordance with the AWS Code. The tube's longitudinal seam welds shall be free of cracks and undercutting, performed with automatic processes, and visually inspected with questionable areas inspected by magnetic particle to AWS D1.1.

All miscellaneous hardware shall be galvanized per ASTM A153.

All materials and products shall be produced in the United States of America. They shall be of the ASTM type as called forth in this specification. Mill certifications shall be supplied for proof of compliance to this specification.

Traffic signal poles, mast arms, luminaire arms, and all incidental mounting hardware (nut covers), excluding banding straps and side of pole hardware, shall be galvanized per ASTM A123.

When specific color code is specified in the plans, all traffic signal poles, mast arms, luminaire arms, and all incidental mounting hardware (nut covers) shall be factory painted in a baked enamel finish on top of the galvanized finish.

Span Wire Pole

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 Engineering Division. Span wire poles and cable shall be in conformance with the CDOT Standard Specifications for Road and Bridge Construction, latest edition, section 614. Span wire poles shall be painted Federal Green, color #14056 (or approved equivalent) and the luminaire mounting height shall be 30 feet.

Pedestal Pole

Pedestal poles shall be designed to meet the structure requirement given in the most recent edition of Standard Specifications for Structural Support for Highway Signs, Luminaries and Traffic Signals, published by AASHTO, for a wind velocity of 90 mph. The pole base shall be frangible and shall include a locking base collar.

Pedestrian Push Button Pole

Pedestrian push button pole shall be illustrated in the standard details. Pole base shall be frangible and shall include a locking base collar.

Controller and Cabinet

Each controller and cabinet assembly shall be in conformance with section 614 of the Colorado Department of Transportation Standard Specifications for Road and Bridge Construction, most recent edition, as clarified by the following.

Each controller and cabinet assembly shall include:

- A Cobalt, or ATC or equivalent controller to be shelf mounted
- Econolite TS type 2 cabinet with precast polymer concrete base
- 2 Ventilation fans controlled with a separate thermostat.

- 1 Heater inside cabinet to reduce cabinet moisture with separate thermostat
- Clary SP1000R traffic uninterruptible power supply (UPS) with a 100-amp hour backup supply or an equivalent 100 amp hour battery backup unit as approved by the Engineering Division.
- A Generator Panel as specified in 12.3.7.19

Notes:

- All products provided, excluding the conflict monitor, shall be on the State of California's latest qualified products listing (QPL).
- The cabinet drawings shall be non-fading prints using the xerography method. No blue line drawings will be acceptable.
- The City's signal maintenance contractor shall be supplied a computer printout of the complete environmental testing results.
- The cabinet shall have eight flash jumper blocks.
- The cabinet field terminals shall be silk-screened with the appropriate phase/color designations.
- Controllers shall be interconnected to the signal system, unless otherwise directed by the Engineering Division. Operation satisfactory to the City shall be demonstrated during the normal twenty-day testing period. The controller and cabinet shall be tested by the Contractor at least ten days prior to installation. When specific color code is specified in the plans, all traffic signal cabinet shall be factory painted in a baked enamel finish to match the traffic signal poles and mast arm structures.

Miscellaneous Hardware

All ferrous mounting hardware and weather heads 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.

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. For each component used, it shall be clearly referenced in the service manual, and its value, ratings and manufacturer part number shall be given.

Generator Panel

A generator panel consisting of a manual transfer switch, and a 30-amp twist-lock connector for generator hookup. The transfer switch knob and twist-lock connector shall be located and labeled on a panel easily accessible behind a separate lockable door.

The door shall be equipped with a tamper resistant hinge. The door assembly shall be weatherproof and dustproof. The door shall have a movable plate to cover an opening for the generator cable.

The generator panel shall be located as close as possible to the AC main circuit breaker and shall not be located on main cabinet doors.

The connection to a generator or other external power source shall be a waterproof, secure connection.

The generator panel shall be permanently wired inside the cabinet through the UPS power supply so that the cabinet can remain secure during operation.

Warning or Regulatory Sign Flashing Beacon Assembly

A warning or regulatory sign flashing beacon assembly shall be as shown in the CDOT Standard Plan S614-14. Payment for these items shall be inclusive of all work to provide an operational flashing assembly, including materials, installation, and electrical service connection. Signs shall be installed as an integral part of the flashing assembly.

School flashers shall be a pelco break away base with a 10-foot (10') to 15-foot (15') long four inch (4") diameter pole with cap and collar. Then the school flasher equipment will be from Gades technologies AI units and be integrated into the existing system.

Video Detection

The uses of Video detection will be determined on a site-specific basis. Video detection shall be approved by the City of Northglenn prior to showing in the project plans. The Video detection unit, if shown in the plans, shall be Grid smart camera system or an approved equivalent. If Video detection is specified in the plans all video feeds shall be streamed into the City's Engineering Division.

12.3.8 Paint Equipment

Paint Existing Structures

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 removed, given a spot coat of primer and the entire exterior surface repainted. Previously painted services, whether finish or prime coated, shall be scuff sanded and particular attention paid to the lower eight feet of the pole.

Inspection of the poles by the City or It' designee 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.

The painting shall be done in a neat and workmanlike 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.

Touch-up painting shall be completed at the direction of the Engineering Division. Nicks and abrasions shall be cleaned, and the Engineering Division shall designate the appropriate primer coat and finish coat, if applicable.

When indicated on the plans, traffic and pedestrian signal heads shall be painted flat black.

12.3.9 General Guarantees & Warranties

Materials and Parts

The Contractor shall supply the Engineering Division with all manufacturer warranties and/or guarantees covering materials and parts.

12.3.10 General Signal Design Requirements

Scope

This section describes general signal design requirements for use in the City of Northglenn.

Signal Head Placement and Sizes

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.

Pedestrian signal heads shall be provided with corresponding pedestrian push buttons. Pedestrian signal heads shall be located for the pedestrian crossing sight line. Pedestrian push button locations shall meet ADA standards for height and horizontal reach. An exclusive pedestrian push button pole may be required.

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.

All mast arm mounted signal heads shall have 5-inch-wide, black aluminum, louvered backplates with one-inch (1") yellow reflective strip along the outside perimeter.

Red, yellow, and green signal sections shall be twelve inches in all cases.

Where mast arms extend over the left turn lane(s), left turn only sign(s) should be provided. Double lefts may be covered with one left turn only sign (R3-5L) per lane, or one double left turn only sign located over the lane line between the double lefts. Where a right turn lane is provided, a right turn only sign (R3-5R) should be provided and centered over the lane.

Pole and Cabinet Placement

All signal poles, pedestals and cabinets shall be placed a minimum of three feet (3') from face of traffic signal item to face of curb where curbing is present, with a desirable separation of a minimum of five feet. The same separations apply from face of traffic signal item to outside edge of shoulder where pavement and shoulder exist with no curbing. Where only pavement exists without shoulder and curbing, a minimum of five feet from face of traffic signal item to edge of pavement shall be maintained, with a desirable separation of a minimum of seven feet (7').

Future Signal Considerations

All intersections undergoing initial development or construction that are anticipated to require signalization in the future shall include signal conduit at the time of initial road construction, in conformance with these specifications. The Developer/Applicant should consult with the Engineering Division to identify intersections to which this requirement applies.

All conduit shall be Schedule 80 PVC and shall include pull boxes, locate wire, pull string and locate balls.

Luminaires

Unless otherwise indicated, the Contractor shall provide luminaires and luminaires' wiring, and shall fully install these items for all corners of the intersection. Luminaire mounting height shall be a minimum of thirty feet (30'). A complete luminaire includes the housing, lens, Light Emitting Diode (LED) luminaire, luminaire housing, driver or power generator, slip-fitting clamp or approved manufacturer mounting, all necessary internal wiring, and photoelectric control. Luminaires shall operate at either 120 VAC, 60 Hz or 277 VAC, 60 Hz. Luminaires shall meet electrical utility company requirements and comply with all requirements identified in the Colorado Department of Transportation Standard Specifications for Road and Bridge Construction or any Revised Standard Special Provision that apply to Sections 613 and 715 LED Roadway Luminaire.

Vehicle Detectors

Stop bar protection shall be provided on all approaches with free-flow speeds of 40 to 45 mph and greater.

Consideration should be given to providing advance detection for dilemma zone protection. 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.

Signal Power

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.

The City of Northglenn Building Division is responsible for inspecting service installations and certifying acceptability to the utility company for hook-up.

12.4 Construction Standards

12.4.1 Regulations & Code

All electrical equipment and material shall conform to the standards of the National Electrical Manufacturers Association (NEMA) the Colorado State Highway Department, whichever is applicable. In addition to requirements of these specifications, the plans, the special contract provisions, all material and work shall conform to the requirements of the National Electrical Code (hereinafter referred to as the "Code"), the Rules for Overhead Electrical Line Construction of the Public Utilities Commission, the Standards of the American Society for Testing Materials (ASTM), the American Standards Association (ASA) and any local ordinance which may apply. Wherever reference is made in these specifications or in the special contract provisions to the code, rules or the standards mentioned above, the reference shall be construed to meet the code, rule or standard that is in effect at the date of bidding.

12.5 Traffic Signing & Pavement Markings

12.5.1 General

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

12.5.2 Traffic Control Devices on Public Property

All permanently fixed traffic signals will generally be installed by the City at the developer's expense. However, if the developer submits a signage plan which is subsequently approved by the Engineering Division, the developer may install these traffic signs. Traffic signs shall be placed to conform to the drawing details.

12.5.3 Traffic Control Devices on Private Property

- **Responsibility.** All traffic control devices on private property, i.e., pavement markings, regulatory signs, fire lane signs and handicapped parking signs shall be installed and maintained by the property owner.
- **Placement.** A signage and striping plan specifying the various types and combinations of traffic control devices shall be submitted to the Engineering Division for approval.

12.5.4 Pavement Markings

All Pavement Markings required to be installed as a result of new construction or development shall be THERMOPLASTIC as per CDOT Standard Specifications. Temporary pavement markings necessary to facilitate construction (i.e. detours) may be installed using paint.

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

12.6 Traffic Signs

12.6.1 General

This section provides the sign materials, design requirements and sign specifications for all signs placed in City Right of Way.

12.6.2 Type and Location of Signs

The Engineering Division shall make the final determination regarding the type and location of signage controls within the Right of Way. These controls shall include traffic control signs, street name signs, delineators, and permanent barricades.

12.6.3 Design, Installation & Maintenance

The City maintains the permanent traffic control devices on public rights-of-way, all traffic control devices shall be fabricated and installed in accordance with this chapter. All design shall be in accordance with this chapter and the latest revision of the MUTCD.

12.6.4 New Roadway or Reconstructed Streets

Permanent signage, unless otherwise approved by the Engineering Division, shall be completed in place before any new roadway or reconstructed roadway is opened to the public.

12.6.5 Signpost, Supports & Mountings

Signposts and their foundations and sign mountings shall be constructed to hold signs in a proper and permanent position, to resist swaying in the wind or displacement by vandalism.

Sign Post

The post shall be constructed in two sections:

- **Anchor (Stub).** A 2-1/4-inch 12-gauge galvanized steel square stub section with holes, three (3) long, is driven into the ground thirty (30) inches with at least 4 inches remaining above the final grade. The signpost system's material specification is Telspar 22F1A 03PG, 2 ¼ inch x 3 feet anchor post with holes or perforated.
- **Sign Post.** A 2-inch square galvanized steel post section with holes is inserted into the stub and bolted. The material specification is Telspar 20F12P-10PG, 2-inch square 12-gauge 10-foot post with holes. The post shall be installed 8 inches into the anchor (stub). **See Standard Drawing T-1.**

Post Bolts

Two 2 ½ inch long 3/8-inch hex head bolts are used to attach sign post to sign anchor (stubs). These bolts shall be installed in adjacent holes at the top of the anchor (stub), at 90 degrees to one another.

Sign Bolts

Signs shall be mounted to the post with a minimum of one drive rivet (TL3806 EG) and nylon washer (against the face) at the top of sign. The bottom of the sign shall be attached with one 5/16" hex bolt, one metal washer and one nylon washer against sign face. The bolt or rivet system is used to fasten signs to the Telspar post.

Other Sign Mounts

Streetlights and approved utility poles, when located appropriately, may be used for signs such as warning, parking, and speed limit signs. Streetlight locations should be checked for potential sign installation during the design process and shown on the sign plan sheets.

Breakaway Post System

Post must be of appropriate length to comply with MUTCD specifications for the location, must conform to Federal breakaway standards.

Sign Reflectivity

All traffic control signs must be fabricated with reflective materials. All reflective materials to be a minimum of diamond grade, except all stop signs, yield signs and "Do Not Enter" sign faces. These signs shall be fabricated from Scotchlite reflective sheeting, high intensity grade or approved equal.

- **Materials Warranty.** All signs shall have a seven-year (7) materials warranty.
- **Backing Plates.** Aluminum blanks of 0.080 gauge are standard, except for signs larger than 36" x 36", which shall be 0.100 or 0.125 gauge aluminum.

Street Name Signs

- **General.** All street name signs must conform to these standards. If the intersection has a traffic signal, the street name signs will be designated as part of the traffic signal.
- **Minor Intersection Street Name Signs.** Eight-inch plates shall be used at all minor intersections; lengths vary to fit street names.
- **Major Intersection Street Name Signs.** Ten-inch plates shall be used at all major intersections which include the intersections with Collector and Arterial Roadways.
- **Color.** Letters and numbers are to be white on a green background face.
- **No Outlet Signs.** On any cul-de-sac, temporary dead-end street, or any other streets with only one access point a "No Outlet" sign is required. The "No Outlet" signs may be placed under the street name signs.
- **Stop Signs.** The location of all stop signs shall be determined and discussed in the Traffic Impact Study. The stop signs shall be placed in accordance with the TIS, approved construction plans and the MUTCD. In general, stop signs should be placed at point of curvature and behind attached sidewalk. All stop signs should be a minimum of 30" x 30" in size.

Traffic Control Signs

- **Design & Size.** Sign specifications and diagrams are detailed in the latest revision of the Federal "Standard Highways Sign," latest version. This publication is available from the U.S. Department of Transportation, Federal Highway Administration.

- **Mounting.** Signs should be mounted on existing streetlight and power poles, with new posts being used only if necessary. Streetlight locations should be checked for potential sign installation during the design process and shown on the signing and striping plan sheets. $\frac{3}{4}$ " stainless steel banding shall be used to mount signs to fiberglass and steel poles.
- **Crosswalk Signs.** Crosswalks shall be signed where adjacent to a school and on an established school pedestrian route. There are usually a minimum of four (4) signs per crosswalk. The color and installation shall be completed according to MUTCD. The color shall be fluorescent yellow green.
- **Fire Lane Signs**
 - The sign is 12 Inches X 18 Inches.
 - The sign shall be black letters on a white background.
 - "No Parking" or "Fire Lane" with arrow
 - The sign shall follow the MUTCD.

12.7 Pavement Marking & Striping

12.7.1 General

Type and Location of Striping and Markings

The Engineering Division shall make the final determination regarding the type and location of pavement markings within the Right of Way.

Design, Installation & Maintenance

- The signing and striping plans should be designed in accordance with these specifications and MUTCD.
- The pavement markings shall be installed with the materials specified herein and in accordance with MUTCD.
- The City will maintain permanent pavement markings after completion of the warranty period.
- On rehabilitated or new roadways, the pavement markings are required to be in place before the roadway is opened to the public.

12.7.2 Pavement Markings (Symbols, Arrows, "ONLYs")

Preformed Thermoplastic Pavement Marking Specifications

- **Thickness.** The prefabricated markings described shall be 125 mils (90 mils for bike symbols) in thickness and consist of white or yellow pigmented plastic film with imbedded reflective glass spheres, uniformly distributed throughout their entire cross-sectional area.
- **Adhesive.** It shall be possible to affix the markings to bituminous or Portland cement concrete pavements by a two-part epoxy adhesive and shall have a black contrasting border.
- **Shapes.** Prefabricated legends and symbols shall conform to the applicable shapes and sizes as outlined in the MUTCD.

- **Removal of Concrete Curing Compound.** All concrete curing compound shall be removed before installing thermoplastic in specific marking locations.

Crosswalks

Crosswalks shall be used at all signalized intersections, approved crossings, school routes, adjacent to schools, and as otherwise directed.

- **Standard Crosswalk.** White 9-foot long x 18-inch wide “Continental” style bars should be used for all crosswalks.

Stop Bars

- **Size and Color.** All stop bars shall be white and a minimum of 18 inches wide.
- **Locations.** Stop bars are required at signalized locations where the speed limit is 35 mph or higher and other locations specified by the Engineering Division.

Symbols

- **Thickness.** Performed thermoplastic pavement marking standard material shall be a minimum of 125 mils thick or approved equal. This shall be used for all arrows, “ONLY”, railroad crossing symbols.

12.7.3 Striping

General

- **Typical.** Typical striping widths for lane lines are four (4”) inches, unless otherwise noted. Double yellow centerline must have a four-inch (4”) gap between stripes according to MUTCD.
- **Pavement.** Epoxy (highway type high-solids fast-dry) shall be used for asphalt and concrete pavement striping. Refer to CDOT Highway Specifications.
- **Layout.** All striping on sealcoats shall require a layout line. Prior to striping, tabs are required for sealcoats (prior to the sealcoat process). All other conditions require spot taping at an interval of twenty-five feet (25’) or closer.
- **Retro-Reflectivity.** The two (2) coats of paint shall be applied with beads for each coat. The application rate for beads shall be 6.5 pounds per gallon. The beads shall be type 2, non-floating, water resistant.

Broken Line

All broken lines shall be 4-inch wide or 8 inches using a 6-foot cycle (two-foot (2’) paint or thermoplastic, four-foot (4’) gap).

Turn Bay Line

All turn bay lines shall be created with a minimum eight-inch (8”) wide line. However, if a turn bay occurs on a horizontal curve, the bay taper from the start of the double wide eight inch (8”) shall be marked with short eight-inch (8”) wide dotted lines. (2’ long with 4’ gap).

Centerline

All centerline striping shall be double yellow, each a minimum of four inches (4”) wide, with a 4-inch minimum gap between the two.



12.7.4 Temporary Striping

All temporary striping shall conform to “Standard Specifications for Road and Bridge Construction,” published by CDOT, the latest revision except as herein amended. When approved, temporary striping shall be required prior to the opening of a roadway for travel where pavement and/or permanent striping cannot be completed due to weather and/or time constraints.

Specifications

Temporary striping shall be the same color and width as for permanent striping. Temporary striping shall consist of tabs of four (4”) x four (4”) inch (min.) tape, depending on the pavement surface, spaced at 25-foot intervals.

Time Duration Limit

Temporary striping is permitted on Collectors and Arterials for no more than seven (7) days.