

# Appendix F - Fort Collins Traffic Operations Manual

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**NOTE: Appendix Information is for Reference Only. Contact Local Entity Engineer for Current Information.**

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Fort Collins Traffic Operations Manual  
(City of Fort Collins Only)

Appendix F - Fort Collins Traffic Operations Manual

**TRAFFIC OPERATIONS MANUAL**

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## Traffic Control Devices - Section 1-1

### General

Traffic control devices will be installed on all new streets accepted by the city for maintenance as set in these STANDARDS AND SPECIFICATION.

### Work Area Traffic Control – Policy

Traffic Operations has the responsibility to assure public safety within the right-of-way within the City of Fort Collins city limits. All traffic control plans are submitted to the Transportation Department for approval or modifications. All traffic control plans include vehicular, pedestrian, and bicycle movement and safety within the project.

Upon approval of a traffic control plan by Traffic Operations, a contractor/developer and/or City department can set up traffic control and work zone safety devices within the city limits and upon the right-of-way. The contractor/developer and /or City departments are responsible for setting the devices as per the approved traffic control plan.

Traffic Operations will periodically monitor job sites to assure that all devices are set according to an approved plan and are in a satisfactory order for the safety of the public.

If a deficiency is found upon review of the work sites by Traffic Operations, they will notify the agency (contractor/developer and/or City Department) of said deficiency. Depending on the situation, if the deficiency is not corrected within due and reasonable time, Traffic Operations will notify the traffic control company under contract with the City of Fort Collins to correct the deficiency. The cost of traffic control and/or work zone safety devices will be the responsibility of said contractor/developer and/or City department.

### Traffic Control Plans - Policy

All City Departments, contractors and/or developers are to submit a traffic control plan for all projects within the right -of-way and adjacent to, within the city limits of the City of Fort Collins.

Failure to submit a traffic control plan by said City department, contractor and/or developer for any project would be subject to denial of work and removal from the right-of-way.

### Traffic Construction Policy for Developers

This policy has been developed to set procedures for traffic construction relating to certificate of occupancy releases, as well as recouping the cost for this work. Notices and payment from developers will be required before work is scheduled. Standard forms have been developed and must be submitted before traffic construction takes place. These forms are available at the City's Traffic Operations Department.

The attached schedules and requirements are made part of this policy. Traffic Operations will attempt to reduce the time upon request. The developer can choose to have all the

work completed by a qualified City traffic contractor. Approved plans will be required, and charges for review and inspection City time will be billed.

NOTICE OF WORK FORM

DATE

\_\_\_\_\_

I am hereby requesting that the City of Fort Collins Department of Transportation prepare a cost estimate and partial billing for signage, pavement marking, and traffic signal work for or caused by my development known as \_\_\_\_\_ I have enclosed four sets of development plans, including block numbers, in order to perform this work. I understand that costs are estimates, and may change upon final construction. I will accept the cost related to all traffic work, including any changes. My present schedule for your construction would be \_\_\_\_\_ 1986.

Signature \_\_\_\_\_

Position \_\_\_\_\_

Company \_\_\_\_\_

Address \_\_\_\_\_

Phone \_\_\_\_\_

Received:

REQUEST OF WORK FORM

DATE

\_\_\_\_\_

I am hereby requesting construction of signage, pavement marking, and traffic signals for all/part of my development known as \_\_\_\_\_ I have enclosed a map of the area of work, and have instructed the other contractors that this work will begin in weeks. I understand that I will receive final billing for this area, and construction will not begin until two weeks after the City receives payment, weather permitting. I understand no refund will be due me for any of this work.

Signature \_\_\_\_\_

Position \_\_\_\_\_

Company \_\_\_\_\_

Address \_\_\_\_\_

Phone \_\_\_\_\_

Received:

TRAFFIC OPERATIONS RELEASE TO OBTAIN CERTIFICATE OF OCUPANCY FORM

All materials and payments have been received for part/all of \_\_\_\_\_ Construction is completed or scheduled shortly. This is to serve as a release for traffic items concerning certificate of occupancy within this area.

cc Building Inspection

## Sign Standard - Section 1-2

### Street Name Sign

Street name signs will be furnished by the Contractor or Developer and will be installed by the City, or a private contractor to be inspected and approved by the Traffic Operation Department. Sufficient signs and posts will be provided to allow installation one corner of each intersection and will have white letters on a green background in conformance with following dimensions:

Intersection Type	Sign Blank Size	Letter Height
Local/Local	6" x 36" or 6' x 30"	4" Street Name or 2" Suffix St., Ave., etc.
Signalized	Illuminated Signs, see 722.02	See 722.02
All Other	9" x 42" or 9" x 48"	6" Street Name or 3" Suffix St., Ave., etc.

### Illuminated Signs

Internally illuminated street name signs will be furnished by the Contractor or Developer and will be installed by the City. Signs will be NU Art Lighting and Manufacturing Co. NAIM series or Ameron. Signs will be provided to allow installation on each traffic signal mast arm at each intersection. Sign lettering shall be in the ten-inch (10") upper case letters series "C". The use of the series "B" letters is permissible where limited breath and stroke widths are required for design purposes. Suffixes are to be five-inch (5") upper case letters. Lettering for supplementary to indicate the type of street or section shall be at least four inches (4") where a two-line application is desired or three inches (3") where a three-line application is desired.

### **Borders**

The sign shall have no border.

### **Spacing**

One line with equal spacing between each word relative to end of blanks.

### **Two Inch (2") Arrow Heads**

Arrows are to M.U.T.C.D. standards as illustrated in the Standard Highway Sign Handbook.

### **Color**

Letters and numbers are to be white on a green background face. Sign panel is to consist of 3M Engineering Grade Green. The colors shall not fade when exposed to an accelerated test of ultraviolet light equivalent to five years of outdoor exposure.

### **Illumination Source**

The entire surface of the sign panel shall be evenly illuminated. The illumination source shall be fluorescent lamps, powered for low temperature operation. There shall be separate ballast for each fluorescent lamp. Photoelectric controls are required and shall

be the "hail resistant" type and of the load intended. The reflectors shall have a minimum reflectance of 85%.

### **Final Layout**

Final layout and lettering details are to be submitted to the City before fabrication

#### **Stop/Yield Signs**

Stop signs will be installed at locations designated by the Traffic Engineer. Stop signs/yield signs will be mounted on the same support posts as street name signs where possible.

#### **Other Signs**

Speed limit signs, school signs, and crosswalk signs will be installed at locations designated by the City Traffic Engineer.

#### **Sign Supports**

All supports or posts will conform with specifications to Cold Rolled Carbon Steel Sheets, Commercial Quality, ASTM Designation A-366. The cross section will be square and consist of ten (10) gauge or Twelve (12) gauge steel (0.135 U.S.S. Gauge or 0.105 U.S.S. Gauge) carefully rolled to size and continuously welded at the corner and will conform to the following side dimensions:

Total Sign Area	Side Dimensions
1-3/4" x 1-3/4"	1-3/4" x 1-3/4"
1-3/4" x 1-3/4"	1-3/4" x 1-3/4"
1-3/4" x 1-3/4"	1-3/4" x 1-3/4"

The finished members will be straight and will have a smooth, uniform finished. It will be possible to telescope consecutive sizes of tubes freely with a minimum amount of play. All holes and cut-off ends will be free from burrs. Seven-sixteenth inch (7/16") diameter holes will be punched on one inch (1") centers on all sides of the tube. All posts will be weather protected by galvanizing. Posts will be formed from cold rolled steel strip, which has been zinc coated and is commercial quality (1.25oz) conforming to ASTM Specification A-525.

### **Traffic Signing Standard - Section 1-3**

#### **General**

The Traffic Engineer shall determine what type and where to install controls based on standard engineering practices and the MUTCD. These controls shall include traffic control signs, street name signs, delineators, permanent barricades and pavement markings.

#### Working Hours

All work within public ROW shall begin after 8:00a.m and shall terminate, clear of public ROW before 4:00p.m. Monday through Friday, unless variations to these time limits are granted or required by the Traffic Engineer.

#### Traffic Control

Precautions shall be taken to insure that proper traffic control measures are provided for safe and convenient movement of public traffic on public roadways while working in or adjacent to the roadways.

#### Materials

All items used in the fabrication, manufacturing and installation of traffic control signing and pavement markings in the City of Fort Collins shall be manufactured in the United States with domestic materials and parts. Domestic materials and parts are those which are melted, cast, formed, shaped, drawn extruded, forged, fabricated, or otherwise processed in the United States, using raw material produced in the United States.

#### Variance Requirements

The Responsible Party shall acquire a City traffic control permit prior to installation of any signs. The permit shall constitute City authorization for the Responsible Party to install official traffic controls on public ROW.

#### Inspection

After installations, the signing Responsible Party shall notify the Traffic Engineer. The Traffic Engineer shall then inspect all installations and notify the Responsible Party of any corrections needed. The Traffic Engineer shall make a second inspection at the time of the final walk-through of all public ROW improvements. The Responsible Party must correct all signing problems.

#### Relocation

The Responsible Party is responsible for the removal and relocation of all existing traffic signs on public ROW affected by the approved project.

#### Sign Fabrication

All standard control and street name signs are to be fabricated on .080/5052 H 38-alodized aluminum blanks with standard radius corners.

All traffic control signs and metro street name signs are to be fabricated using 3M Company Engineer Grade reflective sheeting. Street name signs shall be fabricated with 3M Company Engineering Grade reflective sheeting.

All traffic control sign faces are to be screened in conformance with methods prescribed by 3M Company using 3M inks. No substitutions shall be allowed unless approved by the Traffic Engineer before fabrication in writing.

All standard signs, except street name signs, shall be fabricated to conform exactly to the detailed in the latest Standard Highway Signs Manual as published by the U.S. Department of Transportation/Federal Highway Association.

All street name signs shall be fabricated in accordance with City Standard and Specifications.

All signs shall be fabricated with new materials. Used or reconditioned sign blanks, outdated sheeting, and/or precut letters or numbers shall not be used.

#### Sign Installation

All signs shall be installed in strict conformance with part II of the latest edition of the Manual on Uniform Traffic Control Devices and revisions. All signs are to be mounted on either the approved City Breakaway supports, or cantilever aluminum stand off light pole side mounts, or banded to street light poles.

- Control signs must be either banded to street light poles as determined by the Traffic Engineer, or mounted directly onto a breakaway support.
- Mounting of signs to breakaway supports shall be accomplished by use of drive rivets, except back to back street name signs shall be mounted using five-sixteenths (5/16) of an inch plate nut and bolt arrangement.

Assembly of the breakaway supports to the anchor shall be by using a corner bolt or a drive rivet, or by using a (5/16-18) bolt.

The Responsible Party shall, prior to installing sign support bases, contact all utility agencies, including U.S. West, Public Service, United Power, Cable Company and the City of Fort Collins Utilities, to locate any buried service, and to avoid damage when the base is installed.

All signal multiple sign installations shall be on TELESPAR 16F 10 or equal and ten foot (10') support assemblies. All sign support bases for standard sign installations shall be TELESPAR No. 20F 12 or equal and thirty (30) inches long installed so that four inch (4") plus or minus one-half inch (1/2") protrudes above ground level.

All supports for standard sign installations shall be installed so that a minimum of six inches (6") is inside of support base and the sign height conforms to MUTCD. All sign supports for standard sign installations shall meet or exceed the following specifications:

- The cross section of the post shall be square tubing formed of twelve (12) gauge steel.
- Tubing seam shall be welded in such a manner that the weld or flash shall not interfere with the telescoping of the tubing.
- Support tubing size shall be one and three quarters inch (1-3/4"), U.S.S. twelve (12) gauge, with the weight of 2.06 pounds per lineal foot.
- The length of each post shall be as specified and have a permissible length tolerance of plus or minus one-quarter inch (1/4").

- The finished post shall be straight and shall have a smooth uniform finished.
- It must be possible to telescope a one and one-half inch (1 1/2") by one and one-half (1 1/2) O.D. post into a one and three-quarter inch (1 1/2") by one and three-quarter (1 3/4) O.D. post.
- It must be possible to telescope a one and three-quarter inch (1 3/4") by one and three-quarter inch (1 3/4") O.D. post into a two inch (2") by two inch (2") O.D. post.
- The outside tolerance at all sides at all corners must be as followed:
- For one and one-half inch (1 1/2") by one-half inch (1 1/2") O.D. plus or minus .006 inch
- For one and three-quarter inch (1 1/2) by one and three-quarter (1 3/4) O.D. plus or minus .008 inch
- For two inch (2") inch by two (2) O.D. plus or minus .008 inch
- The wall thickness must fall between a plus .011 inch and a minus .008 of U.S.S. twelve (12) gauge.
- The maximum twist permissible in three foot (3') lengths for a standard one and three quarter inches (1 3/4") by one and three-quarter inch (1 3/4) sign support is .062 inch.
- The maximum tolerance in square's for one and three quarter inch (1 3/4") by one and three quarter inch (1 3/4") supports is plus or minus .010 inch.
- A maximum tolerance in straightness of one-sixteenth (1/16) of an inch in three (3) feet is permissible.
- All supports must be given a double outer finish. The first outer finish is galvanized.

The following specifications must be met:

- Each square steel tube support must be hot dipped galvanized, ASTM a-525 coating, designation G90, or given a triple coated protection by in-line application of a hot dipped galvanized zinc per AASHTO M-120 followed by a chromate conversion coating.
- Tensile strength of 7500psi
- Impact resistance to not less than one hundred and sixty (160) pounds
- Hardness of eighty-seven (87) shore D Durometer
- Flexibility of one hundred (180) degrees bend over one quarter inch diameter mandrel without caking or loss of adhesion
- Dielectric strength of one thousand (1000) v/mil at ten (10) mils

Application of final outer finish shall be accomplished by the following process:

- Pre-treating is required to remove all grease, rust and dirt and then a thin coat of iron or zinc phosphate must be applied. This pretreatment is required to provide maximum adhesion and long term corrosion protection.
- The powdered resins are applied to the cold support tubing through a electrostatic gun. The support must then be baked in order to fuse the finish to the surface.
- The outer finish must have a minimum thickness of (2) miles.
- Before any of the other final finishes being applied, all plastic protective coating shall be removed.

### Sign Maintenance

It is the responsibility of the Responsible Party to maintain all required signs after installation until the City has officially granted the initial acceptance of the adjacent ROW improvements. Signs installed under this standard shall be maintained during the development construction period in two manners.

The Responsible Party shall repair signs damaged, which do not constitute an immediate hazard to the public, within a responsible time, not to exceed ten working days after responsible Party has been notified.

Sign damages that constitute an immediate hazard to the public shall be repaired or replaced by City forces. The Responsible Party shall be responsible of the cost of repairs and or replacement.

## Sign Standards - Section 1-4

### General

All signing shall be in accordance with the following design criteria.

### Design Criteria

- All signs shall conform to current M.U.T.C.D. Standards and Colorado Supplement.
- All signs shall be installed on Unistrut Telespar type perforated posts with anchors at proper height as per current M.U.T.C.D Standards.

Sign backing shall be as followed:

- All signs shall be .80 aluminum.
- All signs shall be mounted with City approval vandal proof bolts or rivets.

Unistrut Telespar type posts shall meet or exceed the following:

- Posts –1 inch x 1 inch, 12 gauge, ASTM Specification No. A446, Grade A, drilled on 1 inch centers.
- Anchors - 2 inch x 2 inch, 12 gauge, ASTM Specification No. A446 drilled on 1-inch centers.
- All posts and anchors shall be galvanized to ASTM Specification A525 coating designation G90.
- All sign shall be minimum engineer grade reflective sheeting, seven (7) year guarantee or approved equal.
- Street name signing dimension and lettering shall conform to Standard Detail S-35 and S-36.

## Traffic Signals - Section 2-1

### General Provisions

These specifications for traffic signals supplement the roadway design specifications and shall govern the materials used and the installations of traffic control signals.

Construction of traffic signal systems shall be done in accordance with these Standards and Specifications, the latest edition of MUTCD for Streets and Highways, the latest revision of the Colorado Supplement thereto, and in conformity with the details as shown on the traffic signal plans.

The Responsible Party shall have an IMSA Certified Traffic Signal Level II Technician on-site during the period and splicing and/or termination of wiring for head and controller installation, and shall provide the Traffic Engineer with a copy of the Technician's certification prior to the start of work.

### Conditions of Materials Furnished

All items furnished shall be new state-of-art equipment and materials. The Responsible Party shall submit a list of equipment and materials, which are proposed to be installed to the Traffic Engineer for approval, before Responsible Party ordering such materials. Each item shall be identified by the trade name, size, and catalog number.

All traffic control equipment installed in the controller cabinet shall be products from the same manufacturer, or fully compatible if equipment from more than one manufacturer is used. At existing traffic signal installations being rebuilt, all traffic control equipment furnished by the Responsible Party shall be compatible with any existing equipment to be retained.

The traffic signal installation shall include all traffic control equipment necessary to provide the sequence of operations as shown on the plans. The Responsible Party shall furnish and install any additional control equipment required to provide the sequence of operation shown on the traffic signal plans.

The Responsible Party shall furnish all labor, tools, equipment and incidentals necessary to complete the project in an efficient manner.

The Responsible Party shall furnish a guarantee from the supplier/manufacturer for all equipment provided. These guarantees shall be delivered to the Traffic Engineer before final payment to the Responsible Party.

## Definitions - Section 2-2

### General

Whenever special engineering terms and words are used in these Standards and Specifications, or in other contract documents, the intent and meaning shall be as defined in the Transportation and Traffic Engineering Handbook, ITE, latest edition.

### Regulations and Codes

In addition to the requirements of the plans, these Standards and Specifications and the Special Provisions, all items shall conform to the requirements of the NEC, hereinafter referred to as the code, Rules for Overhead Electrical Line Construction of the Colorado Public Utilities Commission; standards of ASTM, ANSI, and any local ordinance which may apply.

Wherever reference is made to any of the standards mentioned above, the reference shall be construed to mean the code, order, or standard that is in effect on the date of advertisement for bids.

### Required Documents

Upon completion of the work, Responsible Party shall submit as built drawings or corrected plans and/or additional data required by the Traffic Engineer to detail all construction changes. This shall include but not be limited to writing, cable, location, and depth of conduit and modifications to original cabinet writing.

The Responsible Party shall submit two (2) sets of schematic wiring diagrams to the Traffic Engineer for the traffic signal controller, the signal installations light circuits, and all auxiliary equipment, including units and values of each component used in the cabinet. The diagrams shall show in detail all circuits and components. Such components shown thereon shall be identified by name or number and in such a manner as to be readily interpreted.

All diagrams, plans and drawings shall be prepared using graphic symbols shown in ANSI Y32.2, A Graphic Symbols for Electrical and Electronic Diagrams. One copy of the controller cabinet diagram and the intersection and phase diagram, as approved by the Traffic Engineer shall be placed in a heavy plastic envelope with side opening, and placed inside of each controller cabinet prior to the initial acceptance of the project.

### Schedule of Work and Working Conditions

The Responsible Party shall provide constant attention to the work necessary to facilitate the progress thereof, and shall cooperate with the Traffic Engineer, City inspectors, and other Responsible Party's in every way possible. At the end of each working period, all excavations shall be barricaded and/or covered to provide safe pedestrian and vehicular passage.

At points where the Responsible Party's operations are adjacent to properties of railway, telegraph, telephone, power companies, cable television, water, sanitary or storm sewer lines, where any damage would result in considerable expense, loss or inconvenience, work shall not commence until all arrangements necessary for the protection thereof have been made.

The Responsible Party shall cooperate with all underground and overhead utility line owners for any removal or relocation that is necessary, so that these operations may

progress in a reasonable manner, duplication of work shall be reduced to a minimum, and services rendered by those shall not be unnecessarily interrupted.

In case of an accidental breakage or another cause of interruption to water or utility services, the Responsible Party shall promptly notify the proper authority and shall cooperate with the authority in restoration of service. If water service is interrupted, repair work shall be continuous until the service is restored. Work shall not be undertaken around fire hydrants until approved by the local fire authority.

If any damage is caused to the following: sidewalks, curbs, gutters, Portland cement concrete, asphalt concrete pavement, underlying material, lawns and plants by the Responsible Party's operations, which are not itemized in the plan to be removed, shall be replaced or reconstructed at the Responsible Party's expense. Using the same kind or equal quality of material as used originally and that meet the satisfaction of the Traffic Engineer.

#### Disposition of Keys and Instruction Manuals

When the project is complete, two (2) keys for each controller cabinet and Police Panel shall be delivered to the Traffic Engineer. The Instruction Manual for the controller shall be left inside the controller cabinet.

#### Maintaining Existing Traffic Signal Operations

Existing traffic signals shall be kept in effective operation for the benefit of the traveling public by the city.

At intersections where power to all signals must be turned off, the city shall furnish a Fort Collins police officer. The Responsible Party must request a police officer at least forty-eight (48) hours prior to the time the officer is needed. Requests for Fort Collins police officers must be made through the Traffic Engineer.

The above does not apply to intersections which are completely closed to all traffic due to construction.

The Responsible Party shall maintain a minimum of two (2) three section ( red, yellow, green) traffic signal heads for each approach. In the event that temporary signals are necessary to maintain the minimum signal display, the responsible Party shall be responsible for furnishing all materials, equipment, tools, and labor necessary to install and maintain the temporary signals. The Traffic Engineer prior to installation must approve temporary signals. The Responsible Party shall maintain any temporary signal installed. The City shall furnish electrical energy for operation of a temporary signal. The Traffic Engineer must approve timing and phasing of the temporary signal.

#### Field Test of Equipment

Prior to completion of work, the Responsible Party shall make the following tests on all traffic signal circuits, in the presence of the Traffic Engineer and the controller representative, if a new controller is used:

- Each circuit shall be tested for continuity.
- Each circuit shall be tested for grounds.
- An insulation resistance test shall be made on each circuit between the circuit between the circuit and the ground. The insulation resistance shall not be less than the values specified in the provisions of the NEC.
- Prior to functional testing of a new signal system (new location), the signal shall be run on flash cycle for a minimum of two (2) days and a maximum of four (4) days prior to turn on.
- A functional test shall be made which demonstrates that every part of the system functions as specified herein. The functional test for each traffic signal system shall consist of at least five (5) days of continuous satisfactory operation. If unsatisfactory performance of the system develops, the conditions shall be corrected and the test shall be repeated until five (5) days of continuous, satisfactory operation is obtained.
- Functional test shall start on any working day except Monday or the day preceding a legal holiday.
- During the test period, the city shall provide the electrical energy and repair any damage caused by public traffic. All other maintenance shall be the Responsible Party.

#### Final Equipment Turn-On

Turn-on of new or modified signal systems shall be made only after all traffic signal circuits have been thoroughly tested.

All louvers, hoods and signal heads shall be directed to provide maximum visibility. Initial turn-on shall be between 9:00 a.m. and 2:00 p.m. and the Traffic Engineer must be present. Only, unless otherwise specified. Prior to turn-on, all equipment as shown on the plans shall be installed and operable. This includes pedestrian signals, pedestrian push buttons, vehicle detectors; and Opticom. The Traffic Engineer must approve any exceptions to this.

All components of the system must be complete and in operational condition to the satisfaction of the Traffic Engineer prior to the final turn-on.

#### General

The installation of traffic control devices and street lighting shall comply with all applicable portions of the CDOT Standard Specifications for Road and Bridge Construction, the Manual on Uniform traffic Control Devices and those accepted plans. These STANDARDS AND SPECIFICATIONS and any other requirements determined by the City Engineer will apply to all materials supplied and methods and procedures of work.

## Policies - Section 2-3

#### Procedure for Master Computer Failure

- Determine down time of master computer (expected long term)

- Notify supervisor of master computer status
- Notify police department of situation (may need assistance at major intersections)
- Notify administration/secretarial of condition (for the purpose of answering calls)
- Send traffic personnel to troubled areas upon Notification by police department of administration. (if large area is affected request assistance from other departments)
- If needed, remove master computer off line from local Intersections (disable traffic control to prevent erroneous data Commands from being sent to the local controllers)
- Notify police department of situation to inform Traffic Operations of any problem areas.
- Continue communication to administration/secretarial of conditions. (To answer questions that may be called in and any problem area.)
- Notify department head (first line supervisor needs to notify department head of Status and the length of the time master computer will be disabled).

#### Preventive Maintenance Test

The purpose of the Preventative Maintenance Program is to provide a thorough inspection of each Traffic Signal/Pedestrian Crossing and Controlled School Zone with in the city of Fort Collins. The emphasis is put on self detection methods of finding faults and malfunctions and assuring all faults and malfunctions are corrected in a timely manner. There is also emphasis placed on testing that all equipment at such location does function as it was designed and placed at that location.

The signal division has a Preventive Maintenance Program now in effect. This program provides the basic services that are suggested by the Manual on Uniform Traffic Control Devices. The department provides properly skilled maintenance on an annual and bi-annual basis that will minimize the interruption of signal operation due to equipment failure, and also increase public safety and reduce liabilities within the city of Fort Collins. The following is a list of the annual and bi-annual inspections that take place:

#### Traffic Signal Operations Test - Six Month Check (bi-annual)

- Controller Cabinet
- Controller
- Conflict Monitor
- All Timings
- Amplifiers (Loop)
- Pedestrian Buttons

#### Optics Cleaning and Inspection - Twelve Month Check (annual)

- Inspect heads for stress cracking
- Inspect lens, visors, reflectors, insulators for defects
- Replace parts where needed or document future needs
- Clean lens and reflectors for maximum lamination
- Adjust head angle if needed
- Tighten all hardware

#### Underground Inspection - Twelve Month Check (annual)

- **Inspect pull boxes**

- Inspect ground rod connections
- Inspect loop lead in connections
- Check pole grouting

Visual Appearance Check - Twelve Month Check (annual)

- Inspect visually entire intersection
- Wash pole and controller cabinets
- Repaint or touch up where needed
- Re-caulk controller cabinets

Opticom Optic Cleaning and Inspection - Six Month Check (bi-annual)

- **Clean Lens**

- Drive Test
- Card Test

Preventive Maintenance Program

Traffic Signal Operations Test - Six Month Check (bi-annual)

- Controller Cabinet
- Controller
- Conflict Monitor
- All Timings
- Amplifiers (Loop)
- Pedestrian Buttons

Optics Cleaning and Inspection - Twelve Month Check (annual)

- Inspect heads for stress cracking
- Inspect lens, visors, reflectors, insulators for defects
- Replace parts where needed or document future needs
- Clean lens and reflectors for maximum lamination
- Adjust head angle if needed
- Tighten all hardware

Underground Inspection - Twelve Month Check (annual)

- **Inspect pull boxes**

- Inspect ground rod connections
- Inspect loop lead in connections
- Check pole grouting
- Visual Appearance Check - Twelve Month Check (annual)
- Inspect visually entire intersection
- Wash pole and controller cabinets
- Repaint or touch up where needed
- Re-caulk controller cabinets

This program would cover all aspects of the signalized intersection including electronic operations, visibility of the signal faces, wiring underground for proper connections, and the total appearance of the traffic signal system.

#### Maintenance Program

The City of Fort Collins has been extremely fortunate to be able to upgrade nearly every traffic signal in the traffic signal system. Ninety percent of all -the City's traffic control equipment is ten years old or newer. In the same time period, the City installed a state-of-the-art master computer. With the new equipment, we have made substantial gains in the level of service we provide for the citizens of Fort Collins.

In addition to the upgrading of existing traffic signals, we have added a number of new traffic signals. This puts our total number of signalized intersections at 146, with an additional 35 mid-block pedestrian crossings and flashing school zones, as of 1999.

The signal division has a basic maintenance program in effect. This program provides some of the basic services that are suggested by the Manual on Uniform Traffic Control Devices. We provide properly skilled maintenance, available without undue delay, for all emergency calls, including lamp failures, on a 24-hour basis. We also respond to citizen complaints without undue delay. We repair or replace detector loops as soon as possible, (weather permitting) as well as providing adequate stand-by equipment to minimize the interruption of signal operation due to equipment failure.

The Traffic Signal Division has developed a preventive maintenance program, based on a four-point preventive maintenance test and inspection procedure.

This program will increase public safety and reduce tort liabilities, reduce the probability of signal malfunctions, and improve the appearance of the traffic signal system.

#### Warrants for Left Turn Phases

The City of Fort Collins has adopted a simple test to determine whether the left turns from an approach need a protected phase because of the magnitude of the traffic volume is to calculate the unprotected green time, which would be required. The following procedure can be used for this.

1. If the traffic counts available are for less than an hour, use the actual volumes, however, if they cover a period of an hour or more, multiply these volumes by 1.1 to 1.3 to account for random fluctuations.
2. Assume a reasonable cycle length.
3. Determine the number of cycles in the period under consideration.
4. Reduce the left turn volume by 1 to 1.5 vehicles times the number of cycles in the period under consideration to account for left turns that will clear an the yellow signal.

5. Determine the critical lane volumes per cycle for both the left-turns and the opposing through-movement.
6. Add the per cycle left turn volumes and the through volumes together and multiply by 3 seconds to obtain the needed unprotected green time necessary to accommodate the left-turns
7. If the needed green time is available in the cycle, taking into account all other needed phase greens and clearances, a protected left turn phase is not needed to satisfy traffic demand. It should not be used unless there is a accident problem or an obviously likely accident problem which would be prevented by protecting the left turns. If the analysis is being conducted with a view to removing an existing left turn phase, the left turn phase should be retained unless the needed unprotected green time is 85 percent or less of that which can be made available under unprotected operation.

Phase Change Intervals

The City of Fort Collins Transportation Division has adopted the following method to calculate the timing of the YELLOW AND ALL RED INTERVALS on the traffic signal system we are responsible to maintain and operate.

The equation that we are adopting is stated in the Traffic Control Devices Handbook Part IV, Equation 4-3; on page 4-102.

Phase Change Interval

$$CP = t + 2a + \frac{W + L}{V} + V \pm 64.4g$$

CP = nondilemma change period (yellow plus all-red), seconds

t = perception-reaction time, nominally 1 second

V = approach speed, feet per second (85th % or posted speed limit)

g = percent grade (positive for upgrade, negative for down- grade)

a = deceleration rate, nominally 10 feet per second/second

W = width of intersection, feet

L = length of vehicle, feet (normally 20 feet)

Because the total change period consists of both a yellow change and an all red clearance interval. It is suggested that the 'yellow change interval be equal to the first two terms of the equation rounded up to the next 1/2 second, but no less than 3 seconds and no greater than 5 seconds.

The last term of the equation is the suggested all red intersection clearing time, where:

- W is the width of the intersection in feet, measured from the upstream stop bar or crosswalk to the down stream edge of pavement or flow line.
- L is the length of the clearing vehicle, normally 20-ft.

- $V$  is the approach speed in fps and should take into account slow-moving vehicles if they are significant at some locations.

This criteria shall be applied to the through movements only, left-turn movements will be kept constant: 3 seconds of yellow change interval and 2 seconds of an all red clearance interval. The reason for this is due to the random approach speeds and the distances of the turning radius.

This policy, we believe will provide for a safer operation of traffic signals due to the fact that the all-red clearance interval will, be of sufficient duration to permit traffic to clear the intersection before conflicting traffic movements are released.

#### Operations of Protected/Permissive Left Arrows

The City of Fort Collins Transportation Division has implemented a policy regarding the operation of traffic signals as they pertain to protected/permissive left turn arrows.

The Division will provide a protected/permissive left-turn arrow when the established left-turn warrants have been met. The operation of these left-turn arrows shall be vehicle actuated, so as not to serve the arrow when there are no vehicles present. The Division will also provide a back up Protection operation. The Back-Up-Protection operation will assure that the left-turn arrow will only operate at the beginning of the associated through movement, and as long as the through movement green rests in green, there will be adequate gaps to make a left turn in the permissive portion provided.

#### Traffic signal operation study

The traffic signal operation study can generally be described as providing ongoing services to improve the traffic signal system within the City of Fort Collins by optimizing signal operations, examining leading/lagging left-turn phases at selected intersections, and reviewing flashing operation at various intersections during the nighttime.

The following is an outline of the study procedure:

#### Step 1. Create a Traffic Signal Database

- Collect turning movement counts (AM, NOON & PM PEAKS)
- Collect existing geometric conditions at Signalized Intersections.
- Collect A.D.T. Volumes for each intersection approach
- Use accident history along with A.D.T.'s to generate accident ratios per million vehicles
- Access to all existing timing plans, Time of Day, Cycle Lengths, Splits, Vehicle & Pedestrian Clearance times, Minimum Greens and Phasing Schemes

With this base of data it is possible to define operational characteristics of the traffic signal system and answer questions such as:

- **Where are the high accident Intersections?**
- What Arterial roadways have similar characteristics to aid in grouping?

Step 2. Using Highway Capacity Manual (Signals) Software

- Create signal files using above data base for (AM, NOON & PM PEAKS)

With this software it is possible to look at Basic Level of Service based on Delay. Also, potential geometric improvements. Saturation Flow Rates will also be generated to be used with other Programs.

Step 3. Create and Analyze Sub-groups, Networks, and Sub-Network Files

- Using Passer II-90 Software generate group arterial analysis files for (AM, NOON & PM PEAKS)

With this program it is possible to look at various Cycle Lengths, Bandwidths, Stops and Delay with relationship to the Arterial groups. We also compared the Measures Of Effectiveness (M.O.E.) of various phasing schemes: Leading, lagging or combinations of Leading and Lagging; Skipping Arrow Phases when the volume is >50 V.P.H.

Step 4. Use Transit 7F Database FOP, Network, or Sub-Network

- Using some Bandwidth Constraints that were illustrated with the Passer Model generate Network M.O.E.'s to Optimize Cycle Length, Splits & Offsets for (AM, NOON & PM PEAKS).

Using Transit 7F we were able to move from the Arterial type of Optimization to more of a Network approach and bring the whole system together. At this point we have generated Timing Plans with acceptable Phasing Schemes, Bandwidth Constraints, Pedestrian Needs and System Needs, and are ready to implement the Optimized Traffic Signal Timing Plans.

Step 5. Gather “Before” Traffic Flow Information

- Using a moving vehicle run analysis program, build a Data Base of Test Runs using the Moving Vehicle Approach and the average vehicle technique.
- Do Before Studies for (AM, NOON & PM PEAKS) for all arterial under consideration.

With the MVRAP Program, Distance Measuring Computer and a test vehicle set-up with Lap Top Computer interface these studies can be performed easily. The program out-put gives the M.O.E.'s Average Speed, Stops, Delays and Fuel Consumption.

Step 6. Implement New Timing Plans

- In implementing new timing plans it is important to establish a systematic approach, one that takes into consideration the implementation and fine-tuning processes.

Step 7. Fine Tuning the New Timing Plans

- Perform drive through studies, using test vehicle and MVRAP. Compare MOE's and Speed Profile to Time Space Diagrams. Observe approach vehicle stacking on all

approaches. Make adjustments where possible and where needed with out compromising your established goals and system needs.

Step 8. Gather “After” Traffic Flow Information

- After timing plans have been implemented, fine tuned and accepted, it is time to make your final analysis to see what if any improvements have been made. Again We will use the moving vehicle approach to give us an Arterial System Performance Evaluation and establish a New Base of Data to monitor, adjust and fine tune your current timing plans.

After weekday timing plans are completed for (AM, NOON & PM PEAKS) other plans may need to be developed for, Saturdays, Sundays, seasonal changes, and special events.

Step 9. Get Ready to Start Again

Construction Account Policies

Construction projects shall be estimated and account numbers assigned before any construction monies shall be spent. The estimates shall include labor cost, equipment operation cost, equipment replacement cost, material cost, and overhead. The equipment replacement and overhead cost shall be kept separate from normal accounting areas. The intent is that equipment replacement shall be carried over year after year and even though they might be shown in surplus revenues and not usable except for equipment replacement.

The equipment maintenance, labor, and material for each project are for each supervisor to use at his discretion. The estimates should agree with the final billing, although if project changes (decreases in work) happen the supervisor is responsible in seeing that the costs do not over run the final billing. The costs are based on actual cost determined from like previous projects.

The funds acquired are expected to pay for labor, equipment operation and maintenance, and all material needed to do the construction. Since certain costs, such as equipment maintenance involved with a blown engine, could use all funds available for one construction project, the supervisor should be aware of these costs and use funds accordingly.

Upon completion of the project, a final bill shall be processed. Any funds remaining shall be placed in a holding account. Use of these funds shall be approved by the Traffic Engineer or whomever he designates. The intent of any cost saving acquired by any project is these funds will be used by the division doing the construction since these savings are due to charges of labor or equipment which was used on the project and not fully charged to the project.

Construction Vehicles

In order to maintain cost, our vehicles shall be broken into two separate areas for billing purposes. The supervisors shall be responsible, through the construction accounts, to pay for all costs associated with all equipment used exclusively for construction. The vehicle

used for maintenance and operation shall be paid out of our normal budget. A list of all equipment, classifying their billing area, shall be made each May in order to budget for that equipment. Any construction, which can not be afforded through the construction accounts, shall be sold before the end of the year.

### **Signs and Pavement Markings**

#### Maintenance Equipment

- T204 Pick-up (signs)
- T205 Pick-up (paint)
- T231 Pick-up (large paint machine)
- SP230 Small Paint Machine
- NP201 Trailer
- NP231 Compressor
- NP235 Hydroblaster
- NP229 Post Puller
- Pioniar (post driver)
- Fabrication Machine (2)
- Paint Conditioners (2)
- Hacksaw
- Grinder
- Traffic Counters
- 1400 Watt Generator
- Cata-Quik Machine
- NP263 Duel Axle Utility Trailer (wire trailer)

#### Maintenance

- T224 GMC 1 Ton Van with Bucket
- T229 GMC 1 Ton Pick-up

#### Maintenance Test Equipment:

- **Tecktronics O-Scope**
- Mitchell Controller Tester
- Digital Volt-OHM-Meter
- CONSTRUCTION
- T218 1/2 Ton Ford Pick-up
- T208 2 Ton Ford Dump Truck
- T289 I Ton Ford Lift Truck SP215/NP200
- Series 30 Ditch Witch with Trailer
- SP230 Ingersoll Rand Air Compressor
- SP Concrete Saw
- NP231 Saw Trailer
- Allied Air Tool (hole, hog)
- Case Viber Max (tamper)
- NP263 Duel Axle Utility Trailer (wire trailer)

## Traffic Control Devices - Section 2-4

### General

Traffic control devices will be installed on all new streets accepted by the City for maintenance as set in these STANDARD SPECIFICATIONS.

### Traffic Control Signals

#### **Regulations and Code**

Electrical equipment will conform to the CDOT Standard Specifications for Road and Bridge Construction. In addition to requirements of the accepted plans, all material and work will conform to the requirements of the NEC and these STANDARDS AND SPECIFICATIONS.

#### **Inspection**

The Traffic Engineer will make inspection of all material and work. All material delivered to the site will be subject to inspection, prior to or during installation, as deemed necessary by the Traffic Engineer. The Traffic Engineer may request samples of certain materials from the factory or warehouse for testing purposes prior to delivery on the site. Material, which has been rejected by the Traffic Engineer, will not be delivered to the work site. Failure by the Traffic Engineer to note faulty material or workmanship during progress of the work will not relieve the Contractor of his responsibilities for removing and/or replacing faulty materials at his own expense if any such materials are found at a later date.

Any work within the public right-of-way will require two working days (twenty-four; 24) hours-prior notice to the City Engineer by the Contractor or Developer.

#### **Equipment Lists and Drawings**

The Contractor will submit to the City for review and acceptance a listing of all materials and equipment, which will be used in the work. The list will include the name of the manufacturer, size and catalog number of unit, and will be supplemented by other required data including detailed scale drawings and wiring diagrams of any nonstandard or special equipment and of any purposed deviation from accepted plans. If required by the City Engineer, the Contractor will provide samples of materials proposed for use.

All equipment listings and drawings will be submitted to the City Engineer for review and acceptance. The Contractor will perform no labor until the City Engineer has accepted all details and plans in writing to the Contractor.

All applicable portions of Section 141.00, Protection of Public and Utility Interests and Section 1042.00, Protection of Existing Structures and Utilities, of these STANDARDS AND SPECIFICATIONS shall apply.

The Contractor will furnish all materials, equipment and labor needed to install and maintain temporary traffic signals during progress of the work. All intersections presently signalized will be kept in operation until the new signal equipment is properly

installed and ready for operation. If in opinion of the Traffic Engineer this is not possible because the installation of new equipment is in the same location as existing equipment, the Contractor will not proceed with any work which will cause the present equipment to become inoperative until he has all necessary replacement equipment on hand.

Existing traffic signals will be kept in operation except when shut down due to changing over and connecting to new equipment. Work will be performed so that signal's will be in operation at the close of each day's work, over weekends, and during times when the Contractor is not working. When a signal is shut down, the Traffic Engineer will be notified in writing two working days ( forty-eight [48]) hours in advance of the proposed shut down.

### **Coordination with Other Agencies and Contractors**

It will be made that the Contractor coordinate his conduit work with all other utility companies with the city.

### **Maintenance**

The contractor will maintain the work during construction and until the work is accepted by Traffic Operations. Maintenance will constitute continuous and effective work prosecuted day by day, with sufficient equipment and personnel to complete the work in the shortest time and least disruptive manner.

## **Traffic Signal Conduits and Pull Boxes - Section 2-5**

### **Conduit**

#### **General**

All conductors will be run in conduit, except when run in metal poles. Conduit will be the rigid PVC type conforming to these STANDARDS AND SPECIFICATIONS. Conduit runs shown on the accepted plans are tentative as to routing and may be changed, as directed by the Traffic Engineer, to avoid underground obstructions. Any change in location from those shown on the plans will require the prior approval of the Traffic Engineer and must be accurately recorded on as-built drawings in accordance with Section 161.00, construction Plan Requirements of these STANDARDS AND SPECIFICATIONS.

Excavations for conduit will be two inches (2") wider than the outside diameter of the conduit. Backfilling of the conduit trenches will be accomplished in accordance with all applicable portions of Section 1050.00, Trenching Backfilling and compacting, of these STANDARDS AND SPECIFICATIONS. A nylon pull string will be left in each conduit run for any future pulling of conductors. When trenching in pavement, the cut in the pavement will be to as city Specification for Patching and Repair.

#### **Materials**

Rigid PVC conduit will be Schedule 40, type 2, as specified in NEC, and will be manufactured as high-impact type conforming to industry standards and commercial standard No.CS-207-60. Each length of conduit and all PVC fittings (expansion joints,

coupling adapter, etc.) Will bear the label of Underwriter's Laboratories, Inc. Conduit will be the size or sizes indicated on the accepted plans.

Rigid PVC conduit will be cut with a hacksaw and all ends squared and trimmed after cutting to remove rough edges. Connections will be the solvent weld type except where the connection is made to a steel conduit, in which case the coupling will be threaded on the metal conduit side.

Solvent weld joints will conform to the PVC manufacturer's recommendation. Rigid PVC conduit will be used only for underground installations; all conduits used above ground will be the rigid-galvanized-steel type.

A bare or green #10 AWG copper conductor will be run continuously in all conduit used for traffic signal circuits. This wire will be used for bonding and grounding purposes. Existing underground conduit that is incorporated into a new system will be cleaned and blown out with compressed air.

### **Installation**

Conduit will be laid to a depth of not less than thirty inches (30") below the curb grade roadway construction. Conduit under railroad tracks will not be less than forty-two (42") below the bottom of the tie, and/or as specified by railroad code. It will be the responsibility of the Contractor to obtain clearance from the Railroad Company prior to doing any work within the boundaries of the railroad right-of-way. The minimum size of conduit to be used will be shown on the accepted plans or as required on the wire layout sheets. Conduit smaller than three-fourths inch (3/4") electrical trade size will not be used unless otherwise specified on the accepted plans, except that grounding jumpers at service points may be enclosed in one-half inch (1/2") conduit.

It will be the option of the Contractor to use at his own expense larger size conduit if desired. Where larger size conduit is used, it will be used for the entire length of the run from outlet to outlet. No reducing couplings will be permitted in any conduit run. Conduits terminating in poles, cabinets, or pedestal bases will extend a maximum of four inches (4") and a minimum of two inches (2") above the foundation vertically, or will be sloped toward hand holes in poles or base opening where transformer bases are used.

Conduit entering pull boxes will terminate a minimum of one inch (1") and a maximum of three inches (3") inside the box wall and two inches (2") minimum of four inches (4") maximum above the bottom and will be sloped to facilitate convenient pulling of the wires or cables. Conduit entering through the side of a pull box will be located near the sides and ends of the box in order to leave the major portion of the box clear. Conduits will enter freely through boxes for allowance of expansion and contraction. Conduit required to be terminated, stubbed, and plugged will be shown on the plans as directed by the traffic engineer. All conduit ends will be capped with standard conduit caps until the wiring is started. When caps are removed, the threaded ends will be provided and approved insulated metal ground bushings. The location of all ends of conduit for future electrical circuits in curbs or structures will be marked by a "Y," which is at least three

inches (3") high, cut into the face of a curb, gutter, or wall directly above the conduit. These locations shall be shown on the "as built" drawings in accordance with Section 161.00, Construction Plan Requirements, of these STANDARDS AND SPECIFICATIONS.

Conduit bends, except for factory bends, will have a radius of not less than six (6) times the inside diameter of the conduit. Where factory bends are not used, conduit will be bent without crimping or flattening, using the longest radius practicable. Conduit entering without crimping or flattening, using the longest radius practicable conduit will be bent without crimping or flattening, using the longest radius practicable. Conduit entering controller cabinets will be packed with duct seal after wiring is installed to prevent the entrance of gases. Existing underground conduit to be incorporated into a new system will be cleaned with a mandrel and blown out with compressed air.

Conduit bends in all PVC conduit will be made to conform to all appropriate sections of the NEC or local codes governing bending radius and number of bends allowed, as applicable, for rigid conduit.

At many locations on the City's streets, it is desirable to have conduit installed for future use. When PVC conduit is specified, a galvanized, 12-gauge sheet metal plate twelve inches (12") square will be placed over each conduit end. Each end will be capped with PVC caps. Where a cap is indicated on the plans, a standard non-corrosive cap will be installed.

Conduit termination within a foundation will extend from two inches (2) to four inches (4) above the foundation vertically, and be installed in such a way that it will slope towards the hole opening. All galvanized rigid conduit terminations within pull boxes will be fitted with insulating bushings to prevent chafing of wire on exposed edges.

All conduit ends will be capped with standard conduit caps until wiring is started. When caps are removed, threaded ends will be protected with approved insulated metal ground bushing or insulated bushings if the conduit run is not extended from the threaded end and sealed by duct seal material.

#### Traffic Signal Conduit

##### **General**

Underground utility information shown in the plans is for information only. The Responsible Party is responsible for field locating and verifying utility information before starting installation of underground conduit runs.

Responsible Party shall cooperate, as directed by the Traffic Engineer with any other Responsible Party under contract to the City.

Electrical conduit shall be installed in accordance with the applicable requirements described in the latest revision of the CDOT A Policy on the Accommodation of Utilities on Colorado ROW, as amended.

Larger size conduit can be used, at the Responsible Party's option and own expense. Where larger size conduit is used, it shall be for the entire length of the run from outlet to pull box or from pull box to pull box. No reducing coupling shall be permitted in any conduit run.

When specified, conduits shall be installed under existing pavement by jacking or drilling operations. Where plans show that existing pavement is to be removed, jacking the conduit shall not be required. Jacking or drilling pits shall be kept a minimum of two (2) feet clear of the edge of the pavement whenever possible. Water shall not be permitted as an aid in jacking or drilling operations.

Conduits shall be of the rigid plastic (PVC) type or of the galvanized rigid steel (GRC) type conforming to the plans and these specifications. Conduit runs shown on the plans are tentative as to routing and may be changed as directed by the Traffic Engineer to avoid underground obstructions. In the event of any change from the location shown on the plans, accurate records shall be incorporated into the as built drawings shall be submitted to the Traffic Engineer.

All conduit installation shall include the installation of marking tape laid in the backfilled trench at a depth not more than eight (8) inches or less than four (4) inches below finished grade. Heavy gauge polyethylene film 0.004" tape, with legend "Caution Buried Electric Line Below," shall be used. Where tape length ends and conduit run continues, lapping of not less than six (6) inches shall be provided. No glue or adhesive shall be allowed to join separate tape sections.

### **Nonmetallic Conduit (PVC)**

Rigid PVC conduit shall be Schedule 40, Type 2 and shall be manufactured of high-impact PVC, and shall conform to industry standards and commercial standards No. CS-207-60. Each length of PVC conduit and all of the various PVC fittings (coupling, adapter, etc.) shall bear the label of UL or be approved by the Traffic Engineer. The conduit shall be of the size or sizes shown on the plans or indicated in these specifications.

Rigid PVC conduit shall be cut with a hacksaw and all ends shall be squared and trimmed after cutting to remove rough edges. All connections shall be of solvent weld type except where PVC is to be connected to a steel conduit, in which case the coupling or adapter shall be threaded on the steel conduit side.

Solvent weld joints shall be made in accordance with the PVC manufacturer's recommendations. Rigid PVC conduit shall only be used for underground installations; all conduit used above ground shall be of the rigid-galvanized steel type.

### **Galvanized Rigid Conduit (GRC)**

Steel conduit and fitting shall be rigid galvanized steel and shall be uniformly and adequately zinc-coated by the hot-dipped process conforming to ASTM Designation A153. Joints shall be set up tight with squared ends. Fastenings shall be secured and of a type appropriate in design and dimensions for the particular applications. Couplings, connectors and fittings shall be approved types specifically designed and manufactured for the purpose. Fittings shall be installed to provide a good electrical ground throughout the conduit system. The interior and exterior of a six (6) inch sample cut from a center of a standard length of a conduit, when tested in accordance with the applicable portion of ASTM Designation A239, shall not show a fixed deposit of copper after four (4) one (1) minute immersions in the standard copper sulphate solution. The interior of the rigid conduit shall have a continuous coating of lacquer or enamel. Each length shall bear the label of UL and shall conform to appropriate articles of the NEC.

The end of all metallic conduits shall be threaded and well-reamed to remove burr and rough edges. Field cuts shall be made together for the full circumference. Slip joints or running threads shall not be permitted for coupling conduit. When a standard coupling cannot be used, weather proofed threaded three-piece union shall be used. All three-piece unions must be threaded; non-threaded couplings shall not be accepted.

The threads on all conduits shall be well painted with a good quality lead or rust-prevented paint before couplings are made up. All couplings shall be tightened until the ends of the conduits are brought together so that a good electrical connection shall be made throughout the entire length of the conduit run. Conduit stubs caps and exposed threads, as well as any point along the surface of the conduit that has been injured in handling and installation, shall be painted with good quality asphalt bituminous or other paint suitable for the purpose.

### **Installation Methods**

Conduit sizes and locations shall be as shown on the plans. Conduits shall be stubbed and capped for future use where shown on the plans or where specified in these specifications.

Extending underground conduit to be incorporated into a new system shall be cleaned with a mandrel or cylindrical wire brush and blown out with compressed air.

Conduits terminating in poles, cabinets or pedestal bases shall extend a maximum of three (3) inches and minimum of two (2) inches above the foundation vertically, and shall be sloped toward handholds in poles or base openings where transformer bases are used. Conduit entering pull boxes shall terminate a minimum of three (3) inches above the bottom of the box.

Ninety (90) degree long radius elbows shall accomplish all conduit ends. Where two (2) or more conduits meet, all ninety (90) degree long radius elbows shall be bought together in the center of the pull box or cabinet foundation. Conduit shall only enter through the

bottom of a pull box. All galvanized rigid conduit termination within pull boxes shall be fitted with an end coupling as well as insulation bushings to prevent chafing of wire.

Conduits required to be terminated, stubbed and plugged shall be as show non the plans and as directed by the Traffic Engineer. All conduit ends shall be capped with standard conduit caps.

The location of all ends of conduit for future electrical circuits under curb, gutters, sidewalks, or structures shall be marked by a “y” at three (3) inches high, cut into the face of the curb, gutter or structure directly above the conduit.

All metal type conduit ends shall be threaded and shall be capped with standard pipe caps until conductors are in place. When caps are removed, the threaded ends shall be provided with conduit bushings. Non- metallic type conduit ends shall be capped with a standard PVC cap until conductors are in place.

Conduit under railroad tracks shall not be less than forty-two (42) inches below the bottom of the ties and/or as specified by railroad code. It shall be the responsibility of the Responsible Party to obtain clearance from the Railroad Company prior to performing any work within the boundaries of the railroad ROW. The minimum size of conduit to be used shall be shown on the plans.

Conduit installed outside of the traveled portion of the roadway and out of future roadway areas shall be laid as follows: maximum depth of thirty (30) inches and a minimum depth of twenty-four (24) inches.

### **Excavation and Back filling**

The excavations required for the installation of conduit shall be performed in such a manner as to avoid unnecessary damage to streets, sidewalks, and landscaping and other improvements. Trenches shall not be excavated wider than necessary for the installation of the electrical appurtenances. Excavation shall not be performed until immediately before installation of conduits. The material form the excavation shall be placed in a position not to cause damage or obstruction to vehicular or pedestrian traffic or interfere with surface drainage. Trenches outside the traveled portion of the roadway shall be backfilled with a granular material as approved by the Traffic Engineer, in six (6) inch lifts and each lift compacted. Trenches within the roadway area shall be backfilled with CDOT approved slurry.

Excavations in the street or highway shall be performed in such a manner that not more than one (1) traffic lane is restricted in either direction at any time, unless otherwise permitted by the Traffic Engineer. A minimum of one (1) lane of traffic must be kept open for each direction at all times.

Trenches shall be made with a Rockwell or other machine capable of cutting a narrow trench (four (4) inches) so as to allow traffic to pass over it prior to backfilling. The

machine shall be equipped with shields to direct the soil downward and away from passing vehicles, workers and pedestrians.

Excavation at intersections being reconstructed or improved shall be excavated and backfilled before other improvements are completed as so to not require the repair or replacement of newly installed sidewalks, curbs and gutters, pavement or landscaping.

The one and one-half (1-1/2) inch PVC conduit for system sampling detectors as shown on the plans shall be handled in the following manner:

The trench for this item shall be backfilled with the same material that was removed and shall be compacted and shaped to match the surrounding surface. Standard backfilling of trenches across paved roadways, bike paths and sidewalks shall be filled with CDOT approved slurry mix.

Prior to backfilling, the Traffic Engineer shall inspect the trench, conduit and tape placement. Under no circumstances shall the trench be filled without inspection and approval.

#### Pull Boxes

##### **General**

Pull box locations shown on the plans are approximate. The Traffic Engineer shall determine the exact location in the field, for long runs. They shall be spaced not over one hundred fifty (150) feet apart from each other.

It shall be the opinion of the Responsible Party, to install additional pull boxes desired to facilitate its work, at the expense of the Responsible Party.

Pull boxes shall be a Quazite type concrete fiberglass reinforced of a size approved by the Traffic Engineer, or as approved by the Traffic Engineer. Pull boxes must have lids with the words "Traffic Signal" printed on them.

##### **Installation**

Pull boxes shall be at least two sizes. Pull boxes used for loop detectors on sampling stations shall be a minimum of 13.5 inches wide by 20.5 inches long by 20.5 inches long by twelve (12) inches deep. Pull boxes used at all junctions of roadway conduit crossing and at the controller cabinet shall be a minimum of twenty and one-eighth (20 1/8) inches wide by fifteen (15) inches deep. Use of two (2) pull boxes in place of the larger one shall not be permitted. Steel type pull boxes shall be of similar may be approved by the Traffic Engineer.

All pull boxes shall be or equal to the "Composolite" by Quazite. Enclosure and covers shall be concrete gray color and rated for no less than five thousand (5,000) lbs. Over a ten (10) inch by ten (10) inch area and tested to a temperature of minus fifty (-50) degrees Fahrenheit. Material compressive strength shall be no less than eleven thousand (11,000) psi.

Where practical, pull boxes shown in the vicinity of curbs and gutters shall be placed along the side of the foundations as shown on the plans. The cover of the pull box shall be installed level with the finish grade. The bottom of all boxes shall rest on firm ground with twelve (12) inches of three-quarter (3/4) inch to two (2) inch river run rock below pull box for drainage.

Pull boxes installed in a sidewalk must be tied into the sidewalk to prevent the boxes from being pushed down below the top of the sidewalk.

Pull box-special shall be a water valve stem type pull box made of cast-iron or steel. The pull box shall have the capability of accepting riser rings for future overlays. The lid shall have the word "Traffic" cast into lid.

Care shall be taken during backfill compaction to prevent collapse of the tube.

At least two (2) inches of slack for both feed and loop wire is to be provided so that all testing and splicing can be done outside of the pull box.

Pull box lid is to be sealed watertight by caulking after the loops have been installed, tested and accepted by the city.

## Cable and Conductors - Section 2-6

### General

Cable and conductors will conform to the applicable specifications of the IMSA and to those specifications shown on the accepted plans or as approved by the Traffic Engineer.

All wire furnished to or for the city will carry the label of the Underwriters Laboratories, Inc. This label will be present on each reel, coil or container of wire unless otherwise specifically approved by the Traffic Engineer.

Insulated conductor will be shipped in splice-free continuous lengths, in cartons or on new-bolted-type non-returnable reels plainly and indelibly marked with the name of the manufacturer, net weight, size (AWG) and length of the wire. **ABSOLUTELY NO SPLICES OF ANY KIND WILL BE PERMITTED IN THE WIRE.** A heavy covering of cardboard or burlap will be used to protect the wire and reels, during shipment and handling.

### Multi-conductor Cable

Where multi-conductor cable is required, IMSA Specification 19.1 polyethylene-insulated, polyvinyl chloride-sheathed signal cable will apply, except that the conductors will be stranded.

Conductor color-coding will conform to Table II of IMSA specification 19.1 for unpaired conductor cables. Color-coding for tracers will run spiral and be impregnated into the conductor insulation.

### **Installation Methods - Wiring**

Wiring will conform to appropriate articles of the NEC and NEMA code. Wiring within cabinets, junction boxes, etc., will be neatly arranged and laced. Flaxsoap, or other approved lubricants, may be used for inserting conductors in conduit. No splices of cable will be permitted in the conduit, which is outside of pull boxes, splice boxes, standard or pedestals.

In all signal designs, separate conduits will be shown for separate low voltage and high voltage conductors on the plane. Signal conductors must be run conduits separate from the low voltage detector lead-in or from the telephone interconnection.

Signal Conductor Type wire will not be used for wiring signal heads.

All loop detector wires will be pulled continuously for the full extent of the run from loop detectors to the cabinet with no splicing allowed in the runs. The Contractor will perform his pulling operation in a manner so as to facilitate pulling the wire in continuous runs.

Required tags will be furnished and installed by the Contractor at cabinet locations, at pull boxes, and at terminating pints, or as directed by the Traffic Engineer. A permanent tag of fiber or PVC will be used for tagging all wires. Tags will be marked as indicated on the wire layout sheets and will indicate the direction of the run and pole number of other locations of identified as spare with appropriate numbers as shown on the layout sheets. The ends of the spare wires will be pulled into the terminal compartment or cabinet.

All wiring between the controller and the signal faces will be done with multi-conductor cable. The individual conductor will be 14 gauge stranded copper wire. Separate multi-conductor cables for each signal phrase will be run around the intersection and marked with colored phasing tape at the controller and at each splice point in the pull boxes and pole bases.

Unused conductors will be folded back on the cable and securely taped.

#### **Connections to Signal Heads, Pushbuttons, and Traffic Controllers**

All cable wires will be secured to screw-type terminals in the traffic Signal Heads, pedestrian pushbuttons, and the traffic controller. The connectors will be the shade-tongue type and affixed to the conductors using a tool designed specifically for the connection of the connectors to the conductors.

### **Wire Splicing**

Splices will only be made in pullboxes or pole bases. All splices made in pull boxes will be bundled together, and the bundle and all exposed conductors will be joined with a wire nut.

All splices of individual conductors will be soldered and connected with appropriately sized wire nuts and taped in bundles with electrical tape covering the wire nuts to the point where the outer insulation of the multi-conductor cable was cut. Loop detector and lead-in wire will run continuously from the loop detector to the controller terminals without splicing.

The electrical service connections will be made by the City of Fort Collins Light and Power. The Contractor will furnish two conductor 6-gauge wire from the controller to the pull box, leaving two (2") extra of wire in the pull box. The Contractor will be responsible for coordinating the service connection with all Utility Agencies.

### **Wire Bonding and Grounding**

Metallic cable sheaths, conduit, metal poles and pedestals will be bonded to form a continuous and effectively grounded system. Bonding jumpers will be # 10 AWG copper wire, or larger, as required. Grounding of conduit and neutral at the service point will be # 8 AWG copper wire or larger, as required. At each controller, a ground rod (electrode) will be installed. Each ground rod will be a one-piece solid rod of the copper-weld type, a minimum of one-half inch (1/2") in diameter and eight feet (8") in length. This rod will be driven into the ground to a minimum depth of seven (7) feet below the surface. The ground wire will be completely spliced together at the aforementioned termination point and will tie into the neutral bar at the service facility, load center cabinet, or control cabinet, to become a true and functioning common bond.

Conductors, Cables, and Loop Detectors

### **Installation and Identification**

Aerial cable shall be installed where specified on the plans and secured to messenger cable with cable tie or rings. No self-supported cable shall be installed unless that cable is specifically designed for the purpose. Drip loops shall be provided on all conductors where they enter pole weather heads or signal heads.

Conductors shall be permanently identified as to function. Identification shall be placed on each conductor, or each group of conductors comprising a signal phrase, in each pull box and near the end of terminated conductors.

Identification shall be by bands fastened to the conductors in such a manner that they shall not move along the conductors.

All cables and conductors not shown on the plans as aerial cable or imbedded loop detector shall be installed in conduit unless installed in poles, pedestals or mast arms.

## **Codes**

Grounds and bonding wire, straps, and electrodes shall conform with NEC Article 250.

Wiring and splices shall conform to appropriate article of the code. Wiring within cabinets, junction boxes, etc. shall be neatly arranged and shall be laced within cabinets.

Conductors shall be stranded, tinned copper wire, rated at six hundred (600) volts and individually insulated with heat stabilized polyethylene. Conductors and cables shall conform to specifications 19-1 of the IMSA.

## **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 bare copper wire or copper strap of the same cross sectional area, No. 8 American Wire Gauge (AWG), for all systems. Sheath for detectors shall be grounded on control cabinet only, the other end of the sheath shall be taped and left ungrounded.

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

A ground electrode shall be installed at each control box. Each ground electrode shall be one-piece copper-weld rod of five-eighths (5/8) of an inch diameter and eight (8) feet in length, driven to a depth of at least eight (8) feet below the surface of the ground (top of rod flush with ground or top of cabinet base).

The ground terminal of controller shall be connected to the ground rod with a No. 8 AWG bare copper wire with an approved ground rod clamp.

## **Wire Splices**

Splices in underground systems shall be hermetically sealed. All splices shall be waterproofed by dipping the splice into Scotchkote after splice has been made and circuit checked.

## **Installation Method**

Sufficient signal light conductors shall be provided to perform the functional operation of signal system. Additional conductors for service interconnect, etc., shall be provided as noted on the plans.

Signal light conductors shall conform to the Red-Yellow-Green color sequencing with different colored tracers for each phase provided. Three (3) spare conductors per through-phase shall be provided throughout the signal light circuit. All signal light cable conductor shall have individual terminal lugs for connection to terminal strips.

When conductors and cables are pulled into the conduit, the ends of all these conductor and cables shall be taped to exclude moisture and shall be so kept until the splices are made or terminal appliances attached. Ends of spare conductors shall be taped to exclude moisture.

Powdered soapstone, talc, or other approved lubricant shall be used in placing conductors in conduit. One-half (1/2) inch nylon pull rope shall be installed in all new conduit and all existing conduit where a cable is added or an existing cable is replaced. At least two (2) feet of pull rope shall be doubled back into the conduit at each termination.

Five (5) feet of slack shall be left for each conductor at each support pole and two (2) feet of slack at each pull box containing cable connections. Splicing of cable shall not be permitted in the conduit or outside of pull boxes, standards or at the handhold location in pedestals.

Multi-conductor cable shall be spliced and insulated to provide a watertight joint to prevent absorption of moisture by the cable.

### **Span Wire Cables**

All span wire cables shall conform to CDOT Standards, including tether cables. Aluminum cables shall not be allowed.

### **Loop Detectors**

#### **General**

Loop detectors shall be installed in the configuration shown on the plans. The Traffic Engineer shall determine actual layout. A complete installation consists of a conductor loop or group of loops installed in saw cuts in the roadway, lead-in Beldon cable and a sensor unit with power supply installed in the traffic signal controller cabinet.

Low voltage signal circuits shall have no more than one splice in each detector sensing circuit. Cable sheath for detectors shall be grounded in control cabinet only; the other end of the sheath shall be taped and ungrounded.

All loops are to be made using duct-type wire, 14THHN copper stranded inside a one half (1/2) inch O.D. Polyethylene jacket or a one half (1/2) inch O.D. PVC jacket.

#### **Installation Method**

The saw cut shall be made one half (1/2) inch wide and minimum of three (3) inches deep. The slot shall be as straight as possible and shall not vary more than one-half (1/2) inch when checked with a ten-(10) foot straightedge.

Saw cuts shall be blown free of standing water and debris with compressed air. The cut shall be as dry as possible prior to placement of wire.

After saw cut is cleaned from debris, the wire shall be placed in the loop by pushing it in the slot with a blunt non-metallic object. A screwdriver or other sharp tools shall not be

used. Care shall be used to avoid abrading or damaging the installation.

One continuous length of wire shall be used for each loop from the pull box around the loop with the specified number of turns and back to the pull box. There shall be three (3) twists per foot in the loop wire when pulling the wire through the conduit into the box.

After the loops are properly seated, they shall be tested for continuity and proper loop inductance. The loop slot shall then be sealed with a high-grade sealant. Sealant shall be a one-part formula only 3M Sealant or approved equivalent), made specifically for sealing traffic loops. This sealant shall remain permanently flexible and be non-shrinking to assure maximum protection after installation.

The loop detector wires shall be spliced to the shielded lead-in cable in the pull box and pulled into the controller cabinet via the shortest possible distance using existing conduit. A minimum of three (3) shall be provided in the controller cabinet for attachment to the detector amplifier. Each detector cable shall be clearly labeled in the cabinet, identifying phase relationship and approach leg.

A minimum one and one-half (1 1/2)-inch conduit shall be placed under the curb and into a pull box to accommodate detector loop wires. Conduit shall have a drain "T and Weep Hole" at the lowest point of the run under the curb to facilitate drainage. Conduit may be "pushed" or trench-laid, depending on conditions at projects site and upon approval from the Traffic Engineer. Special traffic-type loop pull boxes in the roadway shall be installed at the locations shown on the traffic signal plans.

### **Detector Lead-in**

All detector lead-in cable shall consist of two (2) No. 14 AWG copper conductors with each conductor insulated with high molecular weight, heat stabilized, colored polyethylene. The conduits shall be a twisted pair (Beldon 8720) and shall be protected with a shield of tinned copper-brass or aluminum-polyester. A No. 16 AWG minimum, stranded tinned copper ground wire shall be provided. The cable shall be provided with a chromedvynal outer jacket with a minimum thickness of thirty-seven (37) mils, suitable for use in conduit or for direct burial when used in conjunction with magnetic or magnetometer detector.

Sampling station detection shall be through separate lead-ins for each lane of detection. Sampling stations shall not consist of loops tied together and run into the controller on a single lead-in pair.

### **Alternative Round Loop Detector Configurations**

As a alternative to the six (6) foot by forty (40) foot rectangular shaped loop detectors, two (2) six (6) foot round loop detector configuration may be proposed by the Responsible Party.

A plan of the alternative loop detector configurations and pull box locations shall be prepared by the Responsible Party for approval by the City prior to installation. If proposed, the six-(6) foot round traffic loop detector cable shall conform to the following specifications:

The Responsible Party shall core drill a round traffic signal loop to be six (6) feet in diameter x .500 inches width x 3.0 inches in depth. A saw cut shall be provided to the appropriate pull box within fifty (50) feet. The saw cut shall be .250 inches in width x 3.5 inches in depth.

All cuts shall be washed cleaned. Water and slurry shall be vacuumed out, leaving a clean and dry loop area. A performed loop wire made of Detecta -Duct Traffic Signal loop wire or approved equivalent shall be stacked in the cuts and secured from footing. All cuts shall be sealed with a high grade sealant. Sealant shall be one part formula only made specifically for sealing traffic signal loops.

A performed loop shall consist of three (3) six (6) foot diameter turns of loop wire, laid one loop on top of the of the other and glued so each loop remains in place. The tails in the loop that run to the pull box shall be approximately fifty (50) feet.

## Signal Hardware - Section 2-7

### General

Signal equipment shall be manufactured in the United States using domestic materials and be designed to operate from a one hundred fifteen (115) volt sixty (60) cycle single-phase source.

All traffic signal equipment shall be designed to operate between an ambient temperature of minus forty (-40) degrees Fahrenheit to plus one hundred sixty-five (+165) degrees Fahrenheit, with relative humidities up to ninety-five (95) percent.

All signal faces installed prior to final turn-on of the system shall be covered to clearly indicate that the signal is not operational. The covering shall be over the entire head and shall be securely fastened. No adhesive used to secure the head covering shall touch any part of the head or mounting assembly.

Adjustable face vehicle traffic control signal heads and associated equipment shall conform to the general specification and definitions contained in the latest issue of Technical Report No. 1, prepared by ITE and as shown on the plans.

Adjustable face pedestrian signal heads and associated equipment shall conform to the general specifications and definitions contained in the latest issue of Technical Report No. 5, prepared by ITE and as shown on the plans.

All exterior parts of die cast aluminum pedestrian signal heads requiring paint shall be painted Federal Highway (yellow) for standard installation. All polycarbonate type

vehicular signal heads shall be colored Federal Highway (yellow) for standard installation.

All signal hardware to be furnished under this bid shall be of standard design and manufacture. No special fittings and/or components shall be used or furnished which are not shelf type items by the manufacturer and/or vendor.

Traffic signal lamps shall conform to the general specifications and definitions contained in the latest issue of Technical Report No. 6, prepared by ITE. Lamps shall be rated for operation at 120V AC. Lamp wattages shall be sixty-nine (69) watts for all eight (8) inch traffic signals and one hundred and fifty (150) watts for all twelve (12) inch traffic signals. All twelve-(12) inch yellow arrows and clamshell pedestrian heads shall be one hundred and sixteen (116) watt bulbs. LED's will be encouraged.

All vertical signal faces and pedestrian signal faces shall be of the adjustable, vertical type as shown on the plans. They shall provide light indication in one direction only and shall be adjusted through three hundred sixty (360) degrees about a vertical axis.

All mast arm mounted heads shall be mounted at the location determined by the Traffic Engineer. No holes shall be placed in the mast arms until actual head location has been determined in the field by the Traffic Engineer.

Unless otherwise shown by the approval plans, traffic faces shall be standard and shall contain three (3) sections arranged vertically; red-top; yellow-center; green-bottom.

All vehicle faces shall be focused to allow maximum visibility to approaching motorists. All signal heads installed at anyone intersection, shall be of the same make and type, unless otherwise stated by the bid Special Provisions, these Special Functions, or by the Traffic Engineer.

#### Programmable Adjustable Face Twelve (12) Inch Signal Heads (Optically Programmable Signals)

Optically programmed signals shall permit the visibility zone of the indication to be determined optically and required no hoods or louvers. The projected indication may be selectively visible or veiled anywhere within fifteen (15) degrees of the optical axis. No indication shall result from external illumination, nor shall one light illuminate a second.

Components of the optical system shall comprise:

- Lamp
- Lamp collar
- Optical limiter-diffuser
- Objective lens

The lamp shall be nominal one hundred fifty (150) watt, 115V AC or seventy -five (75) Watt, 120V, three-prong sealed beam, having an integral reflector with stippled cover and an average rated life of six thousand (6,000) hours when operated in a Optically Programmed Signal according to the manufacture's specifications.

The Optical limiter shall provide an accessible imaging surface at focus on the optical axis for objects nine hundred (900) to 1,200 feet distance, and permit a effective veiling mask to be variously applied as determined by the desired visibility Zone. The optical limiter shall be provided with positive indexing means and composed of heat resistant glass.

The objective lens shall be a high-resolution annular incremental lens hermetically sealed within a flat laminant of weather- resistant acrylic, or approved equivalent. The lens shall be symmetrical in outline and maybe rotated to a 90-degree orientation about the optical axis without displacing the primary image.

The optical system shall accommodate projection of diverse, selected indication to separate portions of the roadway such that only one indication shall be simultaneously apparent to any viewer. The projected indication shall conform to ITE transmittance and chromaticity standards.

#### Construction

Die cast aluminum parts shall conform to ITE alloy and tensile requirements and have a chromate preparatory treatment. The exterior of the signal case, lamp housing and mounting flanges shall be finished with a high-quality baked acrylic finish paint. The lens holder and interior of the case shall be optically flat black.

Signal case and lens holder shall be pre-drilled for backplates and visors. Hinge and latch pins shall be stainless steel. All access openings shall be sealed with weather-resistant rubber gaskets. Each section shall have two (2) drain holes.

Sheet metal parts, including visors and backplates, shall conform to ITE material requirements, and shall include a chromate preparatory treatment and optical flat black on all surfaces, unless otherwise specified.

#### Mounting

The Signal shall mount to standard one and one-half (1-1/2) inch N.P.T. fittings as a single section, a multiple section face, or in combination with other signals. The signal section shall be provided with an adjustable connection that permits incremental tilting from zero (0) degrees to ten (10) degrees above or below the horizontal, while maintaining a common vertical axis through couplers and mounting. Terminal connection shall permit external adjustment about the mounting axis in five-degree increments. The signal can be installed with ordinary tools and serviced with no tools.

Attachments such as visors, backplates or adapter shall conform and readily fasten to existing mounting surfaces without affecting sealing and light integrity of the signal.

### Electrical

Lamp fixture shall comprise a separately accessible housing and integral lamp support, indexed ceramic socket and self aligning, quick-release lamp retainer. Electrical connection between case and lamp housing shall be accomplished with an interlock assembly, which disconnects a lamp housing when opened. Each signal section shall include a covered terminal block or screw attachment of field wires. Concealed # 18 AWM, Stranded and coded wires shall interconnect all sections to permit field connection within any section.

### Photo Controls

Each signal section shall include integral means for regulating its intensity between limits as a function of individual background illumination. Lamp intensity shall not be less than ninety-seven (97) percent of uncontrolled intensity at one thousand (1,000) foot candle (ft-c.) and shall reduce to fifteen (15) plus two (2) percent of maximum at less than one (1) ft-c. over the applied voltage and ambient temperature range. Response shall be proportional and essentially instantaneous to any detectable increase from darkness to one thousand (1,000) ft-c. and damped for any decrease from one thousand (1,000) ft-c.

The intensity controller shall comprise an integrated, directional light sensing and regulating device interposed between lamp and field wires. The device shall be responsive over an applied voltage of 95V to 130V, 60 Hz. temperature range of forty (40) degrees Fahrenheit to one hundred sixty-five (165) degrees Fahrenheit and may provide phase controlled output voltage, but shall have a nominal open circuit terminal impedance of one thousand (1,000) Ohm.

### Installation

The signal should be installed, directed and veiled in accordance with published instructions and the Traffic Engineer's visibility requirement. Each section of the signal should be masked with prescribed materials in an acceptable and workmanlike manner.

### Non-Programmable Signal Heads

All signal heads, eight (8) inch, twelve (12) inch, and combination eight (8) inch and twelve (12) inch shall be cast aluminum and shall come complete with mounting opening plugs, washers and gaskets for mounting. Heads shall be highway signal yellow in color (both faces and housings). Visors shall be aluminum and shall be highway yellow for outside and flat yellow inside.

Pedestrian Signal heads shall be I.C.C. eighteen (18) inch clamshell mounting type, (Portland Orange and Lunar White). Units shall be highway yellow in color. Units shall come complete with a combination cut out and/or honeycombed visors, to prevent sun washout. Units are to be incandescent.

## Mounting Hardware - Section 2-8

#### Mast Arm Mounts

Signal head placement as shown on the plans are representative only. All mast arm signal head mounts shall be of an Astro Type mount. Each head shall be mounted with a separate mount. Horizontal clustering of two (2) arrowed heads next to a three-section standard head shall be permitted on one Astro Type signal mast arm mount.

#### Side of Pole and Top of Pole Mounts

One-way side and top mounts shall be either bronze or malleable iron and shall be highway yellow in color. Two-way side mounts for signal and pedestrian signal heads shall be bronze or malleable iron, and shall be highway yellow in color. Two-way signal head mounting assemblies shall use a "T" fitting in the center frame pipe in lieu of a drop nipple from the top.

#### Backplates

Backplates shall be furnished and installed on all vehicular signal heads. No background light shall show between the backplates and the signal face or between sections of the signal head.

Backplates shall be either all one piece or sectional. Sectional backplates shall be riveted together. No screws shall be allowed for putting backplates together. Backplates shall be five (5) inches in width unless otherwise approved by the traffic Engineer. Backplates shall be louvered to allow airflow and yet not permit background light to be visible to the motorist. Backplates shall be painted Fat Black. Backplates shall be installed to the signal head using the appropriate screws and one-quarter (1/4) inch zinc plated flat washers.

#### Push Button Stations

Pedestrian push buttons shall be of the direct push button contact type. They shall operate on a voltage not to exceed 18V AC. They shall be of tamper-proof design and equipped with a push button instruction sign. Button frames shall be painted yellow.

The assembly shall be weatherproof and constructed so it shall be impossible to receive any electrical shock under any weather conditions.

The pedestrian push button instruction sign shall include informational text To Cross Push Button, Start Crossing (graphic of walking man) Watch for Turning Cars Flashing - Don't start (graphic of hand) – finish.

#### Controller and Cabinet Specifications

820-VMS controller and cabinet assembly consisting of the following:

- The NEMA, 820-VMS Controller is a two-to-eight phase (with pedestrian Service on all phases), four overlap, dual-ring controller.
- NEMA Controller Cabinet Type P aluminum cabinet in accordance with NEMA 3R rating and UL listed.

Including the following:

- **Four (4) Model 430 transfer relays**

- One (1) Model Midtex 136-62T3A1 120 VAC, 30 AMP
- Twelve (12) Model 200 load switches (twenty-five (25) AMP cube type)
- Six (6) Model 262 Detector System dual loop amplifiers
- One (1) NEMA Conflict Monitor LCD-12P
- One (1) front fluorescent lamp assemblies
- A switch (police door) compartment, with removable back panel, shall be supplied on the outside of the cabinet main door.
- One (1) Transient voltage surge suppression system
- One (1) Model 752 opticom discriminator
- Radio interference suppressor (RIS) shall be supplied
- A mercury contractor shall be used to switch AC power on load bay
- Crossing if Started, Steady (graphic of hand)- Pedestrians Should Not Be in Crosswalk.
- Sign dimensions shall conform to mounting frames as shown in details.

#### Electronic Equipment

All loop detector amplifiers shall be two-channel plug in type, which incorporates digital output timing functions. The timing functions are Delay and Extension. All amplifiers shall have both pulse and presence for each channel to be set by thumb wheel switching only. All amplifiers shall have sequential scanning for elimination of cross talk.

- Emergency Vehicle Pre-empt - Opticom No. 711 and 752(3M) units shall be used exclusively.
- Conflict Monitor - The conflict monitor shall be a NEMA Standard TS-1

#### Illuminated Overhead Signage

The internally illuminated signs are for “Naim-Inter Mark II, doubled faced logo and guide. These may be fabricated or of the general type manufactured by Nu-Art lighting and Manufacturing Company, Salt Lake City, Utah; or WinkoMatic signal Company, Avon Lake, Ohio. Some manufacturers fabricate standard sizes of those signs required on the plans. All signs on any single project or at any specific location shall be from the same manufacturer or fabricated.

The face of the panel shall be “Lexan” or an approved type of sufficient thickness to permit minimum deflection, as certified by the manufacturer. All faces shall be of the same material. Colors shall be standard approved colors for highways signs. The colors shall be white, green and blue applied on the interior sign face.

The illumination source shall be fluorescent lamps, powered by a ballast for low temperature operation. The interval illumination shall provide a uniform lighting on the sign message and background. Photoelectric controls are required and shall be of the “hail-resistant” type and of the road rating for the intended use as shown on “Wiring Schematic.”

The front side panels of the case shall be hinged, either by a continuous hinged or extruded interlocking hinge, to provide access to the lamps. A weather tight gasket shall be provided all around the sign face to exclude dust and moisture. The latching device shall be either screw type or latch type to provide a secure attachment of the sign face to the case. All the exterior hardware, hinges, etc. shall be painted mocha brown, in accordance with Subsection 703.3.

The sign case shall be securely attached to the support structure. Close coordination is to be maintained between the sign fabricator to assure all attachments devices are properly placed. The sign layout shall include the street name, metro block number, and the City of Fort Collins Logo on both sides of the sign assembly. Each sign shall have a plug in type photocell.

#### Cabinet Foundations

Cabinet foundations will be completely poured in one operation and will be composed of concrete conforming to Section 600, Concrete work, of these STANDARDS AND SPECIFICATIONS. The ground mount cabinet will be the bench top type and will be as shown on the accepted plans or as directed by the Traffic Engineer. Anchor bolts will be installed using the supplied template with a controller on a foundation that has been poured level so that the cabinet will set flush with the foundation.

As an alternative, the Traffic Engineer may approve a fiberglass cabinet base. Foundations around controllers will be caulked both inside and outside the controller base to prevent water seepage.

#### Cabinet locations

Visual aesthetics should be considered in the location of signal controller cabinets.

## Traffic Signal Poles and Mast Arms - Section 2-9

#### Standard Type Poles

All traffic signal poles and mast arms shall be of American Steel and shall be structurally engineered by the manufacturer in the United States to carry the proposed weight load to sign heads, mounting hardware and traffic control and street name signs and as stated herein; the poles and mast arms shall also be structurally engineered to withstand wind loads of AASHTO 90 standards minimum design criteria with the maximum number of purposed traffic signal heads with five (5) inch backplates and traffic control and street name signs.

All poles shall be furnished with anchor bolts, nuts and washers; pole caps; door covers; rebar cages in conformance with CDOT Specifications (except ten (10) foot poles); anchor bolt nut covers. All curved mast arm traffic signal poles shall be one of the following or approved equivalents:

- Valmont Poles

- Ameron Poles

Roadway clearance at end of signal mast arm shall be twenty-one (21) feet from roadway with side slope of two (2) to three (3) percent.

All traffic signal poles and mast arms shall be of like manufacture. The type of poles shown on the plans is for illustrated purposes only and is not to be construed as representative of one manufacturer. Workmanship and finish shall be equal to the best general practice of metal fabrication shops.

All traffic signal poles, mast arm, concrete foundations, and necessary hardware shall conform to the appropriate requirements of sections 601, 613, 713 and 715 of CDOT Standard Specifications for Road and Bridges, and the details shown on the plans.

#### Standard Poles

Poles shafts shall be straight, with a permissive variation not to exceed one (1) inch measured at the midpoint of a thirty (30) foot or longer pole, and not to exceed three quarters of an inch of an inch measured, at the midpoint of a pole shorter than thirty (30) feet.

Ten (910) foot signal poles shall be capable of supporting a signal head using a standard pole top mount.

#### Signal Mast Arms

All traffic signal mast arms shall be furnished with end caps. If, while being installed, a arm is determined to be shortened, the Responsible Party must fabricate and install a new end cap.

#### Luminare Mast Arms

All luminare are mast arms shall be of the single arching type, and straight, angled or ornamental types shall be acceptable. These mast arms are to be standard eight (8) foot arms.

#### Pole Foundations

All foundations shall be Portland cement concrete conforming to the applicable requirements of Class A, as referenced in the CDOT Standard Specification for Road and Bridge Construction, most current edition. (Foundation dimensions shall be determined by the Traffic Engineer.)

The bottom of concrete foundations shall rest on firm ground. Foundations shall be poured monolithically where practicable. For pole of pedestal, the top four (4) inches shall be poured after the pole or pedestal is in proper position. The exposed portions of the foundation shall be formed to present a new appearance.

Top of foundations, except noted on the plans, shall be finished to curb or sidewalk grade, or as ordered. Forms shall be rigid and securely braced in place. Conduit ends and

anchor bolts shall be placed in proper position and proper height, and shall be held in place by means of template until the concrete sets.

Both forms and ground which shall be in contact with the concrete shall be thoroughly moistened before placing concrete.

Where obstructions prevent construction of a planned foundation, the Responsible Party shall construct an effective foundation, as directed by the Traffic Engineer.

Span wire and mast arm poles shall be installed with the proper rake as recommended by the manufacturers of the poles so as to assure a substantially vertical set when the specified signal and lighting equipment is installed.

Anchor bolts provided by the manufacturer of the poles shall conform to Subsection 715.02 of the CDOT Standard Specification, and shall be provided with two (2) washers and two (2) nuts each. Plumbing the pole shall be accomplished by adjusting the nuts before the foundation is finished to final grade. Shims or other similar devices for plumbing or raking shall be permitted only when approved by the Traffic Engineer.

The excavation required for the installation of pole foundation shall be performed in such a manner as to avoid any unnecessary damage to streets, sidewalks, landscaping, utilities and other improvements. Excavation shall be performed immediately before the installation of the concrete foundation. The material from the excavation shall be placed in a position that shall not cause damage or obstruction to vehicular and pedestrian traffic, or interfere with surface drainage. Foundation hole that have been excavated, and shall not be filled with concrete immediately, must be covered with a solid surface covering and barricaded until concrete is poured.

#### Span Wire Poles

Span wire poles are discouraged and shall only be permitted with a written variance given by the Traffic Engineer. All poles for span wire installation shall be ten (10) inch diameter poles minimum length thirty-five (35) feet. Poles shall have a minimum yield strength of thirty-five thousand (35,000) psi and a minimum unit weight of 40.48 pounds per foot for ten (10) inch poles for a span of one hundred ten (110) feet or less. Spans over one hundred and ten (110) feet in length shall require twelve (12) inch diameter poles with a minimum unit weight of 49.56 pounds per foot. Poles shall be installed so that they shall plumb when deflected by the installed load.

#### Protective Coatings for all Span Wire Poles - Signal Poles with Mast Arms

##### **Scope**

This specification is designed for the use of Amercoat 450 GL aliphatic polyurethane (or approved equivalent) in conjunction with Amercoat 71 polyamide cured epoxy primer (or approved equivalent) for the protection and finish of the exterior of tapered and non-tapered, color steel poles. Interior surfaces shall be prime painted by dip or spray. This specification is designed for the use of galvanized (or approved equivalent) for the protection or finish of the exterior of tapered and non-tapered steel poles.

### **General**

In order to be acceptable, all poles and component parts furnished on this project by a manufacturer, or their authorized representative, shall be in accordance with the terms and requirements set forth herein. Other comparable coating systems that comply with these specifications may be acceptable subject to the approval of the City. The Responsible Party shall be required to furnish the City with a notarized certificate of compliance from the pole manufacturer that guarantees the coating system used in conformance with these Standards and Specifications and is free of defective workmanship.

### **Surface Preparation for Exterior Protective Coating Systems (Painted)**

Exterior surfaces of shaft and arm(s), and component parts, shall be abrasive blasted in accordance with coating manufacturers recommendations. The lower interior portions of the shaft from the base plate bottom to the top of the hand opening, shall receive the same treatment. All rough and sharp edges shall be rounded off. All weld splatter, flux and slag around the base plate, handhole, arm connections and other areas of welding shall be removed. All drilling of holes and welding of tenons or hubs shall be done prior to abrasive blasting.

### **Requirements of Exterior Protective Primer System**

The interior surface of the pole shaft shall be thoroughly cleaned, dried, and free of mill scales, rust, oil, grease, and dirt, or other contaminants before interior primer is applied. Primer shall conform with Federal Specifications TTP-645, yellow or red oxide. Minimum dry film thickness shall be two and one-half (2-1/2) mils.

### **Requirements of Exterior Protective Coating System**

After abrasive blast, all exterior steel surfaces shall receive a treatment with a heavy-duty, corrosion-resistant protective coating system consisting of two (2) coats of polyamide-cured epoxy (Amercoat 71), or approved equivalent, at a minimum of one and one-half (1-1/2) mils dry film thickness per coat to provide basic corrosion protection. Color topcoat shall consist of one aliphatic polyurethane (Amercoat 450 GL or approved equivalent) at minimum of one and one-half (1-1/2) mils thickness. The total exterior coating system shall consist of a minimum of four and one-half (4-1/2) mils. D.F.T. Coating shall be composed of acrylic resins and modifiers in suitable organic solvents forming a satin finish with lasting color, resistant to fumes, splash and spillage of acids and alkalis.

All two-coat systems for exterior application shall be supplied by the same coating manufacturer to ensure a compatible protective coating system resistant to corrosion, abrasion and impact.

Color for finish topcoat shall conform to the City of Fort Collins, Colorado requirements. Color to be determined by City of Fort Collins.

### **Application**

Primer shall be polyamide-cured (#71 Amercoat or approved equivalent) and shall be strictly applied according to manufacture's recommendation. The lower interior portion of the shaft, from the bottom of the base plate to the top of the handhole opening, shall receive the same application treatment. All surfaces are to be kept free of moisture, oil, grease and the organic matter until coated. Failure to do so shall prevent proper adhesion and shall require the abrasive blast procedure to be repeated. Solvent wiping is not satisfactory as contamination may be spread and not be removed. Application shall be by conventional or airless spray only.

### **Drying or Curing Time**

Drying time for both Amercoat #72 or approved equivalent primer coats prior to color topcoat application shall be a minimum of four (4) hours each at seventy-seven (77) degrees Fahrenheit (twenty-five (25) degrees Celsius).

Drying time for the application of Amercoat 450 GL or approved equivalent color topcoat (one and one-half (1-1/2) mils minimum) shall be minimum of four (4) hours at seventy (70) degrees Fahrenheit (twenty-one (21) degrees Celsius).

Curing time after final color coat and prior to packaging, loading and shipment shall be a minimum of seventy-two (72) hours at seventy (70) degrees Fahrenheit (twenty-one (21) degree Celsius). This requirement must be met to ensure complete dry-through time.

### **Wrapping and Packaging**

Upon completion of the coating system, and prior to shipment, poles and arms shall protective Wrapping With two (2) inch minimum overlap applied at all contact points with cushioned dunnage during transport. This wrapping should be a cushioned material, be a minimum of one-eighth (1/8) of a inch thick and twenty-four (24) inch wide, be applied at all contact points, and extend a minimum of eighteen (18) inches on either side of dunnage locations at poles and arms. Minimum thickness of wrap shall be three-eighth (3/8) of a inch at all contact points. All component parts shall be individually wrapped with heavy Kraft paper and boxed for shipment.

### **Handling and Shipment**

Poles shall be handled in a manner that shall preserve the overall appearance and prevent damage to the coating. The use of chains or cables for loading, unloading, shipping or installing is prohibited. Only three-quarters (3/4) of a inch in diameter or larger nonabrasive nylon rope or equivalent nylon belting may be used. Adequate hold-downs and appropriate blocking shall be utilized for shipping to prevent load movement and damage to the outer coating in transit. No handling should be allowed until "dry-through" condition has been achieved with the coating.

### **Delivery, Installation and Acceptance of Poles**

Extra care shall be taken to not damage the coating. Upon arrival of the poles at the delivery point, neither chains nor cable shall be used for either unloading or installation of poles.

### **Procedure for Field Touch-Up**

The Responsible Party shall utilize a pole manufacturer who shall furnish extra primer and color coat paint to satisfy the needs of field touch-up requirements, in the event of minor physical damage to the coating from handling or transit. Damage area must be cleaned and dry before repair application. Field touch-up shall follow the direction of the pole manufacturer or an authorized representative in order to guarantee manufacturers warranty.

### **Surface Preparation for Exterior Protective Coating System (Galvanize)**

The traffic signal poles shall be galvanized in accordance to ASTM A123 Each component must be completely coated in a single dip. No double dipping will be allowed. All miscellaneous hardware shall be galvanized per ASTM A123.

### **Concrete Foundations - Section 2-10**

#### **General**

Foundations will be composed of concrete conforming to Section 600, Concrete work, of these STANDARD AND SPECIFICATIONS. Foundations for all poles, standard, pedestal, and cabinets as shown on the accepted plans, will rest on firm ground. Forms required in pouring bases will be true to line and grade, rigid, and securely braced.

Both forms and ground which contact the concrete will be thoroughly moistened prior to pouring of the concrete. Conduit stubs and anchor bolts will be placed in proper position, alignment, height, and securely held in place by means of a template while concrete is being poured and until the concrete has properly set. After pouring concrete, the anchor bolts will be raised and lowered individually to eliminate air pockets and to allow proper alignment of the anchor bolts in the concrete prior to the setting of the concrete. Any deviation in the pouring of the foundation proposed by the Contractor will require prior approval by the Traffic Engineer.

#### **Poles, Standard and Pedestal Foundations**

Poles, standard, and pedestals will not be erected until the foundation concrete has been set at least seven (7) days (foundation of high-strain poles will set a minimum of ten (10) days and will be plumbed or raked as required and directed by the Traffic Engineer.

Foundation for all poles will normally be flush-top variety and will be located as shown on the plans or as directed by the Traffic Engineer. In each case the maximum distance behind the curb for pole location is desired in locations where the road-way is not curbed, the top of the foundation will be six and one-quarter (6-1/4) inches above the grade of the edge of the payment. Where foundations are located in the sidewalk, the foundations will be two (2) inches above the surface of the sidewalk, and expansion materials will be placed between the foundation and the sidewalk, with the top of the expansion material

level with the sidewalk surface. Foundations for traffic signal control cabinets, which are located in the sidewalk, will rise above the sidewalk surface as shown on the plans.

The foregoing provisions are general descriptions for normal roadway conditions. In certain cases, special foundation requirements may be indicated on the accepted plans or required by the Traffic Engineer, i.e., where heavy excavations, embankments, slopping (rip-rap) areas near roadways, or unusual soil conditions are encountered.

## Service Systems

### **General**

Service points shown on the accepted plans are approximate. The exact location will be determined in the field by the Contractor, The Traffic Engineer, and the City of Fort Collins Light and Power.

The Contractor will furnish and install conduit and conductors to the service points as shown on the plans. Conduit for traffic signal service will not be less than two (2) inches in size.

Conduit and wiring specified in the wire layout sheets and shown on the accepted plans will be furnished and installed from service poles to the controller cabinet, or to the location shown on the accepted plans. Will be furnished and installed from service pole to the controller cabinet, or to the location shown on the accepted plans.

### **Service Poles**

All conduit will be strapped to poles with rigid 2-hole straps and #8 or #9, one and one (1-1/2) long wood screws, or as shown on the accepted plans. Plumber's tape, wire nails or other means of fastening conduit WILL NOT BE PERMITTED. Where necessary, conduits, covers and gaskets will be provided and installed.

All conduit in service installation above ground will be a rigid galvanized steel type of the size specified on the plans. In areas where rigid steel conduit is coupled to rigid PVC conduit, which in turn used for the underground portion of the service run, the joining of two conduits will take place underground from two (2) inches to ten(10) inches below the surface.

The disconnected switch mounted in a weatherproof box will be located on the service pole as designed on the plans. The conduits will be securely bonded to the service pole when deemed necessary by the Traffic Engineer, and will be bonded in a like manner to the service pole ground system.

## **Pavement Markings - Section 3-1**

### **General**

This assistance shall be in the form of advising the Responsible Party's engineers or Responsible Party on what type of layout is required. This shall include the designation of locations where crosswalks, exclusive right-turn lanes, exclusive left-turn lanes, edge

lines, stop bars, white skip lines, solid double yellow lines, and yellow skips are to be installed.

It is the intent of these Standard and Specifications to describe the requirements for reflective pavement marking thermoplastic (performed) to be used on all roadway surfaces within the City, to provide for the submission of samples, to describe the laboratory and service test procedure which must be used to rate the materials proposed for making new city roads, and to describe the requirements for the actual field installation of proposed pavement markings. Alternative markings for temporary installations are also listed as traffic line paints, hot extruded thermoplastics and detour grade tapes.

Policies

### **Signing and Pavement Marking Work Procedures**

Time Frame:

1. Notice of Work from developers
  - Notice
  - Four sets of plans - entire subdivision or PUD
2. Engineering/design of work
  - Site review
  - Work design (three prints)
  - Billing
  - Action report
3. Process billing (50% due) Good for one year. Refund dependent on material cost and work done. Must be received 10 WEEKS prior to work for signage and pavement markings; 7 MONTHS prior to work for traffic signals.
4. Receive payment
5. Process payment
  - Notice to engineer
  - Forward plans (action request) to crew chief
  - Allow four weeks for processing
6. Order and make up materials
7. Request of work (map of area requested) must be received 4 weeks prior to work plans time for contractors' payment of final payment
8. Final engineering work
  - On-site review
  - Design revisions
  - Final billings
  - Action report
9. Process final billing (No refunds)
10. Process payment
  - Notice to engineer
  - Forward area map, final billing, action report, initial action report to crew chief.
  - Release to Engineering and Building Inspection
11. Construction

12. Return and process action report

**Street Signing Specifications**

The City of Fort Collins requires street name and regulatory warning signs for new developments prior to the issuance of Certificates of Occupancy. These signs are necessary to direct emergency services and assist motorists with the proper street identifications.

Only the authority of the Traffic Operations Department shall place traffic control devices. Street name signs and other required signs shall be erected at specific locations as designated by the Traffic Operations Department. It is very important that the developer submits a plat map and a letter of request for street name signs and other required signs to the Traffic Operations Department at least 5 (five) weeks prior to the completion date, with the following information:

- A plat of the development indicating the official street names.
- Block numbers or house addresses.

After the Traffic Operations Department has designated the plat, the developer will be contacted. At this point, the developer may choose to have the City of Fort Collins or a signing company install the signs as designated on the plat. After the signs have been installed, the Traffic Operations Department will perform an inspection to ensure that all signing installations and materials meet the City of Fort Collins signing standards.

If a signing company installs signs, the City of Fort Collins will not be responsible for the upkeep and maintenance of any signing until all standards are met.

It is the responsibility of the developer to assume the initial cost of the signing installations of street name signs and other required signs or devices.

Performed Plastic Pavement Markings and Legends

**General**

The prefabricated markings described shall consist of white or yellow pigmented plastic film with reflective glass spheres, uniformly distributed throughout their entire cross-sectional area, and shall be capable of being affixed to bituminous or Portland cement concrete pavements by either a pressure sensitive pre-coated adhesive or a liquid contact cement. The markings shall be provided in complete, a form that shall facilitate rapid application and protect the markings in shipment and storage. The manufacturer, when bidding, shall identify proper solvent and/or adhesives to be applied at the time of application, all equipment necessary for proper application, and recommendation for application that shall assure an effective performance life. The marking film shall have resealing characteristics such that it shall fuse with itself and with previously applied marking materials of the same composition under normal conditions of use. Prefabricated legends and symbols shall conform to the applicable shapes and sizes as outlined in the MUTCD.

## **Classification**

The markings shall be highly durable retro reflective pliant polymer materials, designed for longitudinal and word/symbol markings subjected to high traffic columns and severe wear conditions, such as shear action from crossover, or encroachment on typical longitudinal configuration such as edge lines, barrier lines and lane lines.

## **General Requirements for Preformed Plastics**

**Composition:** The retro reflective pliant polymer pavement marking film shall consist of a mixture of high quality polymeric materials, pigments, 1.5 index glass beads uniformly distributed throughout its cross sectional area and with a reflective layer of beads bonded to the top surface. The film shall be composed of the following materials.

**Conformability and Resealing:** The retro reflective pliant polymer pavement marking film shall be capable of conforming to pavement contours, breaks, faults, etc. through the action of traffic at normal pavement temperatures. The film shall have resealing characteristics such that it is capable of fusing with itself and previously applied marking film of the same composition under normal conditions of use.

**Pigmentation:** The pigments shall be selected and blended to provide a marking film which is white or yellow conforming to standard highway colors through the expected life of the film.

**Glass Beads:** The glass beads shall be colorless and have a minimum index of refraction of 1.70 when tested using the liquid oil immersion method. The size and quality of the beads shall be such that performance requirements for the retro reflective pliant polymer film shall be met. Bead adhesion shall be such that beads are not easily removed when film surface is scratched firmly with thumbnail. The film shall have glass bead retention qualities such that when a two (2) inch by six (6) inch sample is bent over a one-half (1 1/2) inch dimension perpendicular to the mandrel axis, microscopic examination of the area on the mandrel shall show no more than ten (10) percent of the beads with entrapment by the binder of less than forty (40) percent.

**Skid Resistance:** The surface of the retro reflective pliant polymer film shall provide a minimum resistance value of forty-five (45) BPN when tested according to ASTM E303-83.

**Reflective Intensity:** The white and yellow film shall have the following initial reflective values at 0.2 degrees and 0.5 degrees observation angles measured in accordance of the photometric testing procedures of Federal Specifications FP-74 Section 718.01 (A).

Reflective values shall be expressed as candlepower per foot-candle per five (5) square feet (candelas per lux per five (5) square meters measured on a fifteen (15) square foot panel) (two and one-half (2 1/2) feet by two (2) feet) at an 86.5-degree entrance angle. The five (5) square feet is derived from a standard stripe, defined as four (4) inches by fifteen (15) feet equals five (5) square feet.

	White			Yellow		
Entrance Angle	86.0	86.0	86.5	86.0	86.0	86.5
Observation Angle	0.2	0.5	1.0	0.2	.05	1.0
Specific Luminance	1000	690	550	750	460	395

(SL) [ (mcd . ft ) . fc 1 ]

Reflectivity Retention: To have a good, effective performance life, the glass beads must be strongly bonded and not be easily removed by traffic wear. When installed in accordance with the manufactures recommendations, these markings shall exhibit the follow average reflectance values after forty-eight (48) months, when measured at an entrance angle of 86.5 degrees and an observation retroreflectometer, as described in the Effective Performance Life section.

	White	Yellow
Entrance Angle	86.5	86.5
Observation	1.0	1.0

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**Average Value**

Effective Performance Life: The materials, when applied according to the recommendations of the manufacture, shall provide neat, durable markings that shall not flow or distort due to temperature, if the pavement surface remains stable. Although reflectivity is reduced by wear, the pliant polymer shall provide a cushioned, resilient substrate that reduces bead crushing and loss. The markings shall be weather resistant, and through normal traffic wear, shall show no appreciable fading, lifting or shrinkage which would significantly impair the intended usage of the marking throughout its useful life, and show no significant tearing, roll back or other signs of poor adhesion.

The Responsible Party shall utilize a manufacturer who warrants that longitudinal markings installed using materials meeting this specification shall meet the criteria shown in the table ( under the reflectivity Retention section ) for a period of forty-eight (48) months from the date of installation regardless of average daily traffic volume. The responsible Party and/or the manufacturer shall replace in total the portion of the material shown to be below these values.

Reflective performance shall be determined by an average brightness reading.

**Yellow and White Traffic Line Paint**

**Scope**

Ready mixed paint shall be of a consistency suitable for use on a highway pavements and curbsings of either asphaltic or Portland cement type. It is required that the white and yellow paint furnished shall bind glass spheres which shall be incorporated into the line by a drop-on or pressure-fed dispenser, at a minimal rate of six (6) pounds per gallon of paint. The paint shall be applied to the pavement in such manner as to provide a

satisfactory marking and delineation in all respects, as determined by the Traffic Engineer.

Traffic line paints shall only be used on newly construction areas, which are scheduled to be totally replaced or overlaid within a twenty-four (24) month time period. Paints can also be used on existing roadways adjacent to new section due to newly created alignments. This can be done with the specific written consent of the Traffic Engineer.

### **Requirements**

All manufactured paint shall be prepared at the factory to be ready for application. The addition of thinner or other materials to the paint after the paint has been shipped shall not be permitted.

The finished paint shall be homogenous, free of dirt, water and other foreign matter. The paints shall be strained immediately prior to canning.

An anti-settling agent or combination of anti settling agents shall be incorporated in the paint to prevent caking and excessive settling of the pigment in the package, and to control the viscosity. The total of all these additives may not exceed eight (8) pounds per one hundred (100) gallons, except when "M-P-A 60 (Toluene)" (twenty-four (24) percent solids) alone is used, not more than twelve (12) pounds may be incorporated in one hundred (100) gallons.

There shall be no caking or excessive settling in the package that cannot be readily pumped and processed through striping equipment.

The color of the yellow paint shall conform to Federal Standard 595A.

### **Inspection**

All materials used in formulation shall meet the requirements herein specified. Any materials not specifically covered shall meet the approval of the Traffic Engineer.

### **Testing**

All tests shall be conducted in accordance with the latest test methods of The American Society for Testing and Materials, Federal Test Method Standard No. 141, and if the Traffic Engineer requests, methods in use by CDOT. Evidence of improper formulation, shall be cause for rejection.

#### *Manufacturing Note:*

*The agents used in each formula for achieving satisfactory anti-settling properties, as described in requirements, may vary to suit the manufacturer's method of manufacture. Finished paint shall still be required to conform to the characteristics of the furnished paint as described in requirements.*

#### *Packaging:*

*All shipping containers must comply with Federal Interstate shipping standards of the CDOT and be stamped I7-H in accordance with the standards.*

*All containers of paint shall be labeled with the weather proof markings, the color, manufacturers name, date of manufacture, and manufacture's batch number on the lid only.*

White Pavement Marking Paint Composition

**Pigment**

Pigment shall have the following composition for one hundred (100) gallons of paint.

	LBS/Gallons
Rutile Titanium Dioxide, TT-P-422, Type III or IV	125.0
Magnesium Silicate, TT-P-403	70.5
Diatamacious Silica 1	89.6
Mica 2	70.5
Calcium Carbonate 3	265.9
Copper Phthalocyanine, TT-P-355, Type I	0.1 oz.

**Vehicle**

Vehicle shall have the following composition of approximately one hundred (100) gallon of paint:

	LBS/100 Gallons
Varnish (50% non-volatile in Toluene)	218.9
Chlorinated Paraffin 4	35.9
Chlorinated Rubber 5	89.0
Propylene Oxide	2.0
Toluene TT-T-548	231.9
6% Cobalt Naphthenate, TT-D-643	1.2
24% Lead Naphthenate, TT-D-643	2.4
Anti-Skinning Agent	8.0 max.
Anti-Settling Agent	0.5

**Varnish**

The varnish shall consist of fifteen (15) gallon length bodies conjugated safflower oil 6 or bodies castor oil 6 product, the resin of which shall be a petroleum hydrocarbon resin 7. The thinner shall be Toluene. The ingredients shall be processed in such manner as to yield a varnish which, at fifty (50) percent non-volatile content and seventy seven (77) degrees Fahrenheit temperatures, shall have the following characteristics:

	LBS/100 Gallons
Weight Per Gallon, pounds	7.6-7.8
Saponification No., Federal Test Method No. 141, Method 5081, (on Non-volatile)	100-100
Acid No., Federal Test Method Standard No. 141, Method 5073 (on Non-volatile)	4 max
Viscosity, Gardner Holdt	4 max

### Compatibility

The components of the vehicle shall be compatible when mixed in the proportions specified as listed in the composition of the pavement marking paint.

Characteristics of Finished Paint	LBS/100 Gallons.
Pigment, percent of weight	51.0 -53.5
Volatile, percent by weight	30.5 max
*Viscosity KU at 77 F	72.0 - 80.0
Fineness of grind, Hegman	3 - 5
Weight per gallon, pounds	11.9-12.4

Drying time without beads, 18" wheel patch

- (ASTM D 711) minutes 7 max
- Chlorine content of non-volatile vehicle, percent. 29.5-30.5
- Yellowness Index, Federal: Method 0.10 max  
(Standard No.141 Method 613)
- Aromatic Content of Volatile, percent by weight 100 min

*\*Viscosity must be maintained in storage. Working properties shall be satisfactory.*

Yellow Pavement Marking Paint Composition

### Pigment

Pigment shall have the following composition for on hundred (100) gallons of paint:

	LBS/100 Gallons
Calcium Carbonate 3	278.5
Chrome Yellow Medium TT-P-246, k Type III	130.0
Magnesium Silicate 2	50.0
Diatomaceous Silica 2	80.0
Mica 2	60.0

### Vehicle

Vehicle shall have the following composition for approximately one hundred (100) gallons of paint:

	LBS/100 Gallons
Propylene Oxide	2.0

Varnish, (50% Non- volatile)	229.0
Chlorinated Paraffin 4	42.0
Chlorinated Rubber 5	95.0
Toluene TT-T-548	259.0
6%Cobaft Naphthenate, TT-D-643	1.3
24% Lead Naphthenate, TT-D- 643	2.5
Anti-Skinning Agent	1.2
Anti-Settling Agent	8.0 Max
Soya Lecithin	0.5

### Varnish

The varnish shall consist of fifteen (15) gallon length bodies conjugated safflower oil 6 or bodies dehydrated castor oil 6 product, the resin of which shall be a petroleum hydrocarbon resin 7. The thinner shall be Toluene.

The ingredients shall be processed in such a manner as to yield a varnish which at fifty (50) percent non-volatile content and seventy- seven degrees Fahrenheit temperature shall have the following characteristics:

	LBS/100 Gallons
Weight Per Gallons, pounds	7.6-7.8
Saponification No., Federal Test Method	
No. 141, Method 5081, (on Non-volatile)	100-100
Acid No., Federal Test Method Standard	
No. 141, Method 5073, (on Non-volatile)	4 max
Viscosity , Gardner-Holdt	4 max

### Compatibility

The Components of the vehicle when mixed in the proportions specified under "Vehicle" shall develop no cloudiness when retained in the airtight container.

### Pavement Marking Paint Addendum

Calcined Grade (Celite 499 or equal)

Color	88
+150 Mesh, %	0
+325 Mesh, %	0.1
Oil Absorption, Gardner	160
Wet Density Lbs., Cu. Ft.	19-20
Bulk Density	4
Hegman	
Chemical Analysis	
H2O Maximum	1.0
S102 Minimum	90.0

Ignition Loss, Maximum	0.5
A1203, Maximum	3.3
T120, Maximum	0.5
CA02	0.5
MGO	0.5
NA20	0.5
NA20 and K20	2.0
Water Solubles, Maximum	0.15

<b>Chemical and Physical Characters</b>	<b>%</b>
S102	70.10
A1203	20.15
K20	3.64
CAO	.50
MGO	.41
T102	1.05

**Material Specification- Potassium Aluminosilicate(Type of Muscovite Mica)**

Color Shaded White  
 Specific Resistance-10.000 OHMS Plus  
 Hardness- 2.5-3.0  
 Mesh, Specification -4-X 1000 Mesh  
 Particle Size - Graduated Scale  
 Specific Gravity 2.73

Tap Density Lb./Cu. Ft.	67.9
Apparent Density - Lb./Cu. Ft.	23.0
Oil Absorption	20.0
Hegman Fineness	4.75
Surface Area M2/GM (Nitrogen Absorption)	3.6

**Particle Size Distribution Micron Diameter  
 Percent by Weight/Below Indicated Size**

44 (325 mesh)	-
40	-
30 (450 mesh)	100
20 (625 mesh)	98
15	95
10 (1250 mesh)	85
7.5	65
5	49
4	42
3	34

2	26
1	15
Chlorine, Percent	40-43
Color, Gardner	12 Max
Viscosity at 25 C, Poise	20-30
Specific Gravity at 25/25 C	1.150-1.565
Stability Max. percent of HCL Liberated in hours at 175 C	0.80

Chlorine, Percent	65-68
Viscosity, 20% in Toluene, Centipoise at 25 C	14-20
Specific Gravity	1.550-1.568
Index of Refraction	1.550-1.560

A twenty-five, (25) , percent concentration in Toluene shall show no haziness or turbidity, and when stored for one (1) week at seventy-seven (77) degrees Fahrenheit, shall not corrode the tin plate in a covered tin-coated can.

Acid Number	4 Maximum
Iodine Number	123 Min.
Saponification Number	185-200
Specific Gravity 25/25'C	0.945-0.9555
Viscosity, Gardner-Holdt	73
Color (Gardner)	4 Maximum
Pout Point, degrees F	-5

Color (Gardner 1933)	13 Maximum
Softening Point, ASTM degrees F	200-220
Iodine Number, WIJS	140 Max
Acid Number	2 Maximum
Saponification Number*	2 Maximum
Specific Gravity 60/60'F	1.07-1.20
Non-volatile matter, Wt. Percent	100
Solution 77'F.	F-P
Ash	

*\*Follow Method No. 5081 of Federal Test Method Standard 141 except as follows: Use twenty-five (25) ml of reagent grade Toluene for solution and five (5) ml of 0.5N alcoholic potassium hydroxide. After reflux add excess of standard acid and back titrate very slowly with shaking, using 0.2N standard alkali. Use special alkali resistant flasks.*

## Reflectorize Glass Bead - Section 3-2

### General

This specification is intended to cover free-flowing waterproofed, reflectorizing glass beads for drop-on type application on highway traffic paint for the production of a reflective surface improving night visibility to the painted markings without altering daytime visibility. The beads shall conform to the following specifications:

A blended material consisting of spheres containing refractive indices of 1.50 and 1.65. Manufactured from high grade optical crown glass of a composition designed to be highly resistant to traffic wear and to the effects of weathering. Colorless, clean and transparent.

### Material

The reflectorizing glass beads shall conform to the following:

Refracture Index - When testing by the liquid immersion method at twenty-five (25) degrees Celsius, seventy (70) percent of the spheres shall have an average index of not less than 1.50, and thirty (30) percent shall have an average index of not less than 1.65.

#### 1.50 INDEX GLASS BEADS

<b>U.S. Standard Sieve Number</b>	<b>Percent Passing-by Weight</b>
20	95-100
30	75-95
50	9-32
80	0-15

#### 1.65 INDEX GLASS BEADS

<b>U.S. Standard Sieve Number</b>	<b>Percent Passing by Weight</b>
50	100
80	90-100
100	75-90
200	0-5

Percent Spheres - A minimum of seventy-five (75) percent (by) weight of the spheres shall be true spheres when tested in accordance with ASTM-D-1155-.53.

Color- The glass spheres shall be colorless to the extent that they impart no objectionable day or night time hue to the binder when applied at concentrations equal to those used on the road surface.

Guidelines for Bicycle Facilities Operation and Marking Bike Lane, Stencils, and Sign Locations:

The purpose of the placement of bicycle stencils on the roadway is to reinforce the specified use of this designated area (bikelane) and to supplement the regulatory signs. Bicycle stencils are to be used on collector and arterial roadways with designated bikelanes. Whenever possible, longer last stencil materials (i.e. stamark) should be used. Bicycle stencils are to be re-installed in the same location on roadways that have been under construction for routine street maintenance or rehabilitation. The standard for the placement of bicycle stencils are as follows:

*Arterial Street between two arterial roadways (Example: Drake Road between Shields and Taft Hill Road)*

**Standard: 3 stencils per mile each direction**

Placement:

1. Approximately 50 to 100 past the intersection based upon roadway geometry's (driveways, curb cuts, speed limit signs etc). Example: Drake Road, place stencil approximately 100 west of the Shields Street intersection.
2. Mid-block - install a stencil approximately 100 on the descent of the collector/arterial intersection. Example: Drake Road, place stencil approximately 100' past Dunbar Avenue.
3. Approximately 400 prior to the arterial/arterial intersection. Example: Drake Road, place stencil westbound approximately 400 prior to the intersection of Drake and Taft Hill Road.

*Collector Street between two arterial roadways. Example: Constitution Avenue between W. Drake and W. Stuart*

**Standard: 3 stencils per mile each direction**

Placement:

1. Approximately 50 to 100 past the collector/arterial intersection based upon roadway geometry's (driveways, curb cuts, speed limits etc.). Example: Place stencil approximately 100 on Constitution north of Drake for northbound bike traffic.
2. Mid-block install a stencil approximately 100 past the local street or collector/collector intersection. Example: Place stencil on Constitution Avenue 100 north of the Independence Road intersection.
3. Approximately 400 prior to the Collector/Collector or Collector/Arterial intersection.

*Example: Place stencil on Constitution northbound approximately 400 before the intersection of W. Stuart.*

Bicycle Signs

The City of Fort Collins Bikeway Program has a unique logo that has been used to identify bicycle facilities as part of the overall bikeway system. This logo is being used as a backdrop to the regulatory signs and is a consistent identifier of the bikeway program. All bikeway signs will be mounted on a green sign blank with the FC logo on top and

BIKEWAY printed on the second line in white. The third section of the sign is the regulatory/informational stencil (i.e. R3-17 - Right Lane Bikes Only) . For sketches of the Bikeway Program signs, see appendix A. Bikelane signs placement should parallel the bike stencil locations (three per mile each direction) and serve to reinforce the pavement marking regulations.

Bike Route signs will be used and will follow the previously described sign standard. A Bicycle Route may be relatively short connecting two bike facilities or long providing a recommended alternative when a bikelane is unavailable. Since a bike route does not benefit from the use of pavement stencils, three signs per mile each direction should be installed. The sign locations match the same standards as bikelane signs and stencils previously discussed.

BICYCLE PARKING signs will also utilize the same bike sign design standards previously discussed and will be placed where necessary.

#### Traffic Control Devices

Bicycles should be considered in the traffic signal timing cycles at intersections where bicycle traffic exists or is expected. Special consideration should be given to the use of traffic detection devices at intersections as well. Normally, bicyclist can cross an intersection under the same signal timing phase as vehicles. However, special consideration should be given to multi- lane roadways to ensure adequate crossing time. Bike lanes crossing multi-lane roadways, such as College Avenue at Pitkin Street, should be equipped with bike loop detectors for traffic- actuated signals. These bicycle loop detectors actuate pedestrian timing splits, which extend crossing times for that movement. Detectors for traffic-actuated signals should be sensitive to bicycles and located in the bicyclist's expected path, including left turns. Conveniently located pedestrian/bicyclist push buttons can be used as an alternative to pavement loop detectors if other options are not present.

#### Intersections with Bike Lane Markings

A main point of conflict between automobiles and bicycles occurs at intersections. The placement of bikelanes keep bicyclists to the right side of the roadway and motorists to the left. At intersections, bicyclists proceeding straight and motorists turning right must cross paths, thus creating points of conflicts. Striping and signing will be used to encourage the changing of lanes in advance of the intersection. Bikelanes on roadways without dedicated right turn lanes should be dropped off approximately 50 to 75 prior to the intersection to allow cyclists to merge with forward or left-turn moving traffic

#### Maintenance of Bicycle Facilities

Bikeways are more susceptible to collecting debris, such as sand, rocks, tree limbs, overhanging shrubs, and broken glass; therefore regular sweeping and maintenance of bikelanes and routes is necessary. A smooth surface, free of potholes and debris, is essential to promoting cycling as a safe alternative method of transportation. Additionally, the pavement edges should be smooth, uniform and not have sharp

dropoffs. Seams between the bikelane and travel lane or drainage pan will not exceed 1/411 in height.

The Streets Division is responsible for maintaining the city's roadways, including bikelanes and routes. Potholes and broken pavement should be repaired immediately, as needed. Bikeways on arterial and collector streets should be swept twice a month and more frequently in the winter months as sand and debris collect in the bikelanes. During the summer, the Bike Ranger rides the bikeways weekly and provides minor cleaning where needed.

Overhanging tree limbs or shrubs encroaching into the bikeways are often identified by citizens or the Bike Ranger and are trimmed by the Forestry Division as needed.

Signs and pavement markings should be inspected semi-annually and kept in good condition. Stamark bicycle stencils should be used on roadways not scheduled for street overlay or rehabilitation.