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PART II - CONSTRUCTION MATERIALS AND METHODS

SECTION 50.

TRAFFIC CONTROL

50.1. GENERAL

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

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

50.2. TRAFFIC CONTROL PLAN (TCP)

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

- A.. Identification of construction zone (work area)
- B. Scheduling (start/completion date)
- C. Signs (the size and type to be used and their location relative to the work area)
- D. The method and materials to be used for delineation and channelization of traffic movements
- E. Placement and maintenance of traffic control devices
- F. Removal and/or application of pavement markings
- G. Location of flagging persons, where required
- H. Detour routes where the use of detours is approved by the Traffic Engineering Division.

- I. All elements of the TCP will be dimensioned, and these dimensions will be followed as closely as possible in setting up the work zone and the associated signing.

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

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

50.3. TRAFFIC CONTROL DEVICES

50.3.1. General Requirements

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

50.3.2. Specific Requirements

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

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

50.4. STATE HIGHWAYS

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

50.5. MAJOR STREETS

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

50.6. LOCAL STREETS

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

50.7. ADVANCE SIGNS

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

50.8. FLAGPERSONS

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

50.9. TYPICAL CONSTRUCTION ZONE DRAWINGS

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

50.10. TRAFFIC SIGNAL CONSTRUCTION STANDARDS

50.10.1. General

A. General Requirements

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

B. Traffic Control and Street Closure

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

C. Testing

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

D. Intersection Power

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

E. Equipment Salvage

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

F. Existing Traffic Signals

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

G. Signal Heads

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

H. Field Location

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

I. Utilities

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

J. Notification of Work

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

50.10.2. Regulations and Code

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

50.10.3. Equipment List and Drawings

The contractor shall submit a list of equipment and material which he proposes to furnish within five days of the execution of the owner-contractor agreement. The submittal shall include all equipment and material as identified on the plans or in the specifications by the manufacturer's name which is necessary or customary in the trade to identify such equipment and material. The

list shall be complete as to name of manufacturer, unit size, material composition and shall be supplemented by such other data as may be required by the City Traffic Engineer.

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

50.10.4. Excavating and Backfilling

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

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

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

50.10.5. Removing and Replacing Improvements

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

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

50.10.6. Underground Facilities

A. Foundations

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

B. Conduit

1. All cables and conductors not shown on the plans as aerial cable shall be installed in conduit unless installed in poles, pedestals, or mastarms. All metal conduit referred to in the specifications and shown on the plans shall be rigid and adequately galvanized. All PVC conduit will be of Schedule 80 or greater. No metal conduit shall be used.
2. All trenches excavated in roadways, including new construction areas, shall be backfilled with concrete or State of Colorado approved flow fill, and capped with six inches (6") of Grade E Asphaltic Pavement.
3. Following conduit schedule is in effect unless otherwise specified in the plans:

<u>Run Type</u>	<u>Quant.</u>	<u>Size</u>	<u>Use</u>
Street Crossings	1	3"	120 voltage
Street Crossings	1	2"	Low voltage
Street Crossings	1	2"	Xcel use
Signal Pole	1	3"	Signal cables
Signal Pole	1	2"	Xcel use
Controller Cabinet	2	3"	120 voltage
Controller Cabinet	2	2"	Low voltage
Interconnect	1	2"	Interconnect
Service Point	1	2"	Xcel use

4. The contractor, at his sole expense, may use larger conduit if desired. Where larger conduit is used, it shall be for the entire length of the run from outlet.

No reducing couplings will be permitted underground.

5. Where a "stub out" is called for on the plans, a sweeping ell shall be installed in the direction indicated and properly capped. The locations of ends of all conduits in structures or terminating at curbs shall be marked by a "Y" at least three inches (3") high cut into the face of the curb, gutter, or wall directly above the conduit.
6. Conduit bends, except factory bends, shall have a radius of not less than six (6) times the inside diameter of the conduit. Where factory bends are not used, conduit shall be bent without crimping or flattening, using the longest radius practicable.
7. Conduit shall be laid at a depth of not less than twenty-four inches (24") below the top of curb grade in sidewalk or grass areas and to a depth of not less than thirty inches (30") below the finished grade in all other areas. Conduit under railroad tracks shall be specified and approved by appropriate railroad authority.
8. Trench excavations for conduit shall be two inches (2") wider than the outside diameter of the conduit. Backfilling of conduit trenches shall be accomplished by placing concrete or approved flow-fill up to the bottom surface of the existing or new roadway surface material. The remaining portion of the excavation shall be backfilled with the same type of material used to construct the existing roadway surface.
9. Conduit shall always enter a foundation, pull box, or any other type structure from the direction of the run only.
10. Conduits terminating in a pole shall extend approximately two inches (2") vertically above the foundation.
11. All conduit runs that exceed ten feet (10') in length shall have a continuous nylon line pulled into the conduit along with the specified electrical cables. The line shall be firmly secured at each end of the conduit run with a minimum slack of three feet (3'). The purpose of this line is to be able to pull future electrical cable through the existing conduit runs.
12. Existing underground conduit to be incorporated into a new system shall be cleaned with a mandrel or blown out with an compressed air.
13. New conduit runs shown on the plans are for bidding purposes only and may be changed with approval of the engineer.

C. Pull Boxes

1. A pull box shall always be installed in combination with a steel strain pole and at all other locations shown on the plans and at such additional points as ordered by the engineer. The contractor may install, at his own expense, any additional pull box that he may desire to facilitate the work.
2. Special pull boxes which are required shall be fabricated and installed in general conformance with the size and details shown on standard drawings.
3. Pull boxes installed in finished areas shall be designed for such installations and shall be stackable and manufactured of a pre-cast polymer concrete material such as Quazite or an approved equal. Unless otherwise noted, pull box lids shall have the word "Traffic" cast into them. Pull boxes shall be

installed so that the covers are level with curb or sidewalk grade or level with the surrounding ground when no grade is established. The bottoms of all pull boxes shall be bedded in six (6) inches of crushed rock.

4. When a new conduit run enters an existing pull box, the contractor shall remove the pull box or tunnel under the side at no less than eighteen inches (18") and enter from the direction of the run. No new conduit will be allowed to enter a new or existing pull box in any other manner than that shown on standard drawings.
5. Loop detector pull boxes installed in the street shall be placed according to the plans or as directed by the engineer. The lids shall have the word "Traffic" cast into them.

D. Detector Loop Wire Installation

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

E. Conductor and Cable

1. Wiring shall conform to appropriate articles of the National Electric Code. Wiring within cabinets, junction boxes, etc., shall be neatly arranged and labeled appropriately.
2. Powdered soap stone, talc, or other approved lubricant shall be used in placing conductors in conduit.
3. A common neutral conductor, separate from the signal light circuit neutral, shall be used for all low-voltage circuits, including the detectors and pedestrian push-button circuits.
4. Splicing of cable will not be permitted in conduit or pull boxes or outside of signal heads, standards or foundations.
5. In no case shall any shellac compounds be used. Wire nut type connectors shall not be used. All wire connections shall use crimps and insulating covers. Detector loop lead-in splices in underground systems shall be waterproofed with 3M splice kits or City approved equivalent. A minimum of twelve inches (12") of slack shall be left at each splice except within hand-holes where twenty-four inches (24") shall be left.

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

TABLE 8-26-05
Cable Schedule

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

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

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

F. Bonding and Grounding

1. Metallic cable sheaths, conduit, metal poles, and foundations shall be made mechanically and electrically secure to form a continuous system and shall be effectively grounded. Bonding and grounding jumpers shall be copper wire, No. 8 AWG, for all systems. Beldon cable sheath for loop detectors to be grounded in control cabinet only. The other end of the sheath to be left ungrounded.
2. Bonding of standards shall be by means of a bonding wire attached to a bolt or a three-sixteenths inch (3/16") or larger bolt installed in the lower portion of the shaft.
3. At each pull box the ground electrode shall be a one-piece copper ground rod

of five-eighths inch (5/8") diameter and eight feet (8') in length, driven into the ground so that the top is two inches (2") above the bottom of the pull box. The ground rod connector will be placed so that the bare copper wire, No. 8, can be pulled into a pole, foundation, or attached to the control cabinet ground buss.

G. Maintenance

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

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

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

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

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

H. Field Testing

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

1. A visual inspection of all wiring will be conducted.
2. A functional test shall be made in which it is demonstrated that each and every part of the system functions as specified or intended herein. The functional test for each traffic signal system shall consist of not less than

fourteen (14) days of continuous, satisfactory operation commencing with full operation of all electrical facilities. During the fourteen-day period, the contractor will maintain the system or systems. The cost of any maintenance necessary, except electrical energy and maintenance due to damage by public traffic, shall be borne by the contractor and will be considered as included in the price paid for the contract item involved, and no additional compensation will be allowed.

50.10.7 Traffic Signing and Pavement Markings

A. General

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

B. Traffic Control Devices on Public Property

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

C. Traffic Control Devices on Private Property

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

D. Pavement Markings

All pavement markings required to be installed as a result of new construction or development shall be THERMOPLASTIC as per CDOT specification 627. Temporary pavement markings necessary to facilitate construction (i.e. detours) may be installed using paint.

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

50.11 MATERIALS

50.11.1. Signal Heads

A. Traffic Signal Unit Specifications

1. All signal units shall be of the individual section, adjustable type, black polycarbonate or approved equivalent. Unless otherwise noted on the plans, all signal and pedestrian displays shall be Institute of Traffic Engineers (ITE) approved Light Emitting Diodes (LED) and conform to the appropriate sections below.

2. Visors shall be detachable tunnel type, open at the bottom; be black in color on the outside and flat black on the inside.
3. Reflectors shall be silvered glass or Alzak type units.
4. Lenses shall be in accordance with ITE Specifications.
5. Sockets shall be fixed focus.
6. Doors on the signal heads for the installation of lamps and lens replacement or other maintenance shall not require use of any tool whatsoever to be opened. Doors and lenses shall be equipped with neoprene weatherproof gaskets to insure against infiltration of moisture, road film, and dust. Each three-color signal unit shall have the socket leads from all signal sections connected to a terminal board stamped with identifiable terminals. There shall be a terminal for color indication plus a common terminal where one lead from each socket shall terminate. The terminal board shall be mounted in the middle section and be properly insulated. All openings, top and bottom, shall be for one-half-inch (1/2") pipe or pipe mounting brackets. Gaskets shall be supplied for top and bottom openings.

B. Pedestrian Signal Units

All pedestrian indications shall be countdown indication and LED. All heads shall be black.

C. Backplates

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

D. Traffic Signal Lamps

1. Traffic signal lamps shall meet the requirements of the latest version of the ITE Standard "Traffic Signal Lamps." All lamps shall have 8,000-hour minimum rating. Lamp manufacturers shall be limited to General Electric, Sylvania and Phillips. Size of lamps to be used in traffic signal units shall be as follows:
2. 69 watt, 125 volt, lamps for all eight-inch (8") traffic signals and peds.
3. 150 watt or 1950 lumens minimum, 125 volt, lamps for all twelve-inch (12")

traffic signals.

4. If the manufacturer recommends a lower rating, the City of Arvada will be advised of this recommendation and will have the option to decide which rating will be used.

50.11.2 Electrical Cable

A. Signal Cable

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

B. Interconnect Cable

1. Unless otherwise noted, all traffic signal interconnect communications shall be accomplished through a fiber optic cable system. Provisions for the fiber optic system shall be annotated on the plans or described by supplemental specifications. The remaining portions of this section reference hardwire systems and are applicable when specified. The telephone hardwire interconnect wire shall be #19 AWG, 6 twisted pairs, shielded cable, with petrolatum-polyethylene gel filling compound. The cable shall meet R. E. A. Specification PE-39 (Clifford of Vermont Catalog #6P19-B1-BJFC or approved equivalent).
2. No splicing of the interconnect cable will be allowed. The cable shall be installed between two adjacent controller cabinets in continuous runs.
3. All telephone interconnect cable pairs will be connected to either active or spare terminal points provided in the controller cabinet. The Contractor shall identify and label all terminal points.
4. All interconnect wires shall be checked after installation to determine their resistance and resistance to ground. Each pair shall be shorted together at one end and a resistance check will be made at the other end or wherever a splice exists. Resistance will be checked between each conductor and ground. All resistance readings shall be recorded showing value, color and location of wire. Data is to be supplied to the City's Traffic Department within 30 days of completion of the project.
5. At the terminal points the jackets shall be stripped and the ends taped. Gel filling compound shall be removed using filled cable cleaner.

C. Service Cable

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

D. Loop Wire

Detect-A-Duct Cable consisting of single conductor No. 14 stranded THHN with an

outer protective sleeve.

E. Pedestrian Push-Button Cable

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

F. Loop Lead-In Cable

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

G. Ground

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

H. Optical Detector Lead-In Cable

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

50.11.3. Vehicle Detectors

A. General

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

4. Each detector unit shall include two or four complete detector channels. Each channel shall sequentially energize its loop inputs to eliminate crosstalk (mutual coupling) between large, very closely spaced adjacent loops connected to the same unit. The sequential time sharing and digital processing of loop inductance data shall be accomplished on a single LSI microcircuit per unit for maximum reliability. The method of measuring shall be crystal reference digital period counting and multi-channel scanning. Only one channel input per unit shall be active at any point in time.
 - a. Sequential scanning shall fully prevent crosstalk between channels of a detector connected to closely spaced or overlapped loops for directional detection.
 - b. Sequential scanning shall allow two detection channels to operate with full performance using a common home-run cable.
 - c. Sequential scanning shall allow two or more detection channels to be connected to a single detection amplifier with full operating performance, including separate mode and sensitivity selection capability on each channel.
5. Each channel of the sensor unit shall automatically self tune to any loop and lead-in inductance from 20 to 2500 microhenries within 2 seconds with full sensitivity after application or interruption of supply voltage. Units shall also track changes in loop/lead-in electrical characteristics, as might reasonably be expected to occur in undamaged loops, properly installed in sound pavements, without producing false indications or changes in sensitivity.
6. Each detector unit shall be provided with a loop test switch position to verify loop system integrity and reduce maintenance costs. The "open loop test" position shall indicate a previous fault via the front panel indicator. The memory shall remain intact and can be queried repeatedly. Existing detections shall not be reset and the memory shall only be reset by power interruption as by removing and re-inserting the plug-in detector units.
7. Each channel shall include a 16-position push type wheel switch to allow selection of 8 pulse sensitivities, 7 presence levels and a "Reset" and an "Off" position. Each detector unit shall include 8 sensitivity selections in 2:1 steps that can be correlated to the relationship of the number of turns of wire in a loop versus the sensitivity required to detect a specified vehicle. The selections shall be designed to allow detection of licensable vehicles in loops of two (2) or more turns electrically in series, parallel or series/parallel configuration in non-reinforced or reinforced pavements with lead-in/homerun combinations from 50-feet to 1,000-feet. The number of turns in a loop, electrical configuration of multiple loops and pavement type will dictate the sensitivity required for proper predictable detection.
8. If specified, channel presence time shall be modified if delay or extension time is selected. The timing switch shall select delay or extension or "Off", if no timing is desired. Internal DIP switches shall provide for selection of "Delay" time of 0 to 31 seconds in 1.0 second increments and "Extension" time of 0 to 7.75 seconds in .25 second increments.
9. Presence indicators shall be wide angle, high brightness type LED suitable for sunlight visibility. When timing is selected and a channel is active that channel's indicator shall flash at 4 Hz during Delay and at 16 Hz during Extension to indicate timing is in progress. Further, the timing shall be

aborted when the vehicle is no longer present and/or the channel control input shall become inactive. The Delay timer shall be reset when a vehicle leaves the loop prior to time out and shall abort when the control input becomes inactive. The Extension timer shall operate and reset when a vehicle leaves the loop and be aborted when the control input becomes inactive. Each timer (Delay and Extension) shall be provided with buffer circuitry to enable or disable the timer, based on an external input (green gate) signal. The circuit shall be designed for AC or DC input control on AC powered units and for DC control on DC powered units.

10. Each detector unit shall utilize a $\Delta L = (\text{Delta-L})$ thresholding technique to provide a more constant, predictable vehicle detection sensitivity with series added inductance, i.e., many loops connected in series and/or long lead-in/homeruns will generally require the same sensitivity setting as would be required for a single loop with short lead-in, to simplify setup.
11. Each channel shall automatically recover from intermittent opens or multiple shorts to ground. Each channel shall tolerate and continue to operate with no change with a single point short to ground on the loop or lead-in system. Each channel shall provide a continuous, non-resettable (fail-safe) output and indication in response to an open loop/open lead-in system. The open loop indication and output shall not be resettable as long as the open exists, except that they shall be defeated when the channel "Off" position is selected.
12. Extended features shall include: Two serial ports (front panel RS232 and Edge connector Xmit/Recve), TS1 and TS2 compatible from manual or software switch, microloop occupancy detection, traffic counting capable to include long-loop presence count from 15 minute to infinite intervals all accessible from either serial interface, Dual Detect and Fault LED indicators per channel, External inputs to control Timing functions and enable Remote Reset, Extended diagnostics, programming and Live status available via serial interface utilizing windows compatible software.

50.11.4. Emergency Vehicle Detectors

Optical Communication Detectors for emergency vehicle pre-emption shall be the 3M Model 711, 712 or 722 Optical Detector or approved equivalent as specified in the construction plan notes. Placement of the Detectors shall be determined by the Engineer. Optical phase selector modules for emergency vehicle pre-emption shall be 3M Model M752 or approved equal.

50.11.5. Detectors (Pedestrian Push-Button)

A. General

1. Pedestrian push-buttons shall be of the direct push-button contact type. They shall operate on a voltage not to exceed 18 volts AC. They shall be of tamper-proof design and equipped with a push-button instruction sign as shown in the Standard Details.
2. The assembly shall be weatherproof.
3. The housing shall be shaped to fit the curvature of the pole to which it is attached to provide a rigid installation. Saddles shall be provided to make a neat fit when required. Pedestrian signs shall be installed as shown on the Standard Details.

4. Push-buttons shall be ADA approved.
5. Push-buttons shall be located in accordance with ADA reach specifications.

50.11.6. Traffic Signal Poles, Pedestals and Mastarms

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

50.11.7. Controller Cabinet

A. General

1. All controllers and auxiliary equipment shall be housed in a factory wired, weatherproof, metal cabinet following **NEMA** specification **TS2 type 2**. The cabinet shall have minimum interior dimensions, exclusive of stiffeners, shelf brackets, etc., of height - 46 inches, width - 29 inches, and depth - 15 inches.
2. The cabinet shall be constructed of 0.125 minimum thickness bare aluminum. Cabinets shall be braced internally or by folded seams in order to provide sufficient rigidity to withstand normal handling and transport to the field location without deforming.
3. The main door shall have a self locking, keyed, tumbler lock with two keys. Hinges shall be mounted on the cabinet in such a way that interchange-ability of doors is possible between cabinets of like size and manufacturer. Hinge pins shall be stainless steel. Doors shall have neoprene gaskets of sufficient thickness to provide a rain tight and dust tight seal.
4. A police or auxiliary door shall be provided. It shall be constructed so that no sharp edges protrude from the main door and shall provide access to a panel with labeled switches for automatic to flashing operation and signal power on/off.
5. The cabinet shall be equipped with a thermostatically controlled, ball bearing fan with a capability of at least 100 cubic feet per minute. The fan shall be mounted in a weatherproof housing attached to the top of the cabinet. The thermostat shall be adjustable to turn on between 90° F and 150° F and be so mounted as to be easily accessible for adjustment from the front of the cabinet. Cabinet shall have internally mounted florescent tube light and one goose neck incandescent light.
6. The cabinet shall have two shelves each capable of supporting 75 pounds. Shelves shall be supported on brackets which provide for height adjustments. Each cabinet shall contain a ten (10) mil thick plastic envelope with side opening. It shall be a minimum size of 10" x 12" and be attached to the door by screws.
7. Assembly wiring - All cabinet wiring shall be neatly arranged and laced or enclosed in plastic tubing. No harness or wire shall be attached to any shelf rack or other point where it may be damaged by movement of shelves or doors.
8. Terminal Facilities - Terminal facilities (load bays) shall be firmly attached in a position not less than six (6) inches from the bottom of the cabinet so as to

provide easy access and maximum convenience to the user.

9. Side mounted auxiliary panels should be firmly installed with the forward edge not more than four (4) inches from the door sill and not less than six (6) inches from the bottom of the cabinet in all cabinets.
10. The load bay and its associated equipment, harness, switches, etc., shall be grouped on removable panels. Each panel or group of receptacles and connecting cables shall be arranged to permit so that work can be performed on panel backs or cables.
11. A load switch bay and flash transfer capability is required for each phase. Load switches shall be provided for only the phases shown on the plans.
12. The load bay shall be protected by a main circuit breaker. A gas tube surge arrester with MOV and a suitable radio interference filter shall be supplied. The arrester shall be a three electrode type with the following ratings:
 - a. Impulse Breakdown - less than 1,000 volts in less than .1 microseconds at 10 KV per micro-second.
 - b. Standby Current - less than 1 milliampere
 - c. Striking Voltage - greater than 212 VDC
 - d. Energy Capability - capable of withstanding pulses of peak current each of which will rise in eight (8) microseconds and fall in twenty (20) micro-seconds to one-half the peak voltage at 3 minute intervals.
 - e. Peak Current Ratings shall be 20,000 amps. The MOV shall have ratings equal to or better than a General Electric type VI50LA20A. The RFI filter shall have a current rating equal to or greater than the main circuit breaker capacity.
13. Field terminals shall be screw type, capable of accommodating at least three number 12AWG wires. All terminals in the load bay shall be permanently identified by engraving, silk screening or contrasting plastic labels. Terminal blocks shall be the barrier type and no live parts shall extend above the barrier.
14. A convenience outlet with a ground fault interrupter fused at fifteen (15) amps shall be provided. It should be located in a position which is convenient and safe for service personnel.
15. All AC power busses, switch or relay lugs and/or similar activity connection points which extend more than one and one-half inches (1-1/2") from the panel are to be protected by insulation for safety. The locations of these items shall provide reasonable protection for service personnel.
16. Signal power relays shall be mercury wetted, equal to or greater than circuit breaker capacity. Flash transfer relays shall be as manufactured by Midtex Model 136-62 T 3A1, 120 VAC, DPDT, 30 amp with Jones Plug base and dust cover or approved equivalent.
17. Flasher. The cabinet shall be equipped for flashing operation of signal lights with a two (2) circuit solid state flasher in accordance with the latest NEMA specifications (15 amps per circuit). Flashing operation shall be set for flashing yellow on all main street approaches and red on all other approaches. Pedestrian and turn signals shall be extinguished during flashing operation.

The flashing mechanism shall remain in operation during shutdown or removal of controller.

18. Load Switches. The cabinet shall be equipped with solid state load switching assemblies in accordance with the latest NEMA specification. Each load switch to be equipped with a three (3) input LED indicator. Load switches shall contain three (3) separate cube type solid state relays, which use a solid state switch which is capable of operations at 240 VAC and 25 amps when properly heat sinked but derated to ten (10) amps when used in load pack assembly.
19. Conflict Monitor/Malfunction Management Unit (MMU). The cabinet shall have provision for conflict prevention in accordance with the latest NEMA TS2 specification. Conflict prevention shall be provided by a conflicting display monitor unit that monitors all green, yellow and walk displays and detects absence of reds to cause flashing operation and stop timing if conflicting indications are detected. Removal of the monitor from the cabinet shall cause flashing operation.
20. Emergency Vehicle Preemption. The cabinet shall be equipped and wired with an Opticom Card rack mount for 3M Model or approved equivalent. All equipment shall be capable of accommodating a minimum of two modules with capability of four-channel operation.

50.11.8 . Actuated Controllers

A. General

1. Compatibility - The local controller and cabinet shall be 100% compatible with the City of Arvada's existing computerized signal system which utilizes Econolite equipment
2. An actuated controller shall be completely solid state, electronic device capable of selecting and timing traffic movements. It shall provide timing and load switch control for each major vehicular phase, including concurrent associated pedestrian movements. The controller shall conform to the latest NEMA specifications and shall provide for complete and full operation of eight phases from within either a TS1 or TS2 type 1 cabinet.
3. The controller shall have all electronic components easily accessible and arranged in functional groupings on the printed circuit boards. Printed circuit boards shall be designed to facilitate identification of components for maintenance purposes. Printed circuit design shall be of NEMA specification quality and designed so that components may be removed and replaced without permanent damage to the board or track.
4. Timing shall be adjustable on the controller face by keyboard programming. A security code or other means shall be provided to prevent unauthorized or accidental entry.
5. Timing shall be readable from a display which is sufficient to make certain that all register positions can be easily and definitely recalled. Every keyboard controller shall have an easily followed legend silk screened on the face of the controller or on a metal or plastic card or placard which is securely attached by screws or rivets.
6. All circuitry components shall be available on the open market and the original manufacturer's part number shall be shown on the part's list.

7. Overlap programming shall be provided by NEMA standard overlap board and/or keyboard.
8. An entry mode to any single phase parameter of a keyboard controller shall not affect any other parameter or the same parameter on another phase, unless programmed by specific keyboard instructions, such as, "copy" sequences or other prescribed methods of rapid program entry.
9. Every controller supplied shall be the manufacturer's latest, first line production model tested and delivered by a domestic manufacturer who is regularly engaged in the construction of such equipment.
10. Each controller shall be supplied with a complete set of operational and service manuals, wiring schematics and parts layout up to a maximum of ten sets per order. Any controller for which these documents are not available is not a production model within the meaning of these specifications.
11. Each controller shall have a removable data module.
12. Pre-emption. All actuated controllers shall be equipped to accommodate four (4) E.V.P. inputs and one railroad preemption input.

B. Coordination Unit

1. The coordination unit shall be an internal function within each local controller and shall meet, as a minimum, the following functional requirements.
2. The coordinator shall provide for at least four cycle lengths adjustable from 30 to 255 seconds, three (3) offsets adjustable from 0 to 99 percent with offset correction by dwelling in coordinated phase or smooth transition, and four (4) splits per cycle.
3. Standard NEMA functions shall be used to control the intersection timing.
4. The coordinator shall be capable of changing the controller's phase sequence upon command and telemetry failure.
5. The coordinator shall be capable of setting the intersection free by loss of system sync, cycle/offset false commands, free command and telemetry failure.
6. The coordinator shall be capable of setting the intersection into a flashing operation in accordance with the Manual on Uniform Traffic Control Devices, latest edition.
7. The coordinator shall be capable to operate with telemetry module without additional hardware or software.
8. Time-base coordination mode shall be provided as a backup with all standard coordination features available. At least two (2) 7-day programs shall be available with 50 additional holiday programs in the event of a master controller or communications failure. Time-base standby mode shall be programmable for an entire year with automatic daylight savings and leap-year changes.

C. System Telemetry

1. Telemetry equipment shall be an internal plug-in module to a local controller with easy access for removal. Master controller or stand-alone chassis may

contain standard plug-in module. Each telemetry unit shall be capable of transmitting data to and from local controller, local detectors and system detectors (8 per intersection). A provision shall be made to reject invalid messages. The system command shall be transferred each second to maintain time sync.

2. The telemetry equipment shall be designed so that all communications among intersections in one system can be accomplished over no more than two pairs of hard wire interconnect or leased phone lines. Dedicated pairs from the master to each local intersection are not permitted.

50.11.9. On-Street Master

A. General

1. Cabinet Assembly - The master controller shall be wired into a cabinet assembly which also includes a local intersection equipment configuration. The cabinet shall be wired complete with master connecting cables in accordance with applicable portions of the local controller cabinet specifications. The incoming power service and interconnect terminals shall be adequately equipped with surge arrestors to protect against high energy transients.
2. Incoming Sensor Data - The master shall have the ability to receive output data from at least eight sensors from each local intersection. It shall be possible to assign at least 32 of the incoming sensors to internal computational channels for pattern selection analysis.
3. Traffic Pattern Selection. The program-in-effect shall be selected on a priority basis with the following priority arrangements:
 - a. Manual entry from keyboard
 - b. External command from a master
 - c. Time-of-day/day-of-week schedule
 - d. Traffic responsive -based on sampling sensor analysis
4. The master shall select one of six (6) different cycle lengths or "free" operation, based on inbound or outbound volume levels. It shall be possible to program segments in the volume range levels to change to the next higher or lower cycle lengths.
5. The master shall be able to select any of five (5) different offset plans per cycle. Offset plans shall be chosen based on the differential between inbound and outbound volume levels. The five (5) offset plans shall be designated as follows:
 - a. Heavy inbound
 - b. Inbound
 - c. Average
 - d. Outbound
 - e. Heavy outbound

6. When balanced flow occurs, the master shall select the Average Offset plan. When the volume in one direction exceeds the volume in the other direction by the programmed amount, a standard preferential offset shall be implemented. If the volume differential exceeds a second (higher) programmed amount, a heavy preferential offset must be implemented. It shall also be possible to reserve the heavy preferential offset plans for special pattern implementation only. Programmable settings must be provided for both entering and leaving each offset.
7. Split plan selection shall be identical to offset plan selection except that arterial traffic volume levels must be compared to side street volume levels. Three different split plans shall be provided:
 - a. Heavy arterial
 - b. Average
 - c. Heavy side street
8. The master shall call for the average split plan during normal conditions. If the arterial volume exceeds the side street volume by the programmed amount, the heavy arterial split shall be selected. In the same manner, if side street volume exceeds arterial volume by a programmed amount, the heavy side street split shall be called.
9. Crossing Artery Synchronization - The master controller shall have capability to coordinate with a separate master systems controller of the crossing artery through the common intersection for both systems.
10. System Diagnostics - Diagnostic tests shall be performed on system detectors, telemetry communications and intersection operation.
11. Sampling sensors shall be monitored for absence of calls or constant calls. If a sensor fails, it shall be automatically disconnected from the calculations for traffic responsive plan selection. If normal sensor operation resumes, the sensor shall be automatically reinstated.
12. Telemetry communications diagnostics shall monitor readbacks for no response condition including local telemetry and telemetry channels.
13. Intersection diagnostics shall be available to display intersection status condition. All fault conditions shall be reported and logged.
14. Count storage - The master shall have the ability to tabulate and store fifteen (15) minute count data from up to 32 different sensors. The data shall be available for automatic transfer to the central office facility upon request.
15. The selection of the sensors to be counted in any 24 hour period shall be completely programmable from the central office computer.
16. Miscellaneous Data Storage. The master shall store all of the following data:
 - a. The time of day and location of all sampling sensor failures. If normal operation resumes, this time shall also be recorded.

- b. The time of day, location and mode of all local intersection failures. The time that normal operation resumes must also be recorded.
 - c. The time and mode of all pattern changes. Changes due to external override must be distinguished from normal pattern changes.
 - d. The average volume or occupancy level for each fifteen (15) minute period for all computational channels.
17. It shall be possible to transmit any of the data listed above to the central office computer automatically or upon demand.
 18. Downloading Local Coordination Settings. It shall be possible to download any local intersection coordination setting (offset, force off or permissive period) from the master via the unit's keyboard.
 19. Display. During normal operation, the timing pattern in effect shall be displayed on the front panel, including the cycle, offset plan and split plans selected. Also, the unit shall indicate how the timing plan was selected - through normal volume calculations, by an occupancy channel or by manual or central computer override. The master shall also indicate when the time of day mode is in effect and show whether this mode was selected manually or because of sensor failures.
 20. External Override. The master controller shall have appropriate inputs to externally select any timing pattern and override the pattern selected through traffic analysis.
 21. Telemetry. The master shall include a telemetry module for two (2) way communications between the master and local controllers. The equipment shall be compatible with the telemetry equipment specified for the local controllers

50.11.10. Miscellaneous Hardware

A. General

1. Aluminum pedestal mounts (Type III) shall be either of two (2) types, as called for in the plans and specifications. Center mount with two (2) side ports, plain or offset mount serrated with one (1) side port.
2. Covers for water valve pull boxes shall have the word "Traffic" cast into them to avoid confusion with a water department pull box.
3. Mastarm brackets shall be Astro brackets or City approved equivalent and shall be installed 90 degrees to the roadway.

50.11.11. Paint - Signal Poles

A. New Structures

1. All new signal poles and mastarms shall be factory painted with an epoxy primer and polyurethane top coat liquid coating. Surface preparation shall be blast cleaned to Steel Structure Painting Council Surface Preparation Specification No. 6 (SSPC-SP6) requirement utilizing cast steel abrasives conforming to the Society of Automotive Engineers (SAE) Recommended

Practice J827.

2. All accessible interior surfaces shall be coated with a lead and chromate free red oxide rust inhibitive alkyd primer to a minimum dry film thickness of 1.0 mils.
3. All exterior surfaces shall be coated with a rust-inhibitive Epoxy-Polyamide Primer to a minimum dry film thickness of 2.0 mils. The top coat shall consist of one coat of Semi-Gloss High-Build Acrylic Polyurethane Enamel, Tnemec Endura Shield or approved equivalent, to a minimum dry film thickness of 2.0 mils. The finish shall be dark brown.
4. Any surface areas damaged during handling or installation shall be repaired immediately with a spot coat of epoxy primer and a polyurethane finish as specified above. The paint manufacturer's application instructions shall be followed.

B. Existing Structures

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

50.11.12. Instructions and Wiring Diagrams

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

A. Radio Interconnect Communications

Unless specified on the plans, interconnect to master system, shall be by use of remote radio system. Radio shall be Entra Net 900, remote radio Microwave Data Systems (MDS). All units shall include Yagi Antenna 10db gain, 902-960 MHZ with appropriate mounting hardware and shall include poliphaser surge/lightning suppresser model No. IS-50NX-C2.

50.11.13. Guarantee

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