

SECTION 1800 TRAFFIC SIGNALS

1801 GENERAL.

- A. Scope. The work of this Section shall consist of all labor, materials, equipment, testing, and services necessary to install a complete and operational traffic signal as shown on the Plans and herein specified.
- B. Codes and Standards. All work and material shall be in accordance with the latest requirements of the National Electrical Code (NEC), National Electrical Safety Code (NESC), Standards of the American Society of Testing Materials (ASTM), American Standards Associations (ASA), National Electrical Manufacturers Association (NEMA), Manual on Uniform Traffic Control Devices (MUTCD) and all applicable local ordinances. The standard referred to shall be the latest revision of said standard as amended at the time of the Advertisement, except as noted on the Plans or in the Project Special Provisions.
- C. Modification of Specifications. These Specifications may be modified or deleted by appropriate items in the Project Special Provisions or by written authorization by the City Engineer.
- D. Incidental Work and Parts. Work incidental to the traffic signal installation that is not covered in these Specifications shall be performed in accordance with the City of Liberty specifications and standards. All incidental parts, which are not shown on the Plans or specified in the Specifications and which are necessary to complete the traffic signal installation, shall be supplied and installed by the Contractor to the satisfaction of the City Engineer. No additional payments will be made for incidental work or parts.
- E. Existing Signals. Existing traffic signal equipment shall be maintained in effective operation by the Contractor except for shutdowns with approval from the City Engineer for alterations or final removal. The Contractor shall take all precautions necessary to minimize the downtime of the existing traffic signal equipment to be modified.
- F. Removal of Existing Equipment. All existing traffic signal equipment that is removed from service shall become the property of the Contractor, unless otherwise indicated in the Plans or Project Special Provisions. It is the Contractor's responsibility to remove the equipment from the site and dispose of it. Bases and conduits shall be removed to a minimum depth of 24 inches below finished grade. Bases and conduits below 24 inches may be abandoned in place. Underground cables shall be removed if they are not in service.
- G. Permits and Inspections. The Contractor shall contact the Public Works Department before any project work begins to notify the City Engineer of the construction schedule and to request project inspections. The Contractor is responsible for obtaining all necessary permits from the City, and is responsible for all associated costs, before any work can begin.

The Contractor is responsible for obtaining the owner's building permit from the City's Planning & Development Department before electrical service can be delivered to a service enclosure. The Contractor shall contact the City's Building Division for an electrical inspection when each service enclosure is ready for operation. The Contractor shall contact the City's Planning & Development Department to obtain an address for each service enclosure, which the Contractor shall use when coordinating with the electrical utility company for secondary service.

- H. Electrical Service. The Contractor is responsible for contacting the electrical utility company in advance to schedule delivery of service to each service enclosure. The Contractor shall pay the electrical utility company's fees to deliver electrical service. The Contractor shall also be billed for all electrical utility service charges until the entire project is substantially complete and test period is successfully completed. After those milestones, the electrical service can be transferred to the City.
- I. Contractor's Designated Technician. From the time when work begins on any traffic signal until the signal has been accepted by the City, the Contractor shall provide at least one service technician to remain in the area and be available for day, night and weekend trouble calls. The Contractor shall furnish the name, address and telephone number where each designated technician can be reached at all times.
- J. Maintenance Work. The Contractor is responsible for making all repairs and replacements to the traffic signal, including but not limited to, downed poles, damaged or cut cables, and non-operational signal equipment, regardless of the cause or responsible party, until the work is determined by the City to be substantially complete.

1802 MATERIALS AND EQUIPMENT.

This section governs the furnishing of all traffic signal equipment, poles, conduits, cables, and other material and equipment supplied by the Contractor, as required, to complete the traffic signal installation as shown on the Plans, the Standard Drawings, and as specified in the Project Special Provisions. All traffic signal equipment shall be of new stock unless the contract provides for relocation of existing equipment or use of equipment furnished by others. New equipment and material shall be of the best grade, and shall meet the approval of the City Engineer. Insofar as practical, major items supplied under a single contract or tied contracts shall be of the same type and consist of products of the same manufacturer to secure uniformity.

- A. Traffic Signal Poles and Mast Arms. The type of pole shall be as specified on the Plans. This specification is in addition to the City of Liberty's Standard Drawings, which describes the Specifications and pertinent design details. It is the responsibility of the fabricator to verify and attest that the material sizes proposed are structurally adequate and in full compliance with this specification and Standard Drawings.

Steel Traffic Signal Poles shall conform to these Specifications, the plans and the 2013 edition of AASHTO's Standard Specifications for Structural Supports for Signs, Luminaires and Traffic Signals. The pole and arm shall be a round, tapered monotube made only of one length of the best grade, structural steel sheet of not less than #7 Manufacturing Standard Gauge. Only one longitudinal weld and no transverse welds shall be permitted in the fabrication of the shaft or arm. The steel anchor base of adequate strength, shape and size shall be secured to the lower end of the shaft by welding in such manner as to develop the full strength of the adjacent shaft section to resist bending action. The steel poles shall be galvanized to ASTM A-123 standards. All accessories shall be galvanized to ASTM A-153 standards. The tapered steel shaft shall include high strength anchor bolts and nuts that meet the following requirements:

Tensile Strength (minimum) 75,000 psi
 Yield Strength at 0.2% offset (minimum) 55,000 psi
 Elongation: 8" min. 18%
 2" min. 21%

- B. Pedestal Poles. Pedestal poles shall be schedule 80 straight tubing of 6063-T6 aluminum alloy in accordance with ASTM B 210, with a 4 1/2-inch outside diameter, having a minimum nominal 0.125 inch wall thickness. The shaft shall have no longitudinal welds, nor circumferential welds. The shaft shall have a uniform polished finish. Each shaft shall be tire-wrapped with a heavy water-resistant paper for protection during shipment and installation.

The pedestal base casting shall be either permanent mold casting of Alloy 356.0 F, in accordance with ASTM B 108, or sand castings of Alloy 356.0 F, in accordance with ASTM B 26. The base shall be free from imperfections and shall be provided with an aluminum door for wiring access. The base and pole shall be joined by a threaded connection. Welded connections will not be permitted. The grounding lug shall be provided inside the base. All hardware shall be non-ferrous metal or stainless steel.

- C. Concrete. All concrete for bases and pads, whether reinforced or non-reinforced, shall be KCMMB 4,000 psi mix. Concrete construction shall be in accordance with ACI 301 Standard Specifications for Structural Concrete.
- D. Reinforcing Steel for Concrete Bases. All reinforcing steel shall be Grade 60 deformed bars in accordance with ASTM A 615. Splicing of bars is not allowed. Upon request, Contractor shall provide documentation of reinforcing steel that shall include the steel manufacturer's certified mill test report showing complete chemical and physical test results for each heat.
- E. Signal Heads. Each signal head shall be a weather tight assembly of one or more signal faces of the expansible, adjustable, LED type, together with all brackets and fittings necessary for proper mounting with the type of signal support designated on the plans. All polycarbonate signal head parts, including the housing, housing door, visors and backplates shall be constructed from ultraviolet stabilized black-impregnated polycarbon resin.
1. Vehicle Signal Heads shall consist of one or more signal sections, rigidly and securely fastened together, capable of being positively positioned to control the movement of one direction of traffic. Each signal section shall be a self-contained assembly consisting of an optical unit with housing, housing door, and visor. Tie rods shall not be used to fasten signal sections together to form a signal face. All signal heads on a project shall be the product of one manufacturer. Terminal blocks of suitable size shall be placed in the bottom section of the signal head.
 2. Pedestrian Signal Heads shall have a single-section black durable polycarbonate housing. The access door shall be attached with stainless steel hardware. The housing shall include bi-directional clamshell type mounting. No visors or louvers shall be installed for pedestrian signal heads. There should be ample space inside the housing to accommodate the control module for a 4-wire APS pushbutton system.
 3. Housings for each signal section shall be made of a durable polycarbonate and shall be black in color. It shall be clean, smooth and free from flaws, cracks, blowholes, and other imperfections. It shall be designed as a self-contained unit capable of separate mounting or inclusion in a signal face containing two or more signal sections rigidly and securely fastened together. Housings shall be equipped with round openings in the top and bottom so that it may be rotated between waterproof supporting brackets and thus be capable of being directed at any angle in the horizontal plane. It shall be equipped with positive locking devices to maintain a specific angle of direction when in place. The

doors shall be black in color and suitably hinged and held securely to the body of the housing by simple stainless steel locking devices. All other door parts, such as hinge pins, lens clips, screws, etc., shall also be of stainless steel material. Neoprene gaskets shall be used between the lenses and reflectors to exclude dust and moisture.

4. Visors for each vehicular signal section shall be durable polycarbonate, black in color, not less than 0.05 inches in thickness. It shall be designed to fit tightly against the door, and shall not permit any perceptible filtration of light between it and the housing door. Visors shall be at least 9 inches long, shall angle slightly downward. The optical unit and visor shall be designed as a whole so as to eliminate the return of outside rays entering the unit from above the horizontal.
5. Backplates shall be furnished and attached to the signal faces to provide a dark background for signal indications, where shown on the plans. Backplates shall be 5 inches, constructed of one piece of durable black plastic, and shall have a minimum thickness of 0.125 inch. Backplates shall be designed to precisely fit the specific manufacturers' signal head. Stainless steel bolts, nuts and flat washers shall be used to fasten the backplate to the signal head.
6. Vehicular signal indications shall be light emitting diode (LED) display modules that have the appearance of an incandescent lamp. LED indications shall be 12-inch diameter, 120-volt LED's in a self-contained enclosure with a 10-year life expectancy. LED indications shall comply with the latest edition of ITE's Interim Purchase Specification – Vehicle Traffic Signal Control Heads, Part 2: Light Emitting Diode (LED) Vehicle Traffic Signal Modules. The LED modules shall be field replaceable requiring no special tools or sealants for replacement and shall be smooth on the outside. Enclosures shall be dust and water resistant.

All parts of the LED module shall be mounted on a 12" diameter aluminum front panel designed to replace the lens in the signal head, and shall be mounted on the door of the signal head. All components shall be readily accessible when the door is open. All screws, washers, nuts and bolts shall be corrosion-resistant.

The Bi-Modal LED Green/Yellow Arrow module shall display alternate legends consisting of a green or yellow directional arrow. Provisions shall be made to help balance the intensity between the colors by supplying approximately 50% more light to the indication when the green arrow is being displayed than to the yellow arrow display.

7. Pedestrian signal indications shall conform to the construction materials and colors listed in the previous section with the following additions outlined below. The LED module shall display a solid Portland orange hand and lunar white man and two Portland orange countdown numbers. LED indications shall comply with the latest edition of ITE's Interim Purchase Specification – Vehicle Traffic Signal Control Heads, Part 2: Light Emitting Diode (LED) Vehicle Traffic Signal Modules. The legends shall conform to the ITE Specification Pedestrian Traffic Control Signal Indications.
8. Signal Head Mounting Brackets and hardware, except the aluminum pipe brackets and polycarbonate brackets, shall be galvanized steel or unfinished aluminum. Aluminum pipe brackets shall have a spun finish.

On the side of poles, signal heads shall be supported by a one-piece mounting bracket watertight assembly made entirely of a durable polycarbonate and be black in color. Each bracket shall be either plumb or level, symmetrically arranged and securely assembled. Each bracket shall have serrations for positioning traffic signals in increments of 5 degrees. Construction shall be such that all conductors are concealed within the assembly. Brackets shall be attached to the signal pole with 3/4" stainless steel banding.

On mast arms, signal heads shall be rigid mounted utilizing a universally adjustable bracket consisting of both top and bottom brackets with a center vertical extruded aluminum support tube attached to the mast arm by means of a clamp kit with stainless steel cable. The vertical support tube shall allow wire entry at any point and be equipped with a vinyl insert that conceals the wiring. The lower bracket arm shall be accessible for wiring entry into the signal head.

F. Conduit. The location and type of conduit shall be as shown on the Plans or Standard Drawings. The Contractor may furnish and install polyvinyl chloride (PVC) or high-density polyethylene (HDPE) conduit.

1. Polyvinyl Chloride (PVC) shall be Schedule 40 or Schedule 80, and shall conform to NEMA Standard TC-2 and NEMA TC-3. The conduit shall bear an Underwriters' Laboratories (U.L.) label and shall conform to Federal Specification WC-1094A (latest version). The conduit shall be clearly and durably marked at least every 10 feet with the material designation, nominal duct size, and the name and/or trademark of the manufacturer.

Fittings for PVC conduit shall be in accordance with U.L. 514. Cement used for the fittings shall be in accordance with the conduit manufacturer's recommendations. Conduit, fittings, and cement shall be supplied by the same manufacturer.

2. High Density Polyethylene (HDPE) shall be smooth walled inside and out, and shall be gray in color. The conduit shall be a plastic duct which is intended for underground use and which can be manufactured and coiled or reeled in continuous transportable lengths and uncoiled for further processing and/or installation without adversely affecting its properties of performance. The conduit shall be manufactured to NEMA Standard TC-7 and ASTM D 3035 SDR11 specifications. The conduit shall be clearly and durably marked at least every 10 feet with the material designation, nominal duct size, and the name and/or trademark of the manufacturer.

Fittings for HDPE conduit shall be in accordance with ASTM D 2683. Epoxy used for the fittings shall be in accordance with the conduit manufacturer's recommendations. An approved factory coupling shall be used for connection of the HDPE conduit to a 90° factory PVC elbow or between two lengths of HDPE conduit. The coupling shall be of high density polyethylene material. The coupling shall provide an airtight and watertight lock connection.

G. Pull and Junction Boxes. Pull and junction boxes shall be as shown on the Plans and shall be fiberglass reinforced polymer concrete of a size and shape as indicated on the Standard Drawings. Pull and junction box material is to be an aggregate consisting of sand and gravel bound together with a polymer and reinforced with continuous woven glass strands. Pull boxes shall withstand a wheel load of 20,000 pounds and junction boxes shall withstand a wheel load of 15,000 pounds. All pull and junction boxes are to have an open bottom.

Each pull or junction box shall be equipped with a bolt down cover. The threaded hole that receives the cover lock-down bolt shall be open at the bottom to allow the cleanout of sand, dirt and other debris. Lock-down bolts shall be stainless steel with a hex-head. Pull and junction box covers shall be polymer concrete and shall have a minimum wheel load rating of 20,000 pounds and 15,000 pounds respectively. A lift opening or pull slot shall be provided on all covers. Pull boxes with covers exceeding 36-inches in length shall have a split lid. All covers shall be embossed with "TRAFFIC SIGNALS".

- H. Cable. The types and lengths of cables shall be supplied as shown on the Plans, Standard Drawings, or as specified in the Project Special Provisions. All cable shall be stranded annealed soft drawn copper wire, and shall be the AWG size as listed on the Plans. Cable shall be 600-Volt and be thermoplastic or thermosetting polyethylene insulated. All cable shall be plainly marked on the outside with the manufacturer's name and identification in accordance with industry practice.
1. Signal control cables shall be multi-conductor No. 14 AWG cables, meeting the specifications of IMSA 19-1.
 2. Power lead-in cable shall be No. 2 AWG. The insulation shall be type RHH, RHW-2 or USE-2, meeting the requirements of ICEA S-95-658. The average thickness of insulation shall be no less than 60 mils.
 3. Cables for detection systems shall be per the manufacturer's recommendations.
- I. Traffic Signal Controller, Cabinet, and Components. Traffic signal controllers shall be actuated NEMA type with NTCIP compliant software, housed in a 0.125 inch thick aluminum cabinet. For consistency, compatibility, and ease of maintenance throughout the City, all traffic signal controllers, cabinets, and components shall be furnished and installed as indicated on the City's Approved Products List, and as shown on the Plans. Traffic signal controllers shall be furnished with the following components:
1. Conflict Monitor
 2. Flasher
 3. Load Switches
 4. Flash Transfer Relays
 5. Surge Protector
 6. DC Isolator
 7. AC Isolator
 8. GPS Time Sync
- J. Secondary Service Enclosure. Secondary service enclosures shall consist of all equipment and material necessary for the distribution of secondary electrical power as shown on the Plans. Service enclosures shall be an underground service type, rated for 100 amps, 120/240 volt AC electrical line service, unless otherwise noted. Each service enclosure shall have a ringless meter socket with horn bypass meeting the requirements of the electrical utility company. Service enclosures for traffic signals shall be capable of being mounted to the traffic signal controller cabinet as shown in the City of Liberty Standard Details.

The cabinet shall be fabricated from minimum 1/8 inch thick non-anodized aluminum alloy with NEMA 3R construction. It shall have an individual meter, panel, contactor, and rear service pull "compartments". The meter and panel/contactor compartments shall have piano hinged doors. All hinges, catches and other hardware shall be non-ferrous metal or stainless steel. The meter compartment shall include padlocking provisions, and the panel/contactor outer door shall have a

factory installed Corbin lock assembly designed for a standard number 2 key. The panel/contacter compartment shall have an inside panel door. The outer front and inside panel doors shall be equipped with an approved doorstop. Panelboard shall have silver plated copper buss and shall accept the required number of 1 inch plug in breakers. Panelboard compartment shall contain a photocell and test switch. All factory installed wire shall be 600 volt rated copper. The cabinet shall have a natural aluminum finish.

- K. Photoelectric Cells. Photoelectric cells shall operate a lighting system through mercury load relays. Photoelectric cells shall be of the solid-state type operating on 120 volts. The photoelectric cell circuitry shall be designed to be normally closed at night. The photoelectric cell shall be configured such that in the event of failure, the lights shall be on. The photoelectric cell shall be mounted inside the service enclosure such that all luminaires within the system operate simultaneously and shall illuminate only during hours of darkness or low visibility. Turn-on shall occur at 2.6 foot candles \pm 0.5 foot candles. The photoelectric cell shall have an inverse off/on ratio for energy savings. Photoelectric cells shall sense light levels with a non-drifting phototransistor. The photoelectric cell shall have a time delay to avoid turn off due to lightning and transient light.
- L. LED Luminaires. All luminaires shall be LED as listed on the City's Approved Products List, and as shown on the Plans.

The luminaire shall be equipped with an integral slipfitter for 2-inch bracket arm mounting. The mounting device shall allow the luminaire to be mounted absolutely level and shall have no more than four (4) fasteners serving both the leveling and clamping functions. It shall allow one person to install the luminaire by simultaneously holding it in position and tightening the fasteners, such that the luminaire will be properly level at the first attempt. Mounting provisions shall meet 3G vibration rating per ANSI C136. Wildlife guard shall be provided to conform to the bracket arm with no gaps.

Luminaires shall have a precision-cast aluminum housing with integral light source, driver, and thermal management system. Housing shall have a gray polyester powder-coated finish to provide durability and corrosion resistance.

The electrical compartment shall be accessed through a hinged, removable power door with tool-less entry from the bottom of the fixture. Luminaires shall be pre-wired with quick disconnects, requiring only connection of pole and bracket cables to a terminal block. The manufacturer shall place a permanent tag in the luminaire housing imprinted with: the manufacturer name, luminaire voltage, wattage, and provide a blank area for the Contractor to inscribe the installation date.

Luminaires shall be provided with the following components:

1. 7-Pin photocell receptacle meeting ANSI C136.41 standards and a shorting cap.
2. Internal surge protection device (SPD) rated 10kV/5kA, meeting the requirements of ANSI C136.2. The SPD shall have a fuse that protects the fixture by disconnecting the luminaire from the power at the end of life. It shall have an indicator light that is lit when the SPD is fully functional and dark when it needs to be replaced.
3. Module for field adjusting light output and fixture wattage by up to 50% of full output.

Luminaires shall meet the following requirements:

1. Housing shall be IP66 rated.
2. UL 1598 listed for use in wet locations.
3. Accept an input voltage of 120/208/240/277 volts.

4. Rated for operation in ambient temperatures ranging from -40° C to 40° C.
5. Electromagnetic compatibility meets or exceeds FCC CFR Part 15.
6. Driver shall be rated for 100,000 hours based on IES TM-21 testing procedures, and have a power factor greater than or equal to 90 percent at full load with a total harmonic distortion less than or equal to 20 percent at full load.
7. Maintain 95% of initial intensity at 10,000 hours with an ambient temperature of 25° C based on IES LM-80 testing procedures.
8. Light source shall emit no direct uplight (BUG rating, U = 0).
9. IES Type 2 light distribution with photometric curves developed by a Nationally Recognized Testing Laboratory (NRTL) in accordance with IES LM-79 procedures.
10. Color Correlated Temperature (CCT) of 4,000 K (+/- 250 K).
11. Minimum Color Rendering Index (CRI) of 70.

The manufacturer shall submit a five-year non-prorated full warranty on all components of the luminaire to the City. The warranty shall begin on the project acceptance date and include all components of the luminaire.

- M. Multiple Tap Connectors. All lighting cable splices shall be made in pole bases using multiple tap connectors as shown in the standard drawings. Multiple tap connectors shall be insulated pre-molded electrical power connectors, with one terminal per wire. Connectors shall have set screw type terminals to accommodate the wire sizes indicated in the Plans. All connectors shall be UL listed and rated for 600 volts.
- N. Radar Detection System. For consistency, compatibility, and ease of maintenance throughout the City, all radar detection systems shall be furnished and installed as indicated on the City's Approved Products List, and as shown on the Plans.
- O. Video Detection System. For consistency, compatibility, and ease of maintenance throughout the City, all video detection systems shall be furnished and installed as indicated on the City's Approved Products List, and as shown on the Plans.
- P. Induction Loop Detectors. Induction loop detectors shall be furnished and installed per the current Missouri Department of Transportation standard details and specifications, and as shown on the Plans.
- Q. Emergency Vehicle Pre-emption. For compatibility with existing pre-emption equipment and systems, the Contractor shall be furnished and installed as indicated on the City's Approved Products List, and as shown on the Plans.
- R. Pedestrian Pushbutton Detection. Pedestrian push buttons shall be audible and shall be direct-push, contact-type with a bull-dog style. Each push button shall be a removable contact assembly mounted in a durable yellow case. Contacts shall be normally open, entirely insulated from the case and operating button, and have connecting terminals. The operating button shall be brass or another corrosion resistant metal alloy and shall be sturdy. The entire assembly shall be weatherproof, vandal-resistant, secure against electrical shock to the user, and of such construction as to withstand hard usage. The pedestrian push button shall be mounted directly to the pole in a watertight assembly and shall be the large button type meeting ADA requirements. Each pushbutton shall be wired to the adjacent pedestrian signal head for the corresponding phase using a 4 conductor #14 signal control cable (IMSA specification 19-1). If the reach for any pedestrian buttons exceeds 10 inches, the contractor shall install a pushbutton extender.

Pushbutton assemblies shall include the following features,

- Locating tone during Don't Walk
- Confirmation of button push via LED pilot light, sound, and tactile bounce
- Customizable voice message during Walk
- Vibrotactile pushbutton with large arrow
- Braille indicating the name of the street to be crossed
- Sounds automatically adjust 0 to 5 dB over ambient
- USB interface for customization and updates
- Operating temperature range of -40° F to 130° F
- NEMA TS 2 Certified

- S. Traffic Signal Signs. All permanent traffic signing and traffic control signing shall conform to the requirements of the Manual on Uniform Traffic Control Devices (MUTCD). All signs shall be fabricated from standard aluminum blanks utilizing high intensity reflective sheeting as called for in the accompanying plans. Sign banding shall be 3/4" stainless steel.

Overhead street name signs shall be provided and installed on all mast arm poles and shall be constructed of 0.125" aluminum sheeting, as indicated on the plans. Minimum size requirements for any overhead street name sign shall be 18" x 60". All signs shall have the legends centered on the face with the letters or numbers spaced to produce a readable, professional quality sign. Sign legends shall contain an initial uppercase letter followed by lowercase lettering and shall be 12" series D lettering or numbers, unless otherwise stated on the plans. In addition, all lettering and numbers shall be white in color. Actual size drawings of the proposed signs shall be submitted to the Engineer for approval.

All aluminum sign faces shall be high intensity prismatic reflective sheeting. Aluminum signs shall have a white 0.75" wide border and shall have green backgrounds. Bolt hole locations shall be field located and drilled or punched for proper installation. Signs shall be mounted to the mast arms using universally adjustable brackets attached to the mast arm by means of a clamp kit with stainless steel cable. There shall be a minimum of two brackets per sign placed no more than 3 feet apart with a maximum of 1 foot from the edge of the sign.

1803 INSTALLATION.

This section governs the construction of all bases and the installation of all signal poles, mast arms, signal heads, conduits, cables and other material and equipment as required to complete the traffic signal installation as shown on the Plans, the Standard Drawings, and as specified in the Project Special Provisions.

- A. Conduit Installation. Conduit shall be installed as shown in the Plans and the Standard Drawings. The size of the conduit used shall be as shown on the Plans. It shall be the privilege of the Contractor, at his own expense, to use larger size conduit if desired, as approved by the City Engineer. Where larger size conduit is used, it shall be for the entire length of the run from outlet to outlet. No reducing couplings will be permitted. No additional payment will be made for larger conduit.

Wherever a conduit passes beneath a curbed street, aluminum conduit markers shall be installed in the curb immediately over the conduit location. Conduit markers shall be furnished by the Contractor as detailed in the Standard Drawings and shall be installed in the top of the curb by

drilling the curb and epoxying the conduit marker in place. Conduit markers are subsidiary to the installation of conduit.

The ends of all conduits shall be well-reamed to remove burrs and rough edges. All conduits shall be cleaned and swabbed prior to installation of cable. Field cuts shall be made square and true so that the ends will butt or come together for the full diameter thereof. The end of each conduit run shall be covered to prevent water or debris from entering the conduit while the system is being constructed.

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

An approved factory coupling shall be used for connection of the HDPE conduit to PVC conduit. The interior of all conduit joints shall be sufficiently smooth to prevent cable damage during pulling.

Conduit bends, except factory bends, shall have a radius of not less than six times the inside diameter of the conduit. Where factory bends are not used, conduit bends shall be made without crimping or flattening, using the longest radius practicable and utilizing an appropriate conduit bending tool.

The conduit shall be installed continuous between traffic signal appurtenances, or as otherwise shown on the Plans. With respect to HDPE conduit, no couplings or joints will be allowed at intermediate points unless approved by the City Engineer. In unpaved areas conduit may be directionally bored to minimize disruption to existing surfaces, or it may be plowed or trenched. In paved areas, conduit may be bored or it may be plowed or trenched before pavement is installed. Paved surfaces shall not be sawcut for conduit installation. Conduit shall be installed under pavement sections at a depth not less than 36 inches below top of pavement. In all other areas, conduit shall be installed to a depth of 24 to 36 inches below finish grade.

At all outlets, conduit shall enter from the direction of the run. PVC conduit bends shall enter all junction or pull boxes from below the box and shall extend into the box a minimum of 2 inches. The side of the box shall be drilled per the manufacturer's recommendations. The hole shall be no more than one-half inch larger than the conduit. The gap between the box and conduit shall be filled with sealing compound.

1. Trenching. Trenches shall be excavated to a maximum width of 6 inches and deep enough to provide the minimum cover for conduits as shown in the Standard Drawings. If two or more conduits are placed in a common trench, the conduits shall not cross each other. If the bottom of the trench is in rock or rocky soil, the conduit shall be placed on a 6 inch protective layer of clean, tamped backfill material. Trenches shall be backfilled as soon as practical after the installation of conduit, but after inspection of the trench by the City Engineer. Backfill material installed within 6 inches of the conduit shall be free of rock or other solid material that might cause mechanical damage to conduit. The backfill material shall be placed in layers not to exceed 6 inches deep, and each layer shall be thoroughly compacted to the approximate density of the adjacent material before the next layer is placed. The 4 to 6 inches of backfill material directly below finished grade shall be topsoil. All disturbed areas shall be restored to the satisfaction of the City Engineer.
2. Plowing. Conduit may be installed by plowing in unpaved areas. The equipment used for plowing conduit is designed specifically for that purpose with the power and versatility to

easily and accurately bury the various sizes of conduit under all normal soil conditions. This equipment places the conduit without twisting, kinking, or damaging the material in any way. The vibrating unit shall be attached to a tractor unit in such a manner that the tractor does not dampen the vibration. The cable way and guides shall be smooth, free of obstructions and sharp edges and shall not cause bending of the conduit at shorter than the minimum bending radius recommended by the manufacturer, nor cause excessive strain to the conduit. Conduit reels may be mounted on the tractor or conduit unreel along the proposed route before plowing in such a manner to allow as direct a line as possible to the trench to avoid unnecessary bending of the conduit or rubbing of the conduit against the reel. The plow shall not be backed onto the conduit. If an underground obstruction is encountered, the plow shall be lifted out of the ground and the obstruction removed. After installation of conduit by plowing, the disturbed earth shall be leveled and, if necessary, compacted by a device approved by the City Engineer. Ends of conduit shall be capped immediately after cutting to prevent moisture and debris from entering the conduit. All disturbed areas shall be restored to the satisfaction of the City Engineer.

3. Directional Boring. Pavement shall not be disturbed without the written permission of the City Engineer and then only in the event insurmountable obstructions are encountered. Conduit shall be placed under existing pavement by boring. The Contractor shall complete the boring as to maintain minimum permissible clear distances, both horizontally and vertically, from all underground utilities. Boring pits shall be kept 2 feet clear of the edge of any type of pavement wherever possible. Boring alignment shall be perpendicular to the curb line in order to achieve the shortest possible crossing distance. Excessive use of water such that pavement might be undermined or subgrade softened, will not be permitted. The Contractor shall at all times and for the entire length of the boring alignment be able to demonstrate the horizontal and vertical position of the alignment. All disturbed areas shall be restored to the satisfaction of the City Engineer. Boring may be used instead of trenching or plowing at all other locations.
- B. Pull and Junction Box Installation. Pull and junction boxes shall be installed as shown on the Plans, Standard Drawings, or as directed by the City Engineer.

The top surface of all pull or junction boxes shall be flush with surfaced areas and approximately one inch above earth or sodded areas. All boxes shall have 1/2 inch clean crushed aggregate or other porous material for a minimum depth of 12 inches below the box for drainage. The excavated opening outside the junction box shall be wide enough to allow compaction of the backfill material. Cinders, broken concrete, broken rock or other hard or undesirable material shall not be used for backfilling. The backfill material shall be placed in layers not to exceed 6 inches deep, and each layer shall be thoroughly compacted before the next layer is placed. All disturbed areas shall be restored to the satisfaction of the City Engineer.

A pull or junction box placed in an unpaved area shall have a concrete pad around the perimeter as shown on the Plans. Concrete for the pad shall be per Section 1802. The concrete pad shall be reinforced with welded wire fabric. Concrete pads will not be required for boxes installed in concrete. Pull or junction boxes shall not be installed in sidewalk ramps.

Each pull box shall be equipped with cable hooks as shown on the Plans. Cable hooks shall be galvanized steel or brass with a minimum diameter of 3/8 inch and a minimum length of 5 inches.

Additional pull or junction boxes may be installed when approved by the City Engineer. If it becomes necessary to increase the excavation depth and extend the box, no direct payment will be made.

- C. Concrete Foundation Installation. The Contractor is responsible for verifying the correct line and grade of all concrete foundations prior to installation. The Contractor shall stake the location of all street lighting poles and service enclosures to be installed. The City Engineer shall inspect the staking prior to any excavation and/or construction. Minor relocation of equipment to avoid conflicts may be allowed with the approval of the City Engineer.

All concrete foundations shall be of the size and type show in the Plans, including all reinforcing steel. Reinforcing steel for concrete foundations shall be accurately cut and bent to the dimensions and shapes shown on the Plans. Cutting and bending tolerances for reinforcing steel shall be in accordance with the Concrete Reinforcing Steel Institute's Manual of Standard Practice. When placed in the work and before concrete is placed, reinforcing steel shall be free from dirt, oil, paint, grease, loose mill scale, thick rust, any dried mortar and other foreign substances. Reinforcing bars shall be positively secured against displacement. The bars shall be firmly tied at alternate crossings or closer. The steel shall be spot welded or tied in the correct position with proper clearance maintained between bare earth or the forms and the reinforcement. Measurements to reinforcing steel will be made to the centerline of bar, except where the clear distance from face of concrete is shown on the Plans. Splicing of bars shall not be allowed.

PVC conduits and conduit bends should be set in the forms for concrete foundations. Pole and controller cabinet foundations shall have separate conduits for exiting/entering cables and a separate one inch conduit for the ground wire. The direction of the exiting conduits and the orientation of the cabinet shall be as shown in the Plans. Conduit set in concrete foundations shall extend approximately three inches above the foundation vertically and a minimum of three inches outside the foundation horizontally underground.

The bottom of all concrete foundations shall rest on firm ground. Forms shall be true to line and grade. The top of the foundation for traffic signal poles shall be finished to curb or sidewalk grade, or as directed by the City Engineer. Forms shall be rigid and securely braced in place. Conduits and anchor bolts shall be placed in proper position, to proper heights, and held in place by means of a template until the concrete sets. Conduits shall be covered before concrete is poured to prevent concrete from entering the conduits. All portions of the anchor bolts extending above the foundation shall be threaded. Anchor bolts shall be provided with 2 hex head nuts, 2 flat washers, and 1 lock washer. Both forms and ground which will contact the concrete shall be thoroughly moistened before placing concrete. Concrete shall not be poured until forms and reinforcing steel have been checked and approved by the City Engineer.

Placement of concrete shall be witnessed by the City Engineer. Concrete foundations shall be poured monolithic, except for the pole cap of traffic signal pole foundations. The pole cap shall be formed and poured after the poles are plumbed with arms installed. Foundations shall be consolidated by an internal type vibrator. The vibrator shall operate at frequencies of vibration not less than 4,500 cycles per minute under load. The amplitude of vibration shall be adequate to consolidate concrete properly. The concrete shall be cured with an approved moisture barrier such as wet burlap, polyethylene, etc., for a period of seventy-two hours. Cold weather curing shall be such that the concrete temperature shall be maintained above freezing for the entire curing period. Forms shall not be removed until the concrete is thoroughly set.

The exposed portions of the foundation shall be finished to present a neat appearance. Finishing should be done with the positioning jig in place. If the jig must be removed for finishing, it shall be re-installed immediately after finishing and left in place throughout the cure period. Prior to installing the pole or controller cabinet, the positioning jig shall be removed and loose concrete cleaned from around the anchor bolts and conduits.

Cinders, broken concrete, broken rock or other hard or undesirable material shall not be used for backfilling around the finished foundation. The backfill material shall be placed in layers not to exceed six inches deep, and each layer shall be thoroughly compacted to the approximate density of the adjacent material before the next layer is placed.

Expansion joints shall be provided where a concrete foundation is adjacent to a concrete surface. After concrete has cured a minimum of seven days, the joint shall be cleaned, filled, and sealed per Section 1500.

- D. Controller Cabinet Installation. The controller cabinet and service enclosure shall be constructed and installed as shown on the Plans or as directed by the City Engineer. The service enclosure shall be attached to the controller cabinet so the photoelectric cell is oriented to the North or to the East. The cabinets shall be cleaned of wrapping, shipping material, dirt, grease, etc. Scratches, abrasions or other surface damage shall be repaired to like new condition. The Contractor shall coordinate his activities with the electrical utility company to insure delivery of power to the service enclosure when and where required.
- E. Signal Pole Installation. Traffic signal poles shall not be installed on concrete foundations sooner than seven days after pouring the concrete foundation, or when the concrete reaches a compressive strength of 3,400 psi. All poles and pedestals are to be installed as shown in the plans and the Standard Details. All attachments are to be located in the field and all wire entrances shall be drilled or punched in the field. All drilled or punched surfaces shall be carefully reamed and/or deburred or threaded as appropriate before an application of one field coat of cold galvanizing. The City Engineer shall confirm the location and mounting heights of all pole and pedestal attachments located in the field. Should field adjustment of any attachment be necessary after the City Engineer confirms the locations, the Contractor shall be responsible for plugging any holes caused by the initial installation. Hole plugging methods shall be approved by the City Engineer.

Mast arms on mast arm poles shall be installed after the mast arm poles are erected. In some instances and depending upon the final locations of the signal poles, a short section of the mast arm(s) may need to be cut off, as directed by the City Engineer, in order to accommodate varying field conditions.

Signal heads shall be installed as shown on the Plans and the Standard Details. The City Engineer shall approve the location, mounting and mounting height of all signal heads. Signal heads shall not be installed at any intersection until all other signal equipment, including the controller cabinet, is in place and ready for operation at that intersection, except that the signal heads may be mounted if the heads are covered. The signal heads at a new signalized intersection shall be covered with an orange opaque signal head cover. The color of the covering at a location where a previous traffic signal was installed shall be black. All covers shall be specifically manufactured for traffic signal heads to be wind and weather resistant, and shall be easily installed and removed.

The signal heads shall be adjusted in the field such that a person standing on the pavement, a distance of four times the speed limit (mph) in feet from the stop bar, shall see the brightest image of the red section. All heads shall be plumbed as viewed from the direction in which they face.

- F. Detector Installation. Detection equipment shall be installed per the Standard Details and per the product manufacturer's recommendations.
- G. Circuit Wiring. Installation of wiring shall be in accordance with the Plans and appropriate articles of the NEC. Wiring shall be installed in conduit according to the operating voltage of the equipment. Cables for 120 volt equipment must be installed in separate conduits from low voltage equipment. Where practical, color codes shall be followed according to the following tables for each type of multi-conductor control cable:

2 – Conductor (Pedestrian Pushbutton)	Terminal
Black	Pushbutton Actuation
White	Neutral

5 – Conductor (Pedestrian Signal Head)	Terminal
Red	Don't Walk Indication
Orange (or Yellow)	Neutral
Green	Walk Indication
Black	N/A
White	Neutral

7 – Conductor (Vehicular Signal Head)	Terminal
Red	Red Ball or Red Arrow Indication
Orange (or Yellow)	Yellow Ball Indication
Green	Green Ball Indication
Blue	Green Arrow or Flashing Yellow Arrow Indication
Black	Yellow Arrow Indication
White	Neutral
White with Black Trace	Neutral for Arrows

Cable shall be pulled with minimal dragging on the ground or pavement. Frame mounted pulleys or other suitable devices shall be used for pulling cables out of conduits into pull boxes. Powdered soapstone, talc or other approved lubricant shall be used to facilitate pulling cable in conduits. All cable to be installed in one conduit shall be pulled by the Contractor in one operation, and all ends 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. After cables are installed all conduit ends shall be sealed around the cables with a readily workable, soft, sealing compound. The compound shall be workable at 30° F and shall not melt or run at temperatures up to 175° F.

No splicing of cables will be permitted unless shown on the plans or approved by the City Engineer. Wire nuts shall be used in the signal pole bases convenient to the hand hole for wire connections of control cables. Lighting cables shall be connected to pole and bracket cables in pole bases with multiple tap connectors.

All cables passing through a pull or junction box shall be coiled once around the inside of the box to allow for splicing and connecting wires in the future. Five feet of slack for each cable should be provided in the controller cabinet, and two feet of slack for each cable in pole bases. Wiring within the controller cabinet and pole bases shall be neatly arranged and dressed using nylon cable ties. All circuits shall be properly labeled in all service boxes, pole bases, and controller cabinets by means of round brass or aluminum identification tags with a minimum thickness of 0.1 mil attached to the cables with copper wire. The ends of the copper wire should be wrapped with electrical tape. Information on the tags shall identify equipment served by the conductor cable in accordance with designations used on the plans.

- T. Grounding. All electrical systems, equipment, and appurtenances, including poles and service points shall be properly grounded in accordance with NEC requirements. At each pole foundation or signal controller foundation, a ground rod shall be driven, approximately 6 inches away from foundations. At pole bases, driven ground rods shall be connected to grounding lugs by a No. 6 AWG copper ground wire attached to the rod with a galvanized grounding clamp. At secondary service enclosures, driven ground rods shall be connected to the neutral bus and the service enclosure by a No. 6 AWG copper ground wire attached to the rod with a galvanized grounding clamp. Ground wire is to be run through one-inch diameter PVC conduit in the concrete foundation. At secondary service enclosures, to completed ground rod installation and connection to the ground wire shall not be backfilled until it the service enclosure passes inspection by the City's Building Division. The grounding clamp connection and the listing mark on the rod must be visible for inspection.

Ground rods shall be copper coated to meet NEC requirements, not less than 5/8 inch in diameter, and 8 feet in length. Ground rods shall be driven to a minimum depth of 12 inches below the finished surface. If subsurface conditions exist which prohibit the placement of the ground rod in a vertical position, the rod may be driven at an oblique angle, not to exceed 45-degrees from vertical, or when authorized by the City Engineer, buried in a trench at least 30 inches deep.

- U. Signal Turn-On. The signal turn-on shall be performed by the Contractor, City personnel shall be present at the activation. The signal turn-on shall not occur on Fridays, holidays, or weekends and shall be completed between the hours of 9:00 a.m. and 2:00 p.m., unless otherwise noted in the Plans or directed by the City Engineer. At locations without previous traffic signal control, the new traffic signal shall operate in flash mode for a period of five business days prior to full signal system turn-on.
- V. System Testing. The Contractor is responsible for testing the completed traffic signal. Test shall be performed by the Contractor in the presence of and documented by the City Engineer.
1. Resistance Testing. After a service enclosure is energized, the resistance to ground shall be tested. The ground rod shall have a resistance to ground of 25 ohms or less. If the resistance is more than 25 ohms, the Contractor shall install additional ground rods at least six feet away which are bonded to the first ground rod, until the required resistance is achieved. No payments will be made for additional ground rods.

2. Operational Testing. Prior to acceptance by the City, the Contractor shall notify the City Engineer as soon as the signal is ready for operational testing. A signal operated independently of other signals or signal systems shall be tested as a single installation. A signal operated as part of a system shall not be tested until all signals in the system are ready to be tested. All traffic signal elements shall function properly as a complete system for a minimum period of fifteen consecutive days before acceptance is granted. The fifteen day period shall be initiated by the City Engineer. Any failure or malfunction of equipment during the test period shall be corrected to the satisfaction of the City Engineer at the Contractor's expense. The signal or signal system shall be tested for an additional 15 consecutive day period.

In the event of a failure or malfunction, the Contractor shall provide adequate traffic control for the intersection until the signals are restored to normal operation. Adequate traffic control shall be as shown on the Plans or as directed by the City Engineer. If the signal or signal system malfunctions and the Contractor's designated technician cannot be reached or cannot arrive at the intersection in a reasonable time in the judgment of the City Engineer, then the City Engineer may exercise the option to direct City personnel or a third party to correct the malfunction in the presence of the City Engineer. If this option is invoked, the entire cost of the work performed by City personnel or the third party will be computed and deducted from the payments due the Contractor.

- W. As-Built Plans. Prior to acceptance of the work, the Contractor shall submit marked-up or corrected plans showing in detail all construction changes, especially the location of conduit. The Designer will produce as-built plans from the Contractor's marked-up plans.
- X. Final Clean Up. Before final acceptance, the Contractor shall restore to a condition equal to or better than that existing prior to construction, for all property, both public and private, within, adjacent to and beyond the limits of construction that have been disturbed or damaged while executing the work. This includes, but not limited to, existing curb and gutter, sidewalk, pavement, drainage, structures, irrigation systems, street lighting and traffic signal equipment. All unpaved areas damaged during construction shall be restored to the original condition. Unless otherwise directed, grassy areas which were originally sodded shall be re-sodded. Restoration work shall be at the Contractor's expense. All restoration work shall be acceptable to the City Engineer.