SECTION 2900 – TRAFFIC SIGNALS

CITY OF LEES SUMMIT, MISSOURI
STANDARD SPECIFICATIONS

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2901 General: This work shall consist of furnishing and installing traffic signal equipment and materials as shown on the plans. 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 local ordinances.

2901.1 These Specifications may be modified or deleted by appropriate items in the Project Special Provisions or by written authorization by the City Engineer.

2901.2 Work incidental to traffic signal installation that is not covered in these Specifications shall be performed in accordance with the City of Lee's Summit 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. All systems shall be complete and in operation to the satisfaction of the City Traffic Engineer at the time of acceptance.

2901.3 All appurtenances shall be installed as shown on the Plans, or as specified in the Project Special Provisions. Any deviations must be established by the Contractor and authorized by the City Traffic Engineer.

2901.4 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.

2901.4.1 The Contractor is responsible for obtaining the owner's building permit from the City's Codes Administration Department before electrical service can be delivered to a power supply. The Contractor shall contact the City's Codes Administration Division for an electrical inspection when a power supply is ready for operation. The City Inspector will obtain an address for the power supply, which the Contractor shall use when dealing with the electrical utility company.

2901.4.2 The Contractor is responsible for contacting the electrical utility company in advance to schedule the installation of the power cables to the power supply. The City shall pay the electrical utility company's fees to deliver electrical service. The Contractor shall be billed for all electrical utility service charges until the test period is successfully completed, at which time service can be transferred to the City.

2901.5 Existing traffic signals shall be maintained in effective operation by the Contractor, except for shutdowns approved by the City Traffic Engineer for alterations or final removal. After any modifications have been made or after work is begun on an existing signal installation, the Contractor shall maintain the signals in accordance with Section 2920. The Contractor shall notify the City of Lee's Summit at least two days, excluding weekends and city holidays, prior to operational shutdown of any traffic signal, and or prior to disconnecting existing vehicle or pedestrian detection. All traffic signal equipment that the Contractor uses or installs on the project, whether furnished by the City or the Contractor, either on a temporary or permanent basis, shall, upon installation or upon initial use by the Contractor, be operated and maintained by the Contractor until the project is complete and accepted. Any malfunction of an existing signal installation resulting from the Contractor's operation, regardless of the nature of the work, shall be corrected at the Contractor's expense in accordance with Section 2920. Signal timing will be

provided by the City Traffic Engineer. Programming of the controller will be the responsibility of the City, except when waived by the City Traffic Engineer. If any adjustments are required to the operation of an existing signal installation due to the Contractor's operation, the Contractor shall provide a minimum of two working days notice to the City Traffic Engineer.

2902 Temporary Traffic Signals: Installation of temporary traffic signals shall consist of furnishing and installing poles for span wire signals, span and tether wires, control and power cable, power supply and connection to a power source, the controller, signal heads, detectors, luminaires, and all mounting hardware, unless specified otherwise. Maintenance of the installation and all other equipment and material necessary to provide the temporary installation will be the responsibility of the Contractor. If the temporary traffic signal installation is not shown on the plans, the Contractor shall submit a plan to the City Traffic Engineer for approval prior to the installation of temporary signals. Any existing or City furnished signal equipment to be used in the temporary signal shall be shown on the temporary signal plan. Temporary signals shall have the signal heads covered until placed in operation. A minimum of two signal faces, in accordance with the MUTCD, shall be oriented toward each street approach positioned a minimum of 8 feet apart, center to center, and a minimum of 16 feet above the surface of the traveled way to the bottom of the signal head assembly including backplate. Existing signals shall not be taken out of operation until the temporary signals are ready for operation and approved by the City Traffic Engineer. A flashing operation shall be used during shutdown of the temporary signals.

2902.1 All temporary signal equipment shall be removed by the Contractor after the new installation is in operation, or as directed by the City Traffic Engineer. Contractor furnished equipment that will become the property of the City shall be of new stock and shall meet all applicable specifications. Contractor furnished equipment that will remain the property of the Contractor may be new or used. City owned equipment will remain the property of the City, unless specified otherwise, and shall be disposed of as shown on the plans or as directed by the City Traffic Engineer.

2902.2 The Contractor shall pay all electrical costs incurred by operation of the temporary signals. For temporary signal installations where an existing signal power supply is not available, the Contractor shall make any necessary arrangements to provide power to the temporary signals. Portable generators shall not be used to provide power to temporary signals. No direct payment will be made for power costs. All wire and cable for temporary signals shall be suspended overhead with proper clearance or buried a minimum of 18 inches underground.

2902.3 Temporary signal installations shall be installed to meet the construction schedule. The Contractor shall provide a minimum of two working days notice to the City Traffic Engineer prior to the signal turn-on. The Contractor shall maintain the signals in proper operating condition, in accordance with Section 2920. Any damage to the traffic signal installation from any cause whatsoever shall be repaired by the Contractor at the Contractor's expense.

2903 Span Wire Assemblies: Span wire assemblies shall include 3/8-inch steel messenger wire, 1/4-inch tether wire, guy wire, all bolts, nuts, washers, clamps, cable straps, and other appurtenances shown on the plans or necessary for proper installation. Messenger wire shall be Class A galvanized, high-strength grade, seven-wire strand in accordance with ASTM A 475. Tether wire shall be seven-wire high-strength steel cable. Splicing of messenger and tether wires will not be permitted. Clamps shall be fabricated from low alloy steel. Steel poles for span wire assemblies shall have wire inlets and cable guides with 1-1/2 inch watertight insulator bushings and other features specified in the contract, and shall be in accordance with Section 2909. Wood

poles shall be in accordance with Section 2905. Wood poles and steel poles for span wire assemblies shall be as specified in the contract and as shown on the plans. Luminaire bracket arms, if specified, will be at the Contractor's expense. Conduit, junction boxes, service entrance caps, attachment hardware or other appurtenances on the wood poles or steel poles as shown on the plans will be at the Contractor's expense.

2904 Power Supplies: Power supplies shall conform to the requirements of Section 2800 of the City of Lee's Summit Design and Construction Manual.

2904.1 For temporary traffic signals, the configuration and installation of equipment mounted on substation and service poles shall be in accordance with the requirements of the utility company furnishing electrical power.

2905 Electric Substation, Service and Span Wire Assembly Poles:

2905.1 Electric Substation and Services Poles**:** Electric substation and service poles shall be of the length and class specified in the contract documents, and shall be in accordance with ANSI 05.1. Poles shall be of the species Southern Pine and have either a 0.38 (pounds per cubic foot of wood) minimum retention of Pentachlorophenol preservation or 0.60 (pounds per cubic foot of wood) minimum retention of ACA or CCA preservation treated in accordance with AWPA C4 Specification. Poles may be gained and drilled in the field after treatment. Areas exposed shall be treated in accordance with Section 2905.5 before cross-arms or equipment are mounted.

2905.2 Span Wire Assembly Poles: Span wire assembly poles shall be of the length specified in the contract and shall be in accordance with ANSI 05.1, Class IV, unless otherwise specified. The poles shall be of the species Southern Pine and have either a 0.38 (pounds per cubic foot of wood) minimum retention of Pentachlorophenol preservation or 0.60 (pounds per cubic foot of wood) minimum retention of ACA or CCA preservation treated in accordance with AWPA C4 Specification. All poles shall have a minimum diameter of 6 3/4 inches, measured at the top of the pole.

2905.3 Pole Crossarms: The species, grade and treatment of crossarms to be erected on substation and service poles will be shown on the plans.

2905.4 Timber Preservatives:

2905.4.1 Pentachlorophenol: Pentachlorophenol shall be in accordance with AWPA P8 in a hydrocarbon solvent meeting the requirements of AWPA P9, Type A.

2905.4.2 Ammoniacal Copper Arsenate (ACA) or Chromated Copper Arsenate (CCA): Ammoniacal Copper Arsenate and Chromated Copper Arsenate shall be in accordance with AWPA P5.

2905.4.3 Copper Naphthenate For Repair: Copper Naphthenate shall be prepared with a solvent in accordance with AWPA Standard P9. The preservative concentration shall contain a minimum of 2 percent copper metal.

2905.4.4 Responsibility for Quality: The Contractor shall use preservatives that meet these specifications or the treated material will be subject to rejection, or to approved retreatment with an approved preservative.

2905.4.5 Final Steaming: All substation, service and span wire poles; except material treated with ACA or CCA, shall be cleaned by a final steam bath in accordance with AWPA C2, C4 or C5, as applicable. In lieu of steam cleaning, sign poles may be strip stacked and air-dried for a minimum of 60 days after treatment.

2905.5 Care After Treatment: Care shall be taken in handling pressure-treated material to avoid damage. Cant hooks, peavies, pickaroons and end cant hooks shall not be used on the side surfaces of treated material. All handling of treated round stock with pointed tools shall be confined to the ends. If damaged material is permitted for use by the City Engineer, or framing at site is required, such injuries, cuts or holes shall be liberally field-treated with the preservative of the same type used for the original treatment, or of copper napthenate. A second coat shall not be applied until after the first coat has been absorbed. Holes shall be treated by plugging one end and filling with preservative.

2905.6 Inspection Requirements:

2905.6.1 Inspection: All material shall be inspected for compliance with these specifications in accordance with AWPA Standard M2.

2905.6.1.1 Timber products treated within the State of Missouri or within 100 air miles of the border may be inspected by City personnel.

2905.6.1.2 The inspection of poles shall be performed by the supplier or an approved inspection agency, and the cost for inspection shall be at the Contractor’s expense.

2905.6.2 Inspection Agency: An approved inspection agency will be a laboratory, accredited by the American Lumber Standards Committee, P.O. Box 210, Germantown, MD, or an experienced testing laboratory approved by the City Engineer. Inspection agencies not accredited by the American Lumber Standards Committee shall submit for approval a resume to the City of Lee’s Summit Public Works Engineering Department. The resume of the agency shall include the agency’s history of inspection of timber and treated products, a listing of state highway agencies which have approved the inspection agency and a listing of state agencies for which the inspection agency has performed inspection.

2905.7 Certification: Electric substation, service and span wire assembly poles will not require certified test reports.

2905.8 Acceptance: Acceptance of material will be based on satisfactory supplier's certification or inspection agency certifications, and upon results of any tests deemed necessary by the City Engineer at destination to ascertain compliance with these specifications.

2906 Material: All material, equipment and incidental parts shall be of new stock unless the contract provides for relocation of existing units or use of units furnished by others to be retained by others. New equipment and material shall be similar manufacturer and be the product of reputable manufacturers and shall be in accordance with Caltrans 170 Specifications, ICEA, IMSA, ITE, MUTCD, NEMA, RETMA, NEC and the regulations of the National Board of Fire Underwriters, as applicable, and shall meet the approval of the City Traffic Engineer. The cost of incidental materials not mentioned in the Plans or Specifications shall be considered subsidiary to other items in the contract.

2906.1 Materials for traffic signal equipment, poles, conduit, cable, and other items not specified under section 2906 are covered elsewhere within these Specifications or on the Plans or Project Special Provisions.

2906.2 Stainless Steel Bolts, Nuts and washers. Nuts for Anchor Bolts shall be in accordance with ASTM A 563, Grade C, D or DH or ASTM A 194, Grade 2 or 2H. Stainless Steel Bolts, Screws and Washers shall be in accordance with ASTM A 193, Grades B5, B6, B7 or B16. Stainless Steel Nuts shall be in accordance with ASTM A 194.

2906.3 Bolts, nuts and washers, except stainless steel, shall be galvanized in accordance with AASHTO M 232, Class C or mechanically galvanized in accordance with AASHTO M 298, Class 55. Except for anchor bolts, galvanizing thickness shall not exceed 6 mils. Anchor bolts shall have a minimum yield strength of 55,000 psi and a minimum elongation of 14 percent in 2 inches or 12 percent in 8 inches. For anchor bolts and nuts, and for high strength bolts and nuts, except those in accordance with AASHTO M 164, the Contractor shall furnish to the City Engineer a test report certified to be the last completed set of mechanical tests for each size in each shipment. For high strength bolts and nuts in accordance with AASHTO M 164, the Contractor shall furnish a copy of the manufacturer's inspection test report for each production lot or shipping lot furnished to the City Engineer and shall certify the bolts furnished are in accordance with the requirements specified. Bolts and nuts specified to meet ASTM A 307 shall be accompanied by a manufacturer's statement that the bolts and nuts were manufactured in accordance with ASTM A 307.

2906.4 Concrete: Concrete shall be as specified in the contract. Concrete construction, including but not limited to, material, proportioning, mixing, slump, transporting, placement, finish, curing, and surface seal shall be in accordance with ACI 301 Standard Specifications for Structural Concrete. All reinforcing steel shall meet the requirements of reinforcing steel for concrete structures.

2906.4.1 All material will be subject to the inspection and acceptance by the City Inspector.

2906.5 Reinforcing Steel for Concrete Structures: This work shall consist of furnishing and placing reinforcing steel of the designated shape, size and grade as shown on the Plans. All material shall meet the requirements of steel bars for concrete reinforcement. AASHTO specifications, when referenced, will control the physical properties, chemical properties and handling and storage of the material, except as otherwise specified herein or shown on the Plans.

2906.5.1 Unless otherwise specified, reinforcement shall be deformed bars in accordance with AASHTO M 31, AASHTO M 42 or AASHTO M 53. Bars in accordance with AASHTO M 42 and M 53 shall be in straight lengths only.

2906.5.2 Spiral reinforcement shall be in accordance with Section 2906.5.1, except that the reinforcement may be plain or deformed or shall be cold drawn steel wire in accordance with AASHTO M 32 or deformed steel wire in accordance with AASHTO M 225.

2906.5.3 Welded steel wire fabric shall be in accordance with AASHTO M 55 or AASHTO M 221.

2906.5.4 Epoxy coated reinforcing steel shall be in accordance with AASHTO M 284/M284M-2 except as otherwise specified herein or shown on the Plans. Only steel in accordance with Section 2906.5 shall be used.

2906.5.4.1 Coated bars shall not be spliced except as shown on the Plans.

2906.5.4.2 Organic coatings, other than epoxy, shall not be used.

2906.5.4.3 Patching or repair material shall be compatible with the coating, inert in concrete and in accordance with the epoxy resin manufacturer's recommendations. The material shall be epoxy and be suitable for application at the plant or in the field to uncoated areas and damaged areas of the coating.

2906.5.5 Documentation of uncoated steel shall include the steel manufacturer's certified mill test report showing complete chemical and physical test results for each heat.

2906.5.6 Documentation of coated steel shall include the coating applicator's certification that all material used, the preparation of the bars, coating and curing are in accordance with these Specifications, and that no bar contains more than one holiday per linear foot. The certification shall include or have attached specific results of tests of coating thickness and flexibility of coating.

2906.5.7 Reinforcing steel 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*. Flame-cutting of uncoated reinforcing steel will not be permitted.

2906.5.8 Reinforcing steel shall be protected from damage at all times. 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. A thin layer of powdery rust may remain. All reinforcing steel required for superstructure concrete, such as slabs, girders and beams and top slabs of culverts with more than a 4-foot span, shall be held securely in correct position with approved metal or plastic bar supports and ties. Reinforcing bars shall be positively secured against displacement. For bridge decks and top slabs of culverts, bars in the top mat shall be firmly tied with wire at each cross or lap. At other locations, the bars shall be firmly tied at alternate crossings or closer. The steel shall be tied in the correct position with proper clearance maintained between the forms and the reinforcement. The Contractor shall construct the unit as shown on the Plans. 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.

2906.5.9 Bars shall not be spliced, except as shown on the Plans or as directed by the City Engineer.

2906.5.10 Mechanical bar splice systems, as shown on the Plans, shall be capable of developing 125 percent of the specified yield strength of the bar being spliced and shall be installed in accordance with the manufacturer's recommendations and as modified herein.

2906.5.10.1 The Contractor shall furnish to the City Engineer a manufacturer's certification stating that the mechanical bar splice systems are in accordance with this specification. The certification shall include or have attached specific results of tests showing yield and ultimate tensile load capacities.

2906.5.10.2 The splicing system may attach directly to the bars being coupled or may be of a type that provides reinforcing bars of like size that lap with the bars being joined. A threaded type

splice system will be required where clearance considerations require the splicing device to be placed flush to the face of the construction joint for the initial concrete placement.

2906.5.10.3 Reinforcing bar lengths shown in the bill of reinforcing steel may require modification to accommodate the specific mechanical bar splice system that will be used. The Contractor shall determine the actual reinforcing bar lengths to accommodate the manufacturer's recommendations for installation of the mechanical bar splices.

2906.5.11 High Strength Anchor Bolts, Nuts and Washers: All accessories shall be galvanized to ASTM A-153 standards. The anchor bolts shall be hot dipped galvanized on threaded end after threading. The galvanizing shall include all threads and not less than six inches of the adjacent unthreaded portion of the bolts. Anchor bolts shall be threaded to a length shown on the Plans or in the standard details. Threads shall be Coarse Thread Series as specified in ANSI B1.1 and may be formed by cutting or rolling. Nuts for anchor bolts shall be Heavy Hex leveling nuts and Heavy Hex nuts as specified in ANSI B18.2.2. Nuts shall comply with the proof load or Brinell hardness requirements of ASTM A307. After galvanizing, the thread fit of the bolt-nut combination shall be snug and shall be such that the nuts can be turned on the bolts without the application of excessive torque.

2906.6 Shop Drawings: Before commencing the installation of any material or equipment, the Contractor shall submit four (4) copies of complete shop drawings for manufactured materials and equipment to the City Traffic Engineer for approval. Manufacturers' bulletins, leaflets and other descriptive data that contain cuts, dimensions, specifications and wiring diagrams will be acceptable for standard cataloged equipment. Such bulletins, leaflets and other descriptive data shall be clearly marked to show the item to be used to satisfy a required item in the schedule of materials shown on the Plans, or as specified in the Project Special Provisions. The City Traffic Engineer may require other descriptive data, drawings, and diagrams for non-cataloged equipment or materials. In the event any items of material or equipment contained on the shop drawings fail to comply with the specification requirements, such items may be rejected by the City Traffic Engineer. Orders for material and equipment shall not be placed until written approval is obtained from the City Traffic Engineer. A list of pre-approved equipment and material is available through the Public Works Traffic Engineering Division. Only items on the latest revision of the pre-approved list will be accepted for use. Approval of the items on the equipment and material list will not relieve the Contractor of responsibility for satisfactory performance of the installation.

2907 Signal Heads: Each signal head of one or more signal faces shall be conventional or, if designated on the Plans, optically limiting. The Contractor may furnish aluminum or polycarbonate signal heads. Each vehicle signal head shall be a watertight assembly of one or more signal faces of the sizes shown on the Plans. All brackets and fittings necessary for proper mounting with the type of signal support designated on the Plans shall be furnished. Each signal face 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. All signal heads on a project shall be the product of one manufacturer and shall be single model number for like items. For signal modification projects, new signal heads shall match existing signal heads with respect to manufacturer and model. The position of signal indications shall be as specified in the Plans and Specifications. Each traffic signal face shall consist of a number of identical signal section housings rigidly fastened together. Signal heads shall not be painted in the field. 5-Section signal heads mounted on mast arms shall be "doghouse" style. 5-Section signal heads mounted on poles shall be inline.

2907.1 Housing, Door and Visor: If existing housings are to be combined with new housings, the new housings shall be adaptable to the existing. All housing, doors and visors shall be made of durable polycarbonate and shall be black in color. Each shall be clean, smooth and free from cracks, and other imperfections. The housing shall be designed as a self-contained unit capable of separate mounting or inclusion in a signal face containing two or more signal sections 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. Housings shall be equipped with positive locking devices to maintain a specific angle of direction when in place. The doors shall be suitably hinged and held securely to the body of the housing by simple stainless steel locking devices. All other door parts shall also be of stainless steel material. Doors provided on 5-section "doghouse" style signal heads shall open in opposite directions such that a clear opening is provided between two adjacent housings. Neoprene gasketing shall be used between the lenses and reflectors to exclude dust and moisture. Signal visors shall not be less than 0.05 inches thick and shall be tunnel type. Pedestrian visors shall not be less than 0.06 inches thick. Signal visors shall be at least 9.5 inches long for 12-inch diameter signals and shall angle slightly downward. Pedestrian visors shall have a 9-inch to 9.75 inch length. All visors shall be designed to fit tightly against the door and shall not permit any perceptible filtration of light between it and the housing door. The optical unit and visor shall be designed as a whole so as to eliminate the return of outside rays entering the unit form above the horizontal.

2907.2 Louvers: Louvers, if specified in the Plans, shall be installed in a tunnel visor with the fins or baffles in a vertical position.

2907.3 Hardware. Fittings shall be secured to the signal housing by a closed threaded nipple and hex nut. Cast nipples shall not be used.

2907.4 Signal Head Mounting: Vertical bracket mounted signal heads, as shown on the Plans, 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 conductors are concealed within the assembly. Brackets shall be attached to the pole of pedestal by approved stainless steel banding and brackets. Mast arm signal head assemblies shall be rigid mounted utilizing a universally adjustable bracket consisting of both top and bottom brackets with a center vertical extruded aluminum support tube and terminal compartment (box) attached to the mast arm by means of a clamp kit with 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 vertical support shall not extend more than 3 inches beyond the horizontal bracket. The lower bracket arm shall be hollow for wiring entry into the signal head. Traffic signal heads and pedestrian signal heads shall not share mounting hardware.

2907.5 Backplates: Stainless steel bolts, nuts and flat washers shall be used to fasten the backplate to the head. Bolt lengths shall be selected to not interfere with maintenance operations. Any connection to the top of any signal section shall be watertight. Backplates shall be provided on all signal heads as shown on the Plans. Backplates shall be black in color and constructed of flat pre-cut or preformed thermoplastic. Flat pre-cut thermoplastic backplates shall have a minimum thickness of 0.250 inch. Preformed thermoplastic backplates shall have rolled out edges and a minimum final thickness of 0.10 inch.

2907.6 Indications: All signal indications for new signal installations as well as signal modification projects shall be Light Emitting Diode (LED) displays, 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 Institute of Transportation Engineers (ITE) specifications for LED vehicle traffic signal modules. Pedestrian indication legends shall conform to the ITE specification for pedestrian traffic control signal indications. Pedestrian WALK and Countdown indications shall be lunar white in color. Pedestrian DON'T WALK hand symbol shall be orange in color.

2907.7 Signal Faces: Vehicle and pedestrian signal faces shall be covered or turned away from approaching traffic until placed in operation. When ready for operation, the signal faces shall be securely fastened in position facing approaching traffic. Vehicle and pedestrian signal faces shall be aimed laterally at the approximate center of the lane or lanes the signal face controls.

2907.8 Optically Limiting Signal Heads: The signal section shall be a self-contained assembly consisting of an optical unit, section housing, housing door, terminal block and necessary gaskets to ensure a weatherproof unit. The optically limiting signal head shall be capable of separate mounting or inclusion in a signal face containing two or more signal sections. If existing housings are to be combined with new housings, the new housings shall be adaptable to the existing. Each signal section shall be installed and directed and the optical limiter masked in accordance with manufacturer's recommendations to provide indications in accordance with the Plans or as directed by the City Traffic Engineer.

2907.9 Painting and Finishing: All aluminum signal head parts, including the housing, housing door, visors, louvers and backplates, except the mounting brackets and other hardware, shall be primed and painted flat black in their entirety. All polycarbonate signal head parts, including the housing, housing door, visors and backplates shall be constructed from ultraviolet stabilized black-impregnated polycarbon resin. The 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. Painting of the mounting brackets and hardware will not be permitted. All metal parts reused for modification of a signal installation shall be painted in accordance with the requirements for new material. If the painted surface of any equipment is damaged, the surface shall be repaired to the satisfaction of the City Traffic Engineer.

2908 Signs: Signs for signal installations shall be furnished by the Contractor. Signs shall be mounted to the mast arms using strap supports or Astro-Brackets. There shall be a minimum of two supports per street name sign placed no more than 3 feet apart with a maximum of 1 foot from the edge of the sign. Sign installation and all material required for any sign mounting, shall be furnished by the Contractor. All permanent traffic signs and street name signs shall conform to the requirements of the MUTCD and Section 3000 of the City of Lee's Summit Design and Construction Manual. Any signs not detailed on the Plans shall be in accordance with *Standard Highway Signs* by the U.S. Department of Transportation, Federal Highway Administration. Signs shall be mounted as shown on the Plans.

2909 Poles and Mast Arms: Prior to installation, manufacturer and drawing numbers shall be submitted by the Contractor to the City Traffic Engineer for approval in writing. Four copies of applicable pre-approved drawings shall be supplied with the poles. A grounding lug shall be provided for all units. A grounding conductor shall provide grounding continuity for all metallic, non-current carrying poles in one circuit.

2909.1 Steel Pedestal Poles: Steel pedestal poles shall be 4 1/2 –inch outside diameter schedule 40 steel pipe. The base shall be cast iron, free from imperfections, and shall be provided with a suitable plastic, fiberglass or cast door for wiring access. The grounding lug shall be inside the base. The bolt circle and hole diameter shall be as shown on the Plans. After fabrication, poles and bases shall be fully galvanized.

2909.2 Aluminum Pedestal Poles: Aluminum 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. 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 a suitable 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.

2909.3 Signal Pole and Mast Arm Pre-Approval: Fabricators shall submit six copies of shop drawings and supporting calculations to City of Lee's Summit Public Works Engineering Division. Submittals shall be approved in writing prior to fabrication of the signal poles and mast arms. Shop drawings shall indicate complete design details required for pole and mast arm fabrication, including material grades and thicknesses, welding and orientation of any longitudinal seams. The projected areas and weights of signs and signals used in the design of the pole and mast arms shall be shown on the shop drawings. Design details for all possible pole and mast arm combinations shown on the Plans may be submitted. Shop drawings shall provide pole and mast arm installation and hardware details. All welding procedures shall be prepared by the manufacturer as a written procedure specification and shall be submitted with the shop drawings for approval. Approval of the weld procedures will be required before approval of the shop drawings. Shop drawings shall indicate the specific approved welding procedure to be used for each joint. Shop drawings and supporting stress calculations shall be signed and sealed by a registered professional engineer in the State of Missouri. Manufacturers shall submit all required documentation, in accordance with Section 2909.4.3. Upon written approval, pre-approved drawings may be used on any project where the design conditions of the shop drawings are not exceeded.

2909.4 Steel Poles and Mast Arms: Steel poles and mast arms shall be round, continuously tapered, hollow shafts fabricated as one continuous shaft or as individual segments at least 10 feet long, joined together using electrically welded, intermediate, transverse, full penetration, circumferential joints. Steel poles and mast arms shall be fabricated from basic oxygen or open-hearth steel sheet. The continuous, tapered, hollow shafts or individual segments shall be manufactured from one or two lengths of steel sheet, with one or two continuous, welded, longitudinal seams. The longitudinal seams in the mast arm shall be located outside of the upper half of the cross section of the member. Where transverse, full penetration, circumferential welds are used, the fabricator shall furnish to the City Engineer written certification that 100 percent of all such welds have been radiographed or ultrasonic tested by an independent testing agency using a qualified non-destructive testing technician, as described in Section 6.14.7 of ANSI/AWS D1.1 Structural Welding Code-Steel and equipment calibrated annually. The testing agency shall be approved by the City Engineer prior to fabrication. Pole base and mast arm attachment plates shall be plate steel attached to the larger end of the shafts by continuous welds on the inside and outside of the shaft. After manufacture, the material shall have a minimum yield strength of 48,000 psi.

2909.4.1 A handhole equipped with a suitable metal cover shall be provided in the pole near the base, and 12 inches above the mast arm connection if luminaire mounting is specified. A grounding lug or connector shall be provided inside the pole near the handhole. A removable raintight metal pole cap shall be provided on the top of the pole and on the small end of each mast arm. All handhole covers and metal caps shall be securely attached to the pole or arm with a galvanized steel chain and shall be held in place by screws. The chain shall be attached to the inside of the pole or arm and shall be of sufficient length to allow maintenance access. An aluminum or stainless steel identification tag shall be provided with all poles and mast arms as shown on the Plans. The letters and numbers on the tag shall be embossed or engraved. The pole tag shall be attached to the pole 6 inches above the top of the handhole. The mast arm tag shall be attached 3 inches from the base of the end cap. The base plate shall be equipped with four cast steel or cast iron nut covers in accordance with AASHTO M 103 or M 105, or four aluminum nut covers and shall have four galvanized or stainless steel screws for securing covers to the pole. All poles, shoe bases, base plates and cast steel or cast iron nut covers shall be fully galvanized after fabrication. All anchor bolt nuts shall be completely covered by nut covers. Luminaire bracket arms, when specified, shall be included with the pole and mast arm. The Contractor may furnish poles with the shape, gage and dimensions meeting or exceeding those required by the Plans and Specifications, provided shop drawings are submitted and approved in accordance with Section 2909.3

2909.4.2 Welding and fabrication of the assemblies shall be in accordance with the ANSI/AWS D1.1 Structural Welding Code-Steel. All requirements of the welding code for tubular structures will apply to the fabrication for the pole and mast arm shafts and shall include any welds used to attach these members to plates or other hardware. The manufacturer shall employ qualified personnel to perform all visual and nondestructive testing (NDT) required. In addition to the visual inspections and NDT that may otherwise be required by the welding code, the manufacturer shall perform 100 percent magnetic particle (MT) testing of circumferential fillet welds used to attach the flange plate to the larger end of the mast arm shaft. NDT personnel shall be qualified as set forth in paragraph 6.14.7 of ANSI/AWS D1.1 Structural Welding Code-Steel. Qualifications of NDT personnel shall be submitted to the City Engineer for approval.

2909.4.3 The pole and mast arm manufacturer shall be certified under the AISC certification program, Conventional Steel Building, or higher category. Evidence of current AISC certification will be required prior to the approval of shop drawings, and lapsing of the certification will be cause for the manufacturer's removal from the approved list of suppliers.

2909.4.4 Steel poles, luminaire bracket arms, mast arms, nut covers and plate steel bases shall be hot-dip galvanized inside and out after fabrication to ASTM A-123 standards, visual inspections and NDT testing. Galvanized material shall be handled in such a manner to avoid damage to the surface. Any galvanized material on which the coating has been damaged will be rejected or may, with approval from the City Engineer, be repaired in accordance with Section 2909.4.5.

2909.5 Fabricator's Certification: Prior to erection of the poles and mast arms, the Contractor shall furnish to the City Engineer a fabricator's certification. The certification shall specifically state the fabricated poles and mast arms have been quality control inspected by the fabricator and all material and manufacturing processes used were in full compliance with the specification requirements and the approved shop drawings and weld procedures. Certification shall be accompanied by supporting documentation, including the results of the visual inspections and NDT in accordance with Section 2909.4.2 and copies of the pre-approved drawings required by Section 2909.3.

2910 Traffic Signal/Intersection Lighting: All lighting equipment shall conform to the requirements of Section 2800 of the City of Lee's Summit Design and Construction Manual. All luminaire bracket arms shall be oriented to run parallel with the signal mast arm unless otherwise noted on the Plans.

2911 Traffic Signal Controller Assemblies: The actuated controller and cabinet shall be a NEMA Type Traffic Signal Controller System. Traffic controller assemblies will be defined as the complete assembly of all required equipment and components for control of traffic signal indications. The type of controller assembly required for each location shall be as specified in the Plans. The traffic signal controller, cabinet and related equipment shall be delivered to the City for testing prior to installation. All signal timings will be provided by the City Traffic Engineer. The Contractor shall coordinate material delivery and pick-up with the Public Works Operations Department (969-1870) at least 48 hours prior to transportation. A minimum of 4 weeks shall be permitted for testing between delivery and pick-up. The Contractor assumes all damage liability and should inspect all materials before and after transportation of equipment.

2911.1 NEMA TS1: Each NEMA TS1 controller assembly shall consist of a controller cabinet, signal controller, back panel, conflict monitor, card rack assembly, all required wiring, switches and connectors and all other equipment as defined in these Specifications and as shown on the Plans. Double controller assemblies to control two intersections shall consist of a controller cabinet, two signal controllers, two back panels, two conflict monitors, two card rack assemblies, all required wiring, switches and connectors and all other equipment as defined in these Specifications and as shown on the Plans.

(a) Each controller and associated equipment shall be designed to operate on 120 volts, 60 hertz, single phase, alternating current.

(b) Variations in the voltage of the power supply of ± 10 percent or sustained temperatures inside the cabinet between -20 and 165 F shall not change the total time cycle of pretimed controllers or the length of any interval, portion, period or unit extension of actuated controllers by more than five percent or cause electrical or mechanical damage. Heater elements shall not be used to attain compliance with these requirements.

(c) Vibration shall not affect normal operation of any equipment.

(d) All controllers and other specified auxiliary equipment shall be properly protected with fuses on each applicable unit. Fuses shall be installed in 1/4-twist or screw-in type fuse holders. Pop-out fuse holders will not be permitted.

2911.2 Controller Cabinets: Controller cabinets shall be cast aluminum or 0.125 inch reinforced sheet aluminum alloy and shall be of clean-cut design and appearance. The cabinet shall provide ample space for housing all equipment and components. Controller cabinets housing solid state controllers shall be furnished with unused cabinet space measuring 18 inches wide by 12 inches high by 12 inches deep, unless coordination equipment is specified on the Plans. For pretimed and actuated NEMA controllers, the cabinet shall support a sixteen-position back panel. Double controller cabinets for two controllers shall support two sixteen-position back panels. All double cabinets shall have two doors that are hinged on the outside corners of the cabinet such that the doors open away from each other. Double cabinets shall have a divider between the two halves of the cabinet with an 8-inch opening between the compartments at the bottom of the divider for wiring between the compartments. The cabinet shall contain a rigid mounting table, sliding ways or hinged support of such construction that the controller and auxiliary equipment may be withdrawn from the cabinet without breaking any electrical connections or interrupting normal controller operation. Hinged supports shall be welded to the controller cabinet. Electrical connectors on the controller and auxiliary equipment to all circuits shall be NEMA 1/4 twist or MS type. Components of controller cabinets shall meet the following requirements.

(a) A hinged door or doors shall provide complete access to the interior of the cabinet. Door holds shall secure the door in an open position at least 90 degrees from the closed position and shall be furnished with each cabinet. The doors shall fit against a raintight gasket. Each door shall have a stamped or raised outside designation, "Traffic Control" or other approved identification. Each main cabinet door shall have a No. 2 Corbin cabinet lock and provisions for locking with a padlock. The handles for each door shall swing outward. An auxiliary door, positioned on each main cabinet door, equipped with a raintight gasket, shall allow access to a police panel and shall be equipped with a lock whose key will not unlock the main door. Two keys shall be furnished for each type lock used. The door hinges and pins shall be of corrosion-resistant metal. Pins shall be rolled or solid rod, at least 1/8 inch in diameter, except if continuous hinges are furnished, the pins shall be continuous the full length of the hinges, and shall be no less than 1/16 inch in diameter.

(b) The back panel in all controller cabinets shall be hinged at the bottom to permit the top of the panel to be rotated forward and down to an angle of no less than 45 degrees with all components, including load switches, attached for maintenance purposes. The bottom of the back panel shall be no less than 6 inches above the bottom of the cabinet.

(c) Cabinets housing solid state controllers shall have a thermostatically controlled ventilating fan with exhausting capability in an enclosure of at least 150 cubic feet per minute for cabinets up to 30.5 cubic feet and at least 250 cubic feet per minute for cabinets 30.5 cubic feet and more, installed in the top of the cabinet. Cabinets shall be supplied with a replaceable furnace-type fiberglass filter of at least one square foot area mounted behind louvers in the lower one-fourth of the door.

(d) Each controller cabinet shall be furnished with a clearly labeled switch mounted in the access or police panel to place the signals on flash. Operation of this switch shall not affect the electrical power supply to the controller. This shall be the only control switch accessible from the police panel.

(e) Each cabinet shall be provided with a grounded service outlet and a switch controlled lamp receptacle.

(f) Each cabinet shall contain a separate aluminum power panel containing the following equipment.

(1) Two Type B circuit breakers in accordance with all City of Lee’s Summit lighting specifications. One breaker shall interrupt power to the controller and signals. The frame size and trip rating will be shown on the traffic signal plans or designated in the contract. The second Type B circuit breaker shall be an auxiliary breaker that interrupts power to the cabinet lamp and receptacle. The frame size and trip rating shall be 15 amperes.

(2) One mercury contactor controlling power to the signal bus.

(3) One radio frequency line filter.

(4) One line surge protector.

(5) One terminal block for alternating current power input.

(6) One ground bus terminal block.

(7) One isolated neutral bus terminal block.

(g) If specified, a manual operation push button shall be installed in the police panel. The push button shall be wired for manual operation of the signals. The push button shall be water-resistant, designed to protect the user against electrical shock, and shall be supplied with a coiled cord with a nominal 6-foot stretched length. A clearly labeled switch shall also be installed in the police panel to switch between manual or automatic operation of the controller.

(h) A separate grounded service outlet shall be provided in the controller cabinet for supplying power to auxiliary equipment.

2911.3 Flasher Unit: Each controller, through terminal options, shall permit yellow-red or red-red flash operation. Indications shall be flashed at no less than 50 or more than 60 flashes per minute, with approximately 50 percent dwell time. A two-circuit flasher, alternate flash and three flasher field circuits for each of the two flasher circuits will be required. A separate flasher shall provide flashing pedestrian indications when required by the contract. The timing of flashing pedestrian intervals shall be separately adjustable from all other timed intervals. The flasher shall be solid state with ratings of at least 15 amperes per circuit and shall comply with the latest revision of NEMA Standards Publication TS. The flasher units shall have a 150-volt metal oxide varistor (MOV) placed on each output flash terminal. Uniform code flash circuitry will be required for each controller. Flashing operation shall be in accordance with the MUTCD.

2911.4 External Time Switches: External time switches shall be solid state, keyboard entry and shall contain filtering and shielding circuitry to protect the unit's operation against electrical interference. Timing shall be based on the 60-hertz power supply frequency. Each unit shall contain a programmable automatic central daylight time compensation feature and a back-up power source to maintain time and memory functions during loss of alternating current power. Each unit shall provide a weekly program with at least 20 event changes per week.

2911.5 Wiring: The controller cabinet shall be equipped with a 600-volt heavy-duty one piece mechanical screw connector offset tang assembly attached to a barrier terminal strip for terminating field conductors. Each mechanical screw connector shall accommodate up to four No. 14 AWG conductors. The connector shall be mounted horizontally on the inside back of the cabinet, approximately 6 inches from the bottom of the cabinet. All wiring to the terminal strips, except the incoming field circuits, shall be performed by the controller manufacturer. The terminal strips shall accommodate at least:

(a) Two terminals for the power supply.

(b) An unfused terminal for neutral side of power supply line.

(c) One terminal for each signal lamp circuit and one terminal for the common return from each signal face.

(d) If detectors are used:

(1) Two terminals for each detector.

(2) Screw terminal strips mounted vertically on the side of the cabinet approximately 6 inches from the bottom of the cabinet.

(3) All inductive loop detector inputs shall be protected with two 30-volt MOVs with a 30-j rating. An MOV shall be connected between each field terminal and cabinet ground.

(e) Terminals for interconnect cable when the controller is to be hard-wire interconnected shall be fused and provided with a 150-volt MOV with an 80 j rating.

(f) Terminals for closed loop system interconnect cable shall be fused and provided with a 30-volt MOV with a 30 j rating.

All wiring shall be insulated, stranded copper wire and shall be neatly bundled and secured with plastic cable ties. For double controller cabinets, all wiring for each intersection shall be terminated in the same compartment of the cabinet as the signal controller for that intersection. Incoming field circuits shall be routed horizontally from the conduit to the back of the cabinet, then vertically to the terminal block. All terminals shall be labeled and not be visibly obstructed. All field leads shall be identified by means of round aluminum identification tags with a minimum thickness of 0.1 mils attached to the cables with a copper wire to correspond with the Plans. The outgoing signal circuits shall be of the same polarity as the line side of the power supply, and the common return of the signal circuits shall be of the same polarity as the ground side of the power supply. The power supply shall be provided through three single conductor cables. The ground side of the power supply shall be carried throughout the controller in a

continuous circuit, and shall be secured to a ground bus bar in an approved manner. All field conductors shall be terminated in the controller cabinet.

2911.6 Back Panel Wiring: All wiring on the backside of the controller back panel shall be neatly bundled and secured with plastic cable ties. Any multi-conductor cable between the controller or auxiliary equipment and the back panel shall be contained in an expandable braided sleeve. All wiring shall be discrete insulated wires and shall be soldered directly to lugs on the back of terminal blocks and sockets. Printed circuit boards shall not be used. Regardless of the number of phases specified on the Plans, all load switch positions shall be completely wired for use. If pedestrian phases are not specified, twelve-position back panels for actuated NEMA controllers shall be configured for operation of eight phases and four overlaps. If pedestrian phases are specified, 12-position back panels shall be configured for operation of eight phases and four pedestrian phases or a combination of overlaps and pedestrian phases if specified on the Plans. Twelve-position back panels for pretimed controllers shall be configured for operation of 36 circuit outputs from the controller unless otherwise specified on the Plans. A flash transfer relay socket shall be provided for each pair of load switch positions. Flash circuit one shall be wired to positions one, 3, 5, 7, 9 and 11. Flash circuit 2 shall be wired to positions 2, 4, 6, 8, 10 and 12. All flash transfer relay sockets shall be fully wired for operation. All controller harness wiring shall be connected to labeled terminals on the front of the panel.

2911.7 Solid State Controllers: This section describes the general specifications for actuated solid state controllers. If requested by the City Traffic Engineer, the Contractor shall provide a prototype controller for testing and evaluation.

(a) Each controller shall be solid state keyboard entry and the circuit design shall use microprocessor techniques.

(b) Timing shall be accomplished in a digital manner by counting the 60 hertz power supply frequency. Timing circuits, interval and phase switching functions shall be accomplished by solid state circuitry. Removing, changing wires or using any tools to make timing interval adjustments shall not be necessary. The controller shall indicate the right of way conditions of the phase timing interval in effect, detector or actuation on each phase and memory conditions or demand on each phase for vehicles and pedestrians by use of status lights or display panels.

(c) Opening and closing of signal lamp circuits shall be performed by plug-in solid state load switches, rated at no less than 10 amperes and loaded at a maximum of 6.7 amperes, located external to the controller. All load switch jacks shall be completely wired to field output terminal strips. Actuated and pretimed controllers shall have a minimum of twelve load switch jacks. Each load switch shall provide three independent circuits with "on" indicator lamps and shall comply with the latest revision of NEMA Standards Publication TS.

(d) Each controller assembly shall contain a conflict monitor external to the controller circuitry conforming to NEMA Standards Publication TS. The monitor shall cause immediate transfer to flashing operation when conflicting or absent indications occur or when a voltage fault occurs. When the conflict monitor actuates flashing operation, the controller shall freeze or stop timing in the condition causing the actuation until manually reset. A single lamp failure in any signal head shall not cause the monitor to actuate.

(e) Each controller cabinet shall be furnished with the following switches:

(1) Power Interrupt Switch - A switch located inside the main cabinet shall interrupt electrical power to the controller during maintenance on the controller. Operation of this switch shall not affect the flash operation. This switch shall not be accessible via the police panel.

(2) Flash Switch - A switch mounted in the police panel shall place the signal on flash. Operation of this switch shall not affect the electrical power supply to the

controller. When the signals are returned to normal operation the external start shall be activated causing the controller to revert to the programmed initialization phase(s).

(3) Stop Time Switch - A three-position switch mounted inside the main cabinet shall provide the following functions:

(i) Stop Time - Causes the controller to stop time.

(ii) Normal - Allows the controller to cycle all phases, but during conflict monitor flash causes the controller to stop time.

(iii) Run - Allows the controller to cycle all phases and during any flashing operation allows the controller to continue cycling all phases without displaying them on the signal heads.

For double controller cabinets, two sets of switches shall be provided, one set for each controller installed in each compartment.

(f) During flash condition, controller operation shall permit the cycling of all signal phases without an external load being connected to the field terminals.

(g) Solid state controllers shall have electronic filters to prevent interference caused by the opening and closing of circuits in electro-mechanical auxiliary equipment.

(h) The controller shall be of modular design constructed for individual removal and replacement in the controller by multiple prong jacks or outlets without modifying wiring. Hand operable positive locking devices shall be used to hold the modules securely in the controller.

(i) The functional operating circuits and associated components shall be grouped in plug-in printed circuit assemblies. Similar assemblies shall be interchangeable between controllers manufactured by the same company.

(j) The controller shall contain the necessary phase sequence, interval sequence timing, power supply and monitoring equipment required to supervise the operation for the phasing shown on the Plans, including any future controller expansion. If future phases are specified, the controller shall be completely configured to accept the future phases.

(k) Controllers that are interconnected shall have a coordinated/free operation switch to allow the controller to operate in coordination with the system or run free.

(l) High energy transient surge protection shall be provided on all solid state controllers to minimize damage to the controller and auxiliary equipment. This device shall be located on the incoming 120 volts, 60 hertz power service between the controller and signal circuit breaker and the power inputs to the controller and auxiliary equipment. The arrestor shall meet the latest NEMA specifications for surge protection.

(m) All flash operation called from a source external to the controller shall occur through the flash transfer relay.

(n) Any multi-conductor cable shall be contained in an expandable braided sleeve.

(o) Switches or relays that completely interrupt power to the signal heads other than the protective circuit breaker shall not be installed in the cabinet.

(p) All controllers shall be capable of downloading all programming data to a printer via a front panel RS-232 connection. The controller shall be capable of printing directly to a printer or via an external computer. If an external computer is required, the required software shall be provided with the controller.

(q) All controllers shall be provided with internal pre-emption functions and circuitry.

2911.8 Solid State Actuated Controller: Each solid state actuated controller shall meet the latest revision of NEMA Standards Publication TS. Actuated controllers shall meet the following requirements:

(a) Recall by keyboard entry shall be provided for each phase to furnish continuous recall. With the recall function in the "OFF" position, the controller shall operate normally with

the right of way being transferred only upon pedestrian or vehicle actuation or external force-off control.

(b) Controllers shall be furnished with provisions for external maximum control for each signal phase complete with wiring to permit installation of a coordination unit. All wiring to facilitate coordination shall be terminated on terminal strips and complete information stating the function of each terminal shall be shown on the controller-wiring diagram.

(c) All phases shall contain a non-locking memory feature that can be energized or de-energized by keyboard entry.

(d) All phases shall be capable of being activated or inactivated by keyboard entry.

(e) On the cabinet inside door test panel, an external push button switch for each vehicle and pedestrian phase shall be provided. Each switch shall provide call to the phase assigned and ability to extend the phase. This detector input shall be independent of the circuitry between the amplifier and back panel.

(f) A Full D Panel (37 PIN) shall be provided.

(h) Actuated controllers shall be fully configured for operation of a minimum of eight vehicle phases, four pedestrian phases and four overlaps, regardless of the number of phases shown on the Plans.

2911.9 Timing Function: Timing intervals or periods shall be set by means of keyboard entry. Each timing interval shall be adjustable to any value within the following minimum ranges for each phase. Zero may be satisfied by a time increment of up to 100 milliseconds.

Interval	Range (seconds)
Minimum Initial	0-99
Unit Extension or Passage Time	0-9.9
Yellow Clearance	0-9.9
Red Clearance	0-9.9
Maximum I Green	0-99
Maximum II Green	0-99
Walk	0-99
Pedestrian Clearance	0-99
Seconds per Actuation	0-9.9
Maximum Initial	0-99
Time Before Reduction	0-99
Time to Reduce	0-99
Minimum Gap	0-9.9

2911.10 Auxiliary Equipment and Interfaces for Controllers: Interface panels shall be aluminum panels installed in the controller cabinet containing the required terminals and equipment. Interface panels shall be neatly laid out, neatly wired and easily accessible. Each auxiliary unit shall be enclosed in a suitably finished metal case and shall be mounted in the controller cabinet unless otherwise specified. The function of each auxiliary unit shall be indicated by an identification plate on the case. Auxiliary equipment cases shall be ventilated. Temperature, voltage and frequency shall be in accordance with Section 2911.

2911.11 Pre-Emption Interface: The pre-emption interface shall consist of internal preemption functions in the controller, any field wire termination panels, relays, wiring and connectors required for proper operation. The pre-emption interface shall be wired to transfer control of the signals to the pre-emption sequence when actuated and shall provide the color sequence specified.

After release of pre-emption, normal controller operation shall be automatically resumed except that actuated controllers shall be on recall for one complete cycle.

2911.12 Master and Local Coordination Interface: The coordination interface shall consist of internal coordination functions in the controller, and of any field wire termination panels, wiring and connectors required for proper operation. The master coordination interface shall supervise the actuated controller operating the signals in the intersection at which the actuated controller is located. Local coordination interfaces shall be supervised by the master coordination interface and shall in turn supervise the actuated controllers operating the signals at the intersections where the controllers are located. Coordination interfaces shall be connected to one another or to a telephone interconnection unit by a multi-conductor cable. The master coordination interface shall be furnished with internal time-based functions in the controller. The coordination interface shall provide the following:

(a) Fully actuated operation.

(1) Cycle length of the actuated controller may vary with traffic demand, but shall not exceed the cycle length set on the coordination interface.

(2) Vehicle and pedestrian detectors shall remain energized.

(3) During periods of light traffic, the actuated controller shall respond to detector demand on any signal phase.

(4) When there is continuous demand for all signal phases, the coordination interface shall cause termination of each signal phase in accordance with the time intervals set on the coordination interface for each signal phase.

(5) The actuated controller shall not be forced to transfer right of way to a signal phase if there is no demand.

(b) Semi-actuated operation.

(1) Signal phases, controlling the street on which signal progression is desired, shall be placed on maximum recall.

(2) Vehicle and pedestrian detectors shall remain energized.

(3) Transfer of right of way from the coordinated signal phase(s) shall not occur until there is detector actuation for a non-coordinated signal phase and only after the coordination interface has terminated the coordinated signal phase(s).

(4) The right of way interval awarded the coordinated signal phase(s) shall be governed by the time interval set on the coordination interface.

(5) If detector actuations for a non-coordinated signal phase(s) causes the phase(s) to time to maximum, the phase(s) shall be forced off and the coordinated phase(s) awarded right of way.

(6) If demand for the non-coordinated signal phase(s) is not sufficient to extend the phase(s) to maximum, right of way shall transfer to the coordinated phase(s) and remain there until demand for the non-coordinated phase(s) occurs and the coordination interface times the coordinated phase(s) to maximum.

(7) Detector actuation on a non-coordinated signal phase(s) occurring during the coordinated phase(s) right of way interval shall cause a call to be placed and retained for the non-coordinated signal phase(s).

(c) Fixed cycle length operation.

(1) All signal phases shall be placed on maximum recall.

(2) Vehicle and pedestrian detectors shall remain energized.

(3) The coordination interface shall control the time interval that each signal phase is awarded right of way.

(d) Free operation.

(1) When permitted by internal time-based functions, the coordination interface shall provide free operation of associated actuated controllers. During this operation the actuated controller shall operate without supervision by the coordination interface.

(2) Pretimed controllers, in a signal system supervised by a master coordination interface, shall revert to dial 1, reset 1 or internal time based coordination during free operation at the user's option.

2911.12.1 Each coordination interface shall have the following minimum operational characteristics:

(a) Three cycles.
(b) Eight splits.
(c) Eight force off periods per split.
(d) Three offsets per cycle.
(e) Selectable recall by signal plan.

2911.12.2 Each coordination interface shall have all of the following methods of synchronizing to the master sync pulse:

(a) Dwell. The coordinator shall establish a new offset by stopping the cycle timer in the coordinated phase(s) green, until the new offset value is reached.

(b) Dwell with Interrupt. The coordinator shall establish a new offset by stopping the cycle timer in the coordinated phase(s) green. The maximum time the coordinator can dwell shall be adjustable from 1 to 99 seconds.

(c) Shortway. The coordinator shall establish a new offset by the shortest route possible.

2911.12.3 Each master coordination interface shall be furnished with necessary relays and internal functions in the controller to provide the following supervisory functions:

(a) Semi-actuated operation.
(b) Fixed cycle length operation.
(c) Free operation.
(d) Cycle Transfer (cycle 1 to cycle 2, cycle 3 or cycle 4 and vice versa; cycle 2 to cycle 3 or cycle 4 and vice versa; cycle 3 to cycle 4 and vice versa).

2911.12.4 Each controller shall be capable of permitting the manual selection of the following:

(a) Cycle Length 1, 2, 3, 4 or System.
(b) Offset 1, 2, 3, 4 or System.
(c) Semi-actuated operation, fixed cycle length operation or free operation.

2911.13 Remote "ON - OFF" Switch (Pedestrian Interval Sequence): The following type of "On - Off" switches shall be furnished as specified:

(a) Type I. Type I switches shall consist of one manually operated heavy-duty switch in a circuit not exceeding 18 volts. Necessary relays shall be located in the controller cabinet for including or excluding the pedestrian phase in the phasing sequence or switching signals between flashing and sequence operation. This shall be accomplished by energizing or de-energizing the pedestrian signal indications and push-button detectors. The switch shall be enclosed in a weatherproof, cast aluminum housing equipped for pole mounting. The housing shall have a suitable lock, the key of which shall not unlock the controller cabinet. The housing shall be tapped for conduit.

(b) Type II. The Type II switch shall be operationally identical to the Type I, except the switch may be 120 volts and shall be located inside the police panel of the controller cabinet.

2911.14 Detectors: All detectors shall conform to Section 2912.

2911.15 NEMA Card Rack Assemblies: The supporting and connecting rack shall contain space for a minimum of two power supplies and shall have a minimum of eight card positions for two-channel detector units. Upper and lower slide guides shall be provided for the power supply and each detector card. Where detectors are specified, the rack and power supplies shall be included with the detectors, and no direct payment will be made.

(a) The card mounting rack shall be attached to the controller cabinet by a hinge or pivot assembly, which allows the rack to rotate horizontally so as to expose the rack wiring to facilitate maintenance operations. The rack shall be positioned to rotate out freely 90 degrees without conflicting with other wiring, equipment or the controller cabinet. Sufficient wire lengths shall be provided for rotation. The rack shall not block the back panel or other termination panels.

(b) The power supply shall be capable of supplying a minimum of 200 milliamps to each detection channel position. The power supply shall be capable of operating a full rack of time delay detectors regardless of the amount and type of detectors required. Each power supply channel shall power no more than one detector card. Each channel shall be individually fused.

(c) Each card rack detector shall have a regulator for the power input. The regulator shall have the appropriate power and voltage rating for operation of the detector.

(d) Card racks shall mate with a 44-terminal, double row, 0.156-inch contact spacing, Cinch Jones card edge connection 50-44A-30M or equivalent. Input/output connector pin terminations shall be in accordance with NEMA Specification TS. All useable functions shall be fully wired for use.

(e) All circuitry shall be of solid state, temperature compensating components.

(f) Unless shown otherwise on the Plans, each detector in the card rack shall be associated with the appropriate phase as follows:

Channel	Card Position							
	1	2	3	4	5	6	7	8
1	Phase 1	Phase 1 Phase 6	Phase 6	Phase 6	Phase 3	Phase 3 Phase 8	Phase 8	Phase 8
2	Phase 5	Phase 5 Phase 2	Phase 2	Phase 2	Phase 7	Phase 7 Phase 4	Phase 4	Phase 4

(g) Each detector channel shall be clearly labeled with phase and direction.

2911.16 Card Rack Detectors: Card rack detectors shall meet the following requirements:

(a) Card rack-mounted detectors shall incorporate two detection channels.

(b) Each detector channel shall have at least a two-frequency selection capability, at least two levels of operational sensitivity and shall be capable of tuning to a minimum inductance range of 70 to 1000 micro henries.

(c) All controls and indications shall be mounted on the front panel of the sensing unit, with the exception of extension and delay timing controls on card rack mounted detectors.

(d) A manual control shall be provided for each channel to select pulse or full presence operation.

(e) Each detector channel, after installation and initial adjustment, shall automatically tune to various loop configurations ranging in size from 6 x 6 feet minimum to 6 x 100 feet maximum. The maximum lead-in length shall be 750 feet.

(f) Each detector channel shall time out and retune automatically if a continuous vehicle occupation of the loop field for a nominal time of 10 to 30 minutes is sensed.

(g) In the event of power loss to the detector or channel, a continuous call shall be made to the controller.

(h) All circuitry shall be of solid state, digital design and incorporate temperature compensating components, with the exception of the output relay.

(i) If specified, each channel shall have extension and delay timing features, as follows:

(1) Delay timing range from 0 to 30 seconds in 1.0-second increments.

(2) Extension timing range from 0 to 7.5 seconds in a maximum of 0.5-second increments.

(j) The sensing unit shall have a light that will illuminate when a vehicle is within the loop field. Other visual indications of relay closure may be used if approved by the City Traffic Engineer.

(k) Each detector and channel shall be in accordance with NEMA Standard Publication TS.

2911.17 Dual Output Card Rack Detectors: Dual output card rack detectors shall be in accordance with NEMA and shall provide two relay outputs per induction loop detector. One output shall be capable of pulse detection for the purpose of traffic counting, speed and occupancy measurements. The other output shall be capable of presence detection. Each detector output shall be assigned to a separate detector input into the controller.

2911.18 Calling Detector Relay: A calling detector relay shall operate with any detector and allow the detector to place only one actuation when the red indication is being displayed to the associated phase. The relay shall be self-contained.

2911.19 Warranty: All traffic signal controller assemblies, excluding video detection systems, shall be warranted by the manufacturer to be free from defects in workmanship and material for at least one year from the date of project acceptance. Any components found to be defective during the warranty period shall be replaced free of charge. All warranties provided shall be transferred to the City upon project acceptance. Video detection systems shall be warranted in accordance with Section 2912.4.

2912 Detectors:

2912.1 Induction Detector Probes: Detector probes installed under bridge decks shall be protected by completely encapsulating the probe in a conduit system. Probes shall be oriented such that the detection zone is above the bridge deck, and shall be installed in gasketed junction boxes anchored to the bottom of the deck. The junction boxes shall have a minimum size of 6 x 6 x 4 inches and the probes shall be rigidly anchored in the box. The probes shall be no more than 18 inches below the top of the bridge deck. Conduit shall be sized such that the probe and cable can be pulled through the conduit. Any conduit bends shall be such that the probe and cable can be pulled through the bend. External conduit on the structure shall be in accordance with Section 2916.

2912.1.1 The encapsulated induction detector probe shall detect the passage or presence of all vehicles with a standard induction loop detector amplifier. The induction detector probe shall operate in a temperature range from -35 to 165 F with 0 to 100 percent humidity. The operating field intensity range shall be 0.2 to 1.0 oersted with a nominal inductance of 20 micro henries plus 20 micro henries per 100 feet of cable. The nominal direct current resistance shall be 0.5 ohm plus 3.2 ohms per 100 feet of probe cable. Induction detector probes shall be as specified on the Plans and shall meet the following:

(a) The sensing probes shall be cylindrical having maximum dimensions of 7/8-inch diameter by 4 inches long. The sensing probes shall be suitable for installation in a one-inch

diameter bored hole. The interconnecting four-conductor cable and lead-in cable shall be suitable for installation in a 1/4-inch wide pavement sawed slot.

(b) The jacket on the interconnecting cable and the casing on the sensing probe shall be an abrasion resistant polyurethane elastomer. The device shall be impervious to moisture and chemically resistant to all normal motor vehicle petroleum products. Lead-in cables shall be shielded, chemical resistant and completely waterproof.

(c) The combined probe sets, manufacturer specified lead-in cable and detector probe shall detect all vehicles up to a lead-in cable length of 750 feet with up to six probes per set.

(d) The conductor cable from the probes to the detector panel in the controller assembly shall be as specified by the detector manufacturer, shall be continuous and unspliced and shall be a minimum of 50 feet in length. Probes shall be assembled in a set to form a vehicle detector as shown on the Plans. No more than six probes shall be assembled as a set. The cables between probes shall be long enough to provide the spacing shown on the Plans plus 5 feet. If spacing is not shown on the Plans, 15 feet of cable shall be provided between probes. Each set of probes shall have one lead-in cable.

2912.2 Induction Loop Detectors: A slot for the installation of induction loop cable shall be sawed in the pavement as shown on the Plans. Slots shall not be sawed until seven days after placement of Portland cement concrete. Each loop shall have a separate lead-in slot to the conduit. A separate conduit shall be installed between the sawed loop slot and the first pull box for each loop. The conduit opening at the end of the lead-in slot shall be at the bottom of the sawed slot. The slot shall be clean, and free of jagged edges or sharp corners. The cable shall be pushed into the slot without damaging the insulation. After the loop cable is spliced to the lead-in cable, and before the slot is sealed, the resistance of the loop and lead-in cable to ground shall be checked. The resistance test shall be performed by the Contractor in the presence of the City Traffic Engineer, or designee, and documented. After a satisfactory test, showing a resistance no less than 10 mega ohms, the slot shall be sealed. The conduit opening at the end of the lead-in slot and any drilled conduit holes in the pavement shall be sealed with a pliable duct sealant prior to the application of loop sealant. All sawed slots shall then be sealed with an approved detector loop sealant. All detector cable between the loop and detector amplifier shall be twisted at least three turns per foot.

2912.2.1 Induction loop vehicle detectors shall detect a vehicle stopped within the field of the loop or passing over the loop at speeds up to 80 mph. Induction loop detectors shall be card rack mounted. For double controller cabinets, card rack assemblies and detectors shall be installed in the same compartment as each respective associated controller.

2912.3 Microwave and Ultrasonic Detectors: Microwave and ultrasonic detectors shall be mounted at the locations shown on the Plans in accordance with manufacturer's recommendations. All wiring shall be continuous and unspliced from the detector unit to the controller. The Contractor shall make any necessary adjustments for proper operation of the detector.

2912.3.1 The unit shall detect all vehicles moving within the field of detection at speeds from 2 to 80 mph. The unit shall have a minimum detection range from 3 to 200 feet for all vehicles. The pattern spread of the detection field shall be no more than 16 degrees. The unit shall be self-tuning and capable of continuous operation over a temperature range of -35 to 165 F. The unit shall be microprocessor based using Doppler microwave at an operating frequency of 10.525 GHz. The unit shall have FCC certification and shall be tested to the applicable FCC specifications. The unit shall be capable of side-fire mount or overhead mount. The enclosure shall be constructed of aluminum or stainless steel and shall be water resistant. The unit shall be

capable of detecting directional traffic and the direction shall be user selectable. All user operated controls and adjustments shall be clearly marked and easily accessible. The unit shall have a relay detection output to the controller with a minimum 5-amp rating and shall be designed to place a constant call to the controller in the event of any failure. The unit shall have an easily accessible indicator showing activation of detection relay. Required wiring shall be as specified by the manufacturer. Mounting hardware for the type of mounting shown on the Plans and power supply equipment shall be as specified by the manufacturer and shall be provided with the unit.

2912.4 Video Detection Systems: This work shall consist of furnishing, installing and placing into operation a vehicle detection system that detects vehicles by processing video images and providing detection outputs to a traffic signal controller. The system shall include all equipment shown on the Plans and described in these Specifications, and shall include any incidental items necessary for the satisfactory operation and maintenance of the system. The video detection system shall be installed per the manufacturer's recommendations. All cable runs shall be continuous without splice from the cabinet to the camera. If requested by the City Traffic Engineer, a factory certified representative from the supplier shall be available for on-site assistance for a minimum of one day during installation.

2912.4.1 System Requirements: The video detection system shall provide flexible detection zone placement at any location and at any orientation within the combined field of view of the image processors. Preferred presence detector zone configurations shall be a box or lines placed across lanes of traffic or lines placed parallel with lanes of traffic. Detection zones shall be capable of overlapping.

2912.4.1.1 The detection zones shall be created by using a track ball to draw the detection zones on the video image. A graphical user interface shall be built into the automatic control unit (ACU) and displayed on a video monitor or computer. Editing of previously defined detector configurations to fine-tune detection zone placement shall be possible.

2912.4.1.2 When a vehicle is detected by crossing a detection zone, there shall be a visual change on the video display, such as a flashing symbol or a change in color or intensity to verify proper operation of the detection system.

2912.4.1.3 Overall performance of the video detection system shall be comparable to inductive loops. Using camera optics and in the absence of occlusion, the system shall be able to detect vehicle presence with 95 percent accuracy under normal day and night conditions with only slight deterioration in performance under adverse weather conditions, including fog, snow and rain. When visibility exceeds the capabilities of the camera, the system shall default to placing a call on all detectors.

2912.4.1.4 The video detection system shall be programmable via one dial up modem connection at a minimum of 19,200 bytes per second to the camera(s). Still image and real time detection displays to a remote computer using supplied system software through the modem shall be provided.

2912.4.2 System Components: The video detection system will be defined as the complete assembly of all required equipment and components for detection of vehicles. Each system shall consist of the video camera(s), lightning arrester for video cabling, an ACU, a track ball, software and license, if applicable, for system control via a computer, one dial-up modem, 56.6 kilobytes per second maximum connection and V.90 compliant and a monitor. All camera views shall be obtainable without requiring the disconnection and reconnection of cables within the system.

2912.4.2.1 System Software: The system shall include software that detects vehicles in multiple lanes using only the video image. Detection zones shall be defined using a video monitor and a pointing device to place the zones on a video image, which may include a laptop computer. A minimum of 12 detection zones per camera shall be available.

2912.4.2.2 Automatic Control Unit (ACU): The bus connections used to interconnect modules of the ACU shall be gold-plated DIN connectors. Serial communications to a computer shall be through an RS-232/RS-422 serial port. The port shall have the capability to access detection system data as well as the real-time imagery needed to show detector actuations. A subminiature "D" connector on the front of the ACU shall be used for serial communications with a computer running supplied system software.

2912.4.2.2.1 The equipment shall be provided with a NEMA TS1 interface as shown on the Plans. The ACU process unit shall be equipped with a TS1 detector interface for a minimum of 16 detector outputs or 32 detector outputs, if required by specifications. NEMA red/green inputs for each phase shall be available to provide delay/extend functions, either through the detector or the controller. Logic output levels shall be compatible with the TS1. A subminiature "D" connector on the front of the ACU shall be used for interfacing to these outputs.

2912.4.2.2.2 The video detection system shall be provided for either single camera or multiple camera installations as shown on the Plans.

2912.4.2.2.2.1 For single camera installations, the ACU shall have an RS-170 (NTSC) video input to process the camera or any other synchronous video source in real-time. The ACU shall have an RS-170 (NTSC) video output.

2912.4.2.2.2.2 For multiple camera installations, the ACU shall have a minimum of four RS-170 (NTSC) composite video inputs to process the synchronous video cameras or any other synchronous video source in real-time. A fifth video input shall be provided to allow connection of a local surveillance camera or other non-detection video source. The video from the auxiliary input shall not be processed for video detection. The ACU shall have an RS-170 (NTSC) composite video output, which may correspond to any of the video inputs, as selected remotely via RS-232 or locally by front panel switch. Multiple video inputs requiring external cable connections will not be permitted.

2912.4.2.2.3 The ACU or computer shall store a minimum of two separate detection zone configurations. The ACU shall be capable of switching to any of the different detector patterns at the request of the user and shall be a menu selection with a track ball.

2912.4.3 Video Camera and Housing: The video camera shall be mounted according to the Plans. The ACU supplier shall furnish the video camera for traffic detection. The camera shall produce a video image of vehicles under normal roadway lighting conditions regardless of time of day. The video shall produce a clear image for scenes with a luminance from 0.009 to 929 footcandles.

2912.4.3.1 The camera shall provide a minimum resolution of 500 lines horizontal and 350 lines vertical.

2912.4.3.2 The camera shall include an electronic shutter or auto iris control based on average scene luminance and shall be equipped with an auto iris lens.

2912.4.3.3 The camera shall have a variable focal length. The maximum aperture of the lens shall not be smaller than f1.8 and the minimum aperture shall not be larger than f300. The camera shall have a horizontal field of view ranging from a minimum angle of view between 5 degrees and 10 degrees wide to a maximum angle of view 45 degrees or more. The adjustments for focus and focal length shall be made without opening up the camera housing.

2912.4.3.4 The camera shall be contained in an enclosure that is waterproof and dusttight to NEMA-4 specifications. A heater shall be incorporated in the camera to prevent the formation of condensation and to assure proper operation of the lens' iris mechanism. The heater shall not interfere with the operation of the image sensor electronics and shall not cause interference with the video signal. The enclosure shall allow the camera to be rotated in the field during installation.

2912.4.3.5 The housing shall be equipped with a sun shield that prevents sunlight from directly entering the lens. The sun shield shall include a provision for water diversion to prevent water from flowing in the camera field of view.

2912.4.3.6 The total weight of the enclosure, camera, lens, housing, sun shield and mounting bracket shall be less than 10 pounds.

2912.4.4 Cable: Coaxial cable shall be a 75 ohm, precision video cable with 20 AWG solid or stranded bare copper conductor, maximum of 10.1 ohms/m Nom. Direct current resistance, solid polyethylene insulating dielectric, 96 percent minimum tinned copper double-braided shield with a black polyethylene outer covering. The signal attenuation shall not exceed 0.8 decibels per 100 feet at 10 megahertz. Nominal outside diameter shall be a minimum 0.305 inches. The cable shall be in accordance with Belden Type 8281, West Penn P806 or approved equal.

2912.4.4.1 Seventy-five ohm BNC plug connectors shall be used with coaxial cable. The supplier of the video detection system shall approve the coaxial cable, BNC connectors and crimping tool. The manufacturer's instructions shall be followed.

2912.4.4.2 Multi-conductor cable shall be per the manufacturer's recommendations and in accordance with Section 2918.

2912.4.5 Maintenance and Support: The supplier shall maintain an ongoing program of technical support and software updates for the video detection system following expiration of the warranty period. The supplier shall maintain an adequate inventory of parts to support maintenance and repair of the video detection system.

2912.4.6 Warranty of Video Detection System: The video detection system shall be warranted to be free of defects in material and workmanship for a minimum of two years. During the warranty period, technical support from factory certified personnel or factory certified installers shall be available from the supplier. Ongoing software support by the supplier shall include updates for the ACU and computer software and shall be provided at no cost to the City during the warranty period. The update of the ACU software to be National Transportation Communications for ITS Protocol (NTCIP) compliant shall be included.

2912.4.7 Training of Video Detection System: A minimum of one day of training shall be provided in the operation, setup and maintenance of the video detection system.

2912.4.3 Extra Service Outlet: A separate grounded service outlet shall be provided in the controller cabinet for supplying power to the video detection system. Use of the grounded service outlet located on the cabinet door will not be permitted.

2912.4.3 Monitor: The monitor shall be installed to automatically power on when the cabinet door is opened and automatically power off when the cabinet door is closed. A manual on/off switch shall also be provided.

2912.4.3.1 The monitor shall have a 9-inch screen, an NTSC-M system and BNC video in-out connections.

2912.5 Detector Loop Sealant: Loop sealant shall be proportioned, mixed and installed per the manufacturer's specifications and recommendations. After the loop slots are cut into the pavement, the surface shall be thoroughly cleaned, and all loose debris shall be removed. After application of the sealant, the roadway shall be tack-free and capable of being open to the motoring public within four hours without tracking. Loop sealant shall fully encapsulate the loop wires as shown on the Plans. Backer rods shall be placed to ensure one-inch depth coverage of loops. Excessive overfill will not be permitted.

2912.5.1 Loop sealant shall have the following minimum characteristics:

(a) The loop sealant used to fill the saw cuts and other gaps shall be of a type intended for and designed to be used as traffic loop embedding. The sealant shall be designed for installation when the surface temperature of the roadway is between 40 and 120 F and exhibit minimal shrinkage and stringing during and after installation. The curing time of the sealant shall be a maximum of 72 hours. Cured sealant shall retain permanent flexibility to 0 F, be temperature stable and ensure the integrity of the loop detector installation from -40 to 200 F. The loop sealant shall adhere to the roadway pavement and resist the effects of weather, including freeze-thaw cycles, de-icing chemicals, salts, gasoline and motor oils, such that the operation of the detector is not affected.

(b) The three types of allowable loop sealant will be two-part polyester resin, one-part moisture curing polyurethane and hot-melt bituminous.

(c) The loop sealant shall provide a minimum shelf life of nine months. Prior to the installation of any detector loop sealant, the MSDS or an OSHA Form 20 along with the manufacturer's technical data sheet, shall be submitted to the City Traffic Engineer. Any sealant used on loop detectors shall meet the approval of the City Traffic Engineer.

2912.6 Pedestrian Push Buttons: Pedestrian push buttons shall be direct push contact type. Each push button shall be a removable contact assembly mounted in a durable natural aluminum cast finished case, black in color. The housing shall be shaped to fit the curvature of the pole to which it is attached and shall provide a rigid installation. Contacts shall be normally open, entirely insulated from the case and operating button, and have connecting terminals. The operating button shall be recessed and made of brass or other corrosion resistant metal alloy or non-metallic material and shall be sturdy. The operating voltage shall not exceed 24 volts. The entire assembly shall be waterproof, secure against electrical shock to the user, and of such construction as to withstand continuous hard usage. The pedestrian push button shall be mounted directly to the pole with a watertight assembly with no external pipe or mounting hardware and shall be the large button type meeting ADA requirements.

2913 Emergency Preemption: The Contractor shall furnish and install Opticom emergency preemption equipment as shown on the Plans. Opticom equipment shall be mounted inside the controller cabinet, no housing boxes outside of the cabinet will be allowed. The cable shall be run

continuous from the detector to the controller cabinet with no splices. The detector shall be installed as shown on the Plans or as approved by the City Traffic Engineer. The Contractor shall be responsible for the proper alignment of the detector to ensure maximum detection time for the emergency preemption equipment.

2914 Pull and Junction Boxes: Pull and junction boxes shall be installed as shown on the Plans. Pull boxes placed in traveled ways, auxiliary lanes, shoulders and low profile islands shall be concrete. Pull boxes may be cast-in-place concrete, precast concrete, preformed polymer concrete or preformed fiberglass reinforced polymer concrete. Pull box dimensions shall be as shown on the Plans. 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.

2914.1 Conduit shall enter the pull box in the side of the box and shall extend a minimum of 2 inches and a maximum of 4 inches as shown on the Plans. Conduit shall enter from the direction of the run. If it becomes necessary to increase the excavation depth and extend the pull box, no direct payment will be made. The excavated opening outside the pull 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. Where preformed pull boxes are used, the holes for the conduit shall be drilled as recommended by the manufacturer. The holes shall be round and no more than 1/2 inch larger than the conduit.

2914.3 A pull box placed in an unpaved area shall have a concrete pad around the perimeter as shown on the Plans. Concrete pads will not be required for pull boxes installed in concrete. Pull boxes shall not be installed in sidewalk ramps. Concrete for the pad shall be a KCMMB 4k psi, or higher, approved concrete mix. The top surface of all pull boxes shall be flush with surfaced areas and approximately one inch above earth or sodded areas.

2914.4 If preformed pull boxes are specified, the Contractor may use standard concrete pull boxes in lieu of the Class 1 or 2 preformed pull boxes, or the Type A double concrete pull box in lieu of the Class 3 preformed pull boxes. For installations requiring different voltages for lighting and signal applications, the Type B double concrete pull box may be used in lieu of two preformed pull boxes at the Contractor's expense. If the Type B double concrete pull box is specified, no substitutions will be permitted.

2914.5 Class 5 preformed pull boxes shall be in accordance with all requirements in the contract documents. Installation of Class 5 pull boxes shall be as shown on the Plans and in accordance with the manufacturer's recommendations.

2914.6 Pull boxes with covers exceeding 36-inches in length shall be split lid Class 3.

2914.7 Cast-in-place concrete pull boxes shall be constructed using a KCMMB 4k psi, or higher, approved concrete mix. Concrete construction shall be in accordance with ACI 301 Standard Specifications for Structural Concrete. Pull boxes shall be cast in a neat and workmanlike manner. Forms will be required for the inside surfaces of the pull box walls; and if the excavation is irregular, forms will also be required for the outside surfaces of the walls. An outside form shall be installed across all trenches leading into the pull box excavation. The ends of all conduits through the walls shall fit tightly against the form.

2914.8 Precast concrete pull boxes shall be constructed using a KCMMB 3k psi, or higher, approved concrete mix. Concrete construction shall be in accordance with ACI 301 Standard Specifications for Structural Concrete.

2914.9 Preformed pull boxes shall withstand a wheel load of 20,000 pounds. Pull box walls may be either flared or vertical. Pull boxes shall have a collar or ring at the top that will allow for securing the concrete apron. Metal conduit, if used in preformed pull boxes, shall be electrically bonded to one another inside each pull box.

2914.10 Pull Box Covers: Each pull 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 or brass with a hex-head. Frames and covers for cast-in-place and precast concrete pull boxes shall be cast iron in accordance with AASHTO M 105, Class 30, and shall be of the dimensions and weights shown on the Plans. Preformed pull box covers shall be polymer concrete and shall have a minimum wheel load rating of 20,000 pounds. A lift opening shall be provided on all covers. Covers for pull boxes to be used for traffic signals, or a combination of traffic signals and street lighting, shall be embossed with "TRAFFIC SIGNALS". Covers for pull boxes to be used for fiber optics shall be embossed with “FIBER OPTICS”.

2914.11 Metal Junction Boxes (Power): Metal Junction boxes shall be flanged and designed for flush mounting if encased in concrete, or designed for surface mounting if external mounting is specified. Metal junction boxes shall be drilled or tapped for all conduit connections. Metal junction boxes shall be installed such that covers are removable. Metal junction boxes shall be stainless steel, watertight NEMA 4 enclosures. Metal junction boxes shall be in accordance with the following minimum sizes unless otherwise specified:

Maximum Entering Conduit Size, Inches	Minimum Box Size, Inches
2	(L)12 x (W)12 x(D) 4
4	(L)16 x (W)12 x (D)6

2914.11.1 PVC and metal conduit shall be joined to metal junction boxes to make a rigid and waterproof connection. If metal conduit is used, an insulated bushing shall be provided at the end of the metal conduit on the inside of the junction box to prevent scuffing of the cable insulation.

2914.11.2 The metal junction box cover shall be made watertight with a suitable gasket and secured with stainless steel or cadmium plated screws or bolts.

2915 Concrete Bases: Excavation for bases shall be made in a neat and workmanlike manner. While concrete is being placed, forms shall be level and sufficiently rigid to prevent warping or deflection. Concrete shall be a KCMMB 4k psi, or higher, approved concrete mix. Conduit and anchor bolts shall be held rigidly in place before and during concrete placement. Tops of all bases shall be finished level and the perimeter edged to a radius of 1/2 inch. Exposed surfaces of bases shall be finished in a workmanlike manner as soon as practical after removing forms. Concrete construction shall be in accordance with ACI 301 Standard Specifications for Structural Concrete.

2915.1 Pole Bases: Concrete bases for poles shall be in accordance with the dimensions shown on the Plans. Metal forms no less than 26 inches high shall be used for all Type A bases. The top 12 inches of Type B bases shall be formed. Reinforcing steel for concrete bases shall be in accordance with Section 2906.5. Anchor bolts for steel poles and mast arms shall be as shown on the fabricator’s approved shop drawings. Conduit shall extend above all pole bases a nominal 4

inches and be covered prior to pouring concrete. All threaded portions of anchor bolts shall be taped during the concrete pour. Any concrete splashed on poles when pouring shall be cleaned off.

2915.2 Controller and Power Supply Bases: Concrete bases for controllers and power supplies shall be constructed as shown on the Plans. Aprons will be considered part of the controller base. A minimum of four anchor bolts shall be used for single controller cabinets and a minimum of six anchor bolts shall be used for double controller cabinets. The size of anchor bolts for controller cabinets shall be as specified by the cabinet manufacturer. A ground rod shall be placed into the ground with a minimum of 8 feet of earth contact as shown on the Plans. Ground rods shall not be in concrete. Conduit shall extend above all controller bases no more than one inch. Bases for double controller cabinets shall have multiple conduits to the first pull box, with a minimum of one positioned in each compartment. All conduit openings in the controller cabinet or controller cabinet base shall be sealed with a pliable duct sealant after wiring is completed. The sealant shall be 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.

2916 Conduit Systems: 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 for the distribution system. Galvanized Rigid Steel (GRS) conduit shall be used where conduit is to be installed externally on a structure. It shall be the privilege of the Contractor, at his own expense, to use larger size conduit if desired, as approved by the City Traffic 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.

2916.1 Polyvinyl Chloride (PVC): Rigid non-metallic conduit shall be polyvinyl chloride (PVC), 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.

2916.2 High Density Polyethylene (HDPE): Flexible non-metallic conduit shall be high-density polyethylene conduit (HDPE). The conduit 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. 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. 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.

2916.3 Galvanized Rigid Steel (GRS): Galvanized rigid steel conduit shall be shall be in accordance with ANSI C80.1. GRS conduit shall be galvanized on both the inside and the outside surfaces. The weight (mass) of zinc coating shall be no less than 0.5 ounce per square foot

of coated surface, as determined in accordance with AASHTO T 65. The interior or exterior surface, or both, may be given a coating of suitable material to facilitate installation of wires and cables and to permit the conduit to be readily distinguished from pipe used for purposes other than electrical. All metal conduit ends shall be provided with a bushing to protect the cable from abrasion. Fittings shall be in accordance with ANSI C80.4. A sufficient number of conduit hangers shall be supplied to attach the GRS conduit to the structure, as recommended by the manufacturer. One (1) No. 6 AWG, bare copper ground wire shall be attached to each end of the GRS conduit with a grounding bushing. The ground wire shall be connected to a ground rod at each end of a GRS conduit run, or extended to an adjacent GRS conduit or ground rod.

2916.4 Conduit Installation: Conduit shall be bored under pavement. 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.

2916.4.1 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 and GRS conduits shall be cleaned with a mandrel and blown out with compressed air.

2916.4.2 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.

2916.4.3 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.

2916.4.4 The conduit shall be installed continuous from outlet to outlet 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 Traffic Engineer. The conduit may be directional bored to minimize disruption to the existing improvements or may be plowed or trenched. Conduit shall be installed under pavement sections at a depth not less than 24 inches (24”); and where laid in trenches in unpaved areas, conduit shall be laid to a depth of 24 to 36 inches (24” to 36”) below natural ground level or finish grade.

2916.4.5 At all outlets, conduit shall enter from the direction of the run. Where conduit enters a pull or junction box the side of the box shall be drilled per the manufacturer’s recommendations. The hole shall be no more than one-half inch (½”) larger than the conduit. The gap between the box and conduit shall be filled with sealing compound.

2916.5 Trenching: Conduit may be installed by trenching in unpaved areas. Trenches shall be excavated to a maximum width of six inches (6”) and deep enough to provide the minimum cover for conduits as shown in the Standard Drawings. Conduit shall be allowed to "snake" in the trench, but there shall be no sharp bends and 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 six inch (6") 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 or designee. Backfill material installed within six inches (6”) 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 (6”) deep, and each layer shall be thoroughly compacted to the approximate density of the adjacent material before the next layer is placed. Red burial tape imprinted with "CAUTION - BURIED CABLE BELOW" shall be installed in all trenches at approximately 1/3 to 1/2 of the depth of the trench. The four to six inches (4” to 6”) of backfill material directly below finished grade shall be topsoil. All disturbed areas shall be restored to the satisfaction of the City Inspector.

2916.6 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 unreeled 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. Conduit may be installed utilizing the pull plow method if approved by the City Engineer. 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. Red burial tape imprinted with "CAUTION - BURIED CABLE BELOW" shall be installed in all trenches at approximately 1/3 to 1/2 of the depth of the trench. All disturbed areas shall be restored to the satisfaction of the City Inspector.

2916.7 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 two feet (2’) 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 Inspector. Boring may be used instead of trenching at all other locations at the Contractors expense.

2916.8 External Conduit on Structure: GRS conduit shall be used when conduit is to be installed externally on structures. Conduit on structures will include conduit on bridges, retaining walls or other structures, and shall be installed as shown on the Plans or as directed by the City Engineer or designee. The final location of all conduit and junction boxes shall be approved by the City Engineer before installation begins. Conduit shall not be attached to prestressed concrete girders or prestressed, precast concrete deck panels. The conduit shall be secured to the concrete with clamps at no more than 5-foot intervals. Concrete anchors shall be in accordance with federal specification FF-S-325, Group II, Type 4, Class I, and shall be galvanized in accordance

with ASTM A 153, B 695-91 Class 50, or constructed of stainless steel. The minimum embedment in concrete shall be 1 3/4 inches. If it is necessary to anchor the conduit to steel bridge members, the attachment method shall not involve drilling, grinding or welding. Attachment method to steel members shall be approved by the City Engineer. Expansion fittings shall be installed at each end of a bridge and each location where the conduit crosses a bridge expansion joint. The expansion fitting shall provide a minimum movement in either direction as shown on the Plans or as specified by the City Engineer. Clamps, concrete anchors, expansion fittings, and any hardware or material required for conduit installation on structures shall be at the Contractor's expense.

2916.9 Ground Wire Installation: A bare No. 6 AWG stranded copper ground wire shall be installed in each conduit and attached to the ground lug in signal poles, except as otherwise specified in this section. All bare ground wires shall be electrically bonded by means of a clamp or crimp type connection. All bare ground wires in the controller base shall be electrically bonded to the power company ground. Conduit containing only fiber optic cable shall contain a bare or green-jacketed No. 14 AWG stranded copper tracer wire instead of a bare No. 6 AWG copper ground wire. Tracer wire shall not be pulled into the controller cabinet or bases. An additional 6 feet of tracer wire shall be coiled in each pull box through which the fiber optic cable passes. Tracer wire in pull boxes shall be capped, not electrically bonded to any ground wires labeled "TRACER" and tagged in accordance with Sec 2917. Ground wire and tracer wire shall be at the Contractor's expense.

2916.10 Certification: The Contractor shall furnish a manufacturer's certification that the material supplied is in accordance with all requirements. If requested by the City City Traffic Engineer, the Contractor shall also furnish typical test results representative of the material.

2917 Pole Erection: Pole bases shall be securely anchored to concrete bases. Pedestal poles shall be erected vertically without the use of leveling nuts. Metal poles for span wire and cantilever mast arms shall be adjusted by leveling nuts. All poles for span wire and cantilever mast arms shall be raked as directed by the City Traffic Engineer.

2918 Wiring: Installation of wiring shall be in accordance with the Plans and Specifications and appropriate articles of the NEC. Electrical conductors and associated equipment shall be in accordance with applicable requirements of ICEA, IMSA, NEMA, RETMA, NEC, NFPA and regulations of the National Board of Fire Underwriters and shall meet the approval of the City Traffic Engineer. Contractor furnished equipment that will become the property of the City shall be of new stock unless stated otherwise in the Plans.

2918.1 Except as noted, all conductors shall be soft drawn, Class B or C stranded copper wire in accordance with ICEA S-6-402, Part 2. Solid conductors may be used only for grounding where connected to a ground rod.

2918.2 All cable runs, with the exception of street lighting cable, shall be continuous and unspliced from the connections in the terminal block of the signal head to the terminal strip in the controller cabinet, from the signal terminal block to another signal terminal block or as shown on the Plans. When a terminal compartment is provided, all cable runs shall be continuous from the terminal compartment to the terminal strip in the controller cabinet. When parallel connections are required from an overhead signal head on a mast arm to a side-mounted signal head, cable shall be routed from the controller to the terminal compartment of the signal on the mast arm and then parallel-circuited back to the side mounted signal. All other conductor cable combinations to signal heads shall be as shown on the Plans or as directed by the City Traffic Engineer. Where

double controller cabinets are specified, wires shall be sorted between the controllers and first pull box such that field wires enter the associated controller compartment. All cables shall be supported within the pole at the mast arm connection using cable hooks so that the cables do not rest on the mast arm connection.

2918.2.1 Multi-conductor cable for traffic signals shall be No. 14 AWG, rated at 600 volts. The cable shall be in accordance with IMSA Specification No. 19-1.

2918.3 Power cable runs shall be continuous and unspliced from the power disconnect switch located on the power supply to controller cabinet terminals. Power cable shall be encased in conduit of the size shown on the Plans. Energized power cables shall run to circuit breakers. The neutral cable shall be terminated on the ground bus bar in the controller cabinet.

2918.3.1 The voltage rating for high voltage power cable supplying primary electrical power shall be 5 KV for primary voltages less than 5000 volts, and 15 KV for voltages of 5000 volts and greater. The specific type of cable shall be as recommended and approved by the utility company or municipality supplying power.

2918.3.2 Low voltage power cable shall be 600-volt, single conductor cable and 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. Insulation type shall be THW, RHH, RHW, RHW-2 or USE. Average thickness of insulation shall be no less than specified in the following table, with a minimum thickness of 90 percent thereof.

AWG No.	Thickness, Mils
14-10	45
8-2	60
1-4/0	80
213-500	95
501-1000	110

2918.3.3 Cable-conduit shall consist of one to four low voltage power cables with an insulated sized electrical neutral and a bare safety ground, factory installed in black polyethylene conduit intended for direct burial. The conduit shall be plainly marked on the outside with manufacturer's name and identification in accordance with industry practice and shall be in accordance with ASTM D 3485. Cable-conduit shall be accompanied by the manufacturer's certification stating the conduit is in accordance with the requirements of this specification.

2918.4 Where luminaires are required, they may be connected to a street lighting system or they may be powered from the traffic signal power supply. Lighting cables shall not run through the traffic signal controller. Cables can be run through signal conduits and pull boxes. Lighting cable may be spliced in pull boxes using copper type K split bolt connectors. All splices shall be protected with a waterproof resin splice kit installed in accordance with the manufacturer's recommendations.

2918.4.1 All lighting cables that are to be installed underground must meet the requirements for low voltage power cables. Break-away connectors are not required to be installed in traffic signal poles.

2918.5 Induction loop dimensions shall be as shown on the Plans. All loop conductors shall be wound in the same direction with the start and end clearly marked on the conductors at the junction box or pull box. The City Traffic Engineer or designee will determine the exact location of loops. When construction of a loop is started, it shall be completed the same construction day. Should the Contractor start a loop installation and fail to satisfactorily complete it, the entire loop may be subject to replacement at the discretion of the City Traffic Engineer. Construction of loops shall only be started when the ambient air temperature is 40 degrees F and rising. Wire shall be installed so as to minimize stress at corner locations. Wire shall be kept dry when installing in the saw slot and shall be inserted by use of a blunt, preferably nonmetallic, flat paddle. Each induction loop shall be connected to the detector by a separate lead-in cable. Single-conductor No. 14 AWG cable shown on the Plans is an approximation of cable quantity required to construct the induction loop. If the number of turns shown on the Plans is not in accordance with the manufacturer's recommendation for the sensing units furnished, the Plans will be revised, and the induction loop cable will be field measured and quantities adjusted accordingly. Induction loop detector cable shall be installed in accordance with manufacturer's recommendations. Induction loop detector lead-in cable will be shown on the Plans as two-conductor No. 14 AWG cable. Should the manufacturer recommend a different type of cable, the two-conductor cable shall be revised to the manufacturer's specification, but will be considered completely covered by the contract unit price for loop detector lead-in cable. Cable for loop detectors shall be continuous from the terminal strip in the controller cabinet to a splice with the detector leads in the pull box adjacent to the detector. The conductor splice shall be soldered without an open flame. The soldered splice shall then be capped and inserted into a direct buried splice kit.

2918.5.1 Induction loop detector cable shall be single conductor No. 14 AWG wire, with Type XHHW insulation, marked as such, rated at 600 volts. The cable shall be in accordance with IMSA Specification No. 51-7.

2918.5.2 Lead-in cable used between the loop detector and the controller shall be two-conductor, twisted, shielded No. 14 AWG wire rated at 600 volts. The cable shall be in accordance with IMSA Specification No. 50-2.

2918.6 Where practical, color codes shall be followed according to the following tables for each type of multi-conductor cable:

2 – Conductor (Pedestrian Push Button)	Terminal
Black	Push Button Actuation
White	Neutral

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

7 – Conductor (3 Section & 5 Section Head)	Terminal
Red	Red Ball Indication
Orange	Yellow Ball Indication
Green (or Brown)	Green Ball Indication
Blue	Green Arrow Indication
Black	Yellow Arrow Indication
White	Neutral
White With Black Trace	Neutral for Arrow Indications

Circuits shall be properly labeled in the controller cabinet and all pull boxes by means of round aluminum identification tags with a minimum thickness of 0.1 mils, attached to the cables with a copper wire. Information stamped on the tags shall identify equipment served by the conductor cable in accordance with designations used on the Plans.

2918.7 Cables shall be pulled through conduit by a cable grip providing a firm hold on exterior coverings. Cable shall be pulled with a minimum of dragging on the ground or pavement. Frame-mounted pulleys or other suitable devices shall be used for pulling cables out of conduit into pull boxes. Lubricants may be used to facilitate pulling cable. Polyester rope will not be permitted to facilitate pulling of cable. Slack in each cable shall be provided by a 6-foot loop coiled in each pull box and a 3-foot loop coiled in each junction box. All signal poles and controllers shall be grounded by bare No. 6 AWG stranded copper wire.

2918.8 Certification. All cables and conductors shall be accompanied by certification from the supplier indicating: (1) the supplier is familiar with the requirements of these Specifications and, (2) cable furnished was from a lot manufactured by (manufacturer's name) whose test results are in accordance with these Specifications.

2919 Test Equipment: During installation of equipment and material, the Contractor shall furnish to the City Traffic Engineer suitable equipment to test all or part of the completed facility to establish compliance with requirements of the contract. Minimum test equipment shall be a voltmeter, ohmmeter and ammeter. For testing induction loop detectors, the Contractor shall also provide a suitable 500-volt, direct current, 0 to 100- mega ohm range, hand-operated, resistance measuring device.

2920 Test Period: After the project is open to normal traffic, the Contractor shall notify the City Traffic Engineer in writing the date the signal or signal system will be ready for testing. Upon concurrence from the City Traffic Engineer, the Contractor shall place the signal or signal system in operation for a 15 consecutive day test period. 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, holiday 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 Traffic Engineer. At locations without previous traffic signal control, the new traffic signal shall flash for a period of five business days prior to full signal system turn-on. 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. A system shall be tested as a unit. Any failure or malfunction of equipment during the test period shall be corrected at the Contractor's expense, and the signal or signal system tested for an additional 15 consecutive day period. This procedure shall be repeated until the signal equipment has operated to the City Traffic Engineer's satisfaction for 15 consecutive days. The Contractor shall, in the presence of

the City Traffic Engineer or designee, demonstrate the proper action of the controller's monitor as part of the testing system, if applicable.

2920.1 When the test period is initiated and until the test period is completed, following the turn on of temporary traffic signals or after work is begun on an existing signal installation, 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. In the event of a 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 Traffic Engineer. If the signal or signal system malfunctions and a designated technician cannot be reached or cannot arrive at the intersection in a reasonable time in the judgment of the City Traffic Engineer, then the City Traffic Engineer may exercise the option to direct City personnel or a third party to correct the malfunction in the presence of the City Traffic Engineer or designee. 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.

2920.2 Whether or not the City Traffic Engineer elects to correct the signal malfunction, nothing in this specification shall be construed or interpreted to relieve the Contractor of any liability for personal injury or property damage that results either directly or indirectly from a signal malfunction during the test period. The Contractor and surety shall indemnify and save harmless the City, the City's agents, employees and assigns for any legal liability incurred for such a signal malfunction.

2921 Maintenance Information: Before acceptance of the work, the Contractor shall furnish the City Traffic Engineer with three copies of the manufacturer's instructions for maintenance and operation of all signal equipment including, but not limited to, controllers, conflict monitors, load switches, detectors, software, interconnect and auxiliary equipment. At a minimum, the manufacturer's instructions shall include organized written instructions, wiring diagrams, diagrams showing component layouts and parts lists with part numbers and serial numbers, where applicable. Serial numbers listed by the supplier will be verified with the shipping invoice and on the controller and conflict monitor received for installation. The Contractor shall furnish three copies of wiring diagrams of the installation or system. The cabinet wiring diagrams shall include labeling for all field terminal connections and shall provide an orientation of the terminal layout that conforms to the intersection information specified.

2921.1 Prior to acceptance of the work, the Contractor shall submit marked-up plans showing in detail all construction changes, especially the location and depth of conduit.

2921.2 The Contractor is responsible for making all repairs and replacements, including downed poles, damaged or cut cables, and burnt out indications, to the traffic signal system, regardless of the cause or responsible party, until the entire system is completed, inspected, and accepted as substantially complete by the City.

2922 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 Inspector.

2923 Measurement and Payment: See Division I – General Requirements for CIP, Section 01120.