Section 904 St. Louis County Traffic Signals

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904.1 Description This work shall consist of furnishing and installing traffic signal materials and equipment as shown on the drawings and as specified in the contract.

904.2 General Requirements for Materials and Equipment

1) Materials and equipment shall be new stock unless the contract provides for relocation of existing equipment or use of equipment furnished by others. New materials and equipment shall be the product of reputable manufacturers; shall conform to current requirements of IPCEA, NEMA, RETMA, NEC, IMSA, NESC, ITE, AASHTO, ASTM and regulations of the National Board of Fire Underwriters, as applicable; shall be in accordance with the County's current specifications; and shall meet the approval of the Engineer. Special approval of manufacturers' controller equipment, including panel wiring, is required and may be obtained by fulfilling the requirements as specified in Section 904.4.6.12.

2) Each Bidder shall indicate on his proposal the major manufacturers of the traffic signal materials and equipment to be installed and the time required for their delivery.

3) If all signal materials and equipment for which a bid is submitted are not in exact accordance with these specifications, the Bidder shall attach to his proposal a detailed list wherein all deviations from these specifications shall be expressly listed.

4) Upon request by the Engineer, the Contractor shall produce manufacturers' letters of certification or certified test reports to show that traffic signal materials and equipment are in compliance with the specifications.

5) Six (6) sets of catalog cuts identifying the project name and the manufacturers' model numbers of traffic signal equipment shall be submitted by the Contractor to the Engineer for approval before signal construction commences. Approval of these catalog cuts does not relieve the Contractor of responsibility for satisfactory performance of this equipment. Catalog cuts shall be submitted at least two (2) weeks in advance of the Contractor's need for approval. This time requirement for approval does not relieve the Contractor of his responsibility for delivery of signal materials and equipment within the time specified on the bid forms.

6) If mast arms are specified in the contract, six (6) sets of shop drawings shall be submitted by the Contractor to the Engineer for approval prior to fabrication, as specified in Section 904.4.3(13).

904.3 Materials All materials shall conform to Division 1000, Materials Details.

904.3.1 Conduit The size of conduit to be installed shall be as specified in the contract or noted on the plans. The type of conduit to all power supplies and span wire poles shall be polyvinyl chloride (PVC) conduit. The type of conduit to all other structures and facilities

shall be either PVC or polyethylene duct (PE), as chosen by the contractor, unless otherwise specified in the contract or noted on the plans.

904.3.1.1 Polyvinyl Chloride Conduit Polyvinyl chloride (PVC) conduit and fittings shall be Schedule 40, heavy-wall type, and conform to the requirements of the current Underwriters Laboratories Standard for Rigid Nonmetallic Conduit, UL 651, as specified in Section 1060.

904.3.1.2 Polyethylene Duct Polyethylene (PE) duct should be smoothwall duct and conform to ASTM D3035 SDR 11. Conventional PVC couplings shall not be attached to PE duct. All couplings used with PE duct shall be approved by the Engineer.

904.3.2 Conductor Cable and Wire

904.3.2.1 Power Cable All power cable shall be 600 volt, single conductor cable, with type THW polyvinyl chloride insulation. The single conductor shall be soft drawn, Class B, 7 strand, copper wire conforming to the current requirements of IPCEA S-61-402, Part 2. All power cable shall be plainly marked on the outside of the insulation with the manufacturer's name and identification of the type of cable.

1) Polyvinyl chloride insulation shall be Type THW and shall conform to the current requirements of IPCEA S-61-402, Paragraph 3.8, or Underwriters Laboratories Standard UL 83. The insulation shall be applied directly to and shall tightly fit the surface of the conductor.

2) The polyvinyl chloride insulation shall be color coded so that the AC(+) cable is black and the neutral cable is white.

3) The average thickness of insulation shall be as specified in Table I, with a minimum thickness of 90 percent thereof for insulation. Conductor sizes and thickness of insulation may be increased if approved by the Engineer.

TABLE I

SINGLE CONDUCTOR POWER CABLE - TYPE THW

Conductor Size (AWG No.)	Insulation Thickness (Inch)	Maximum Outside Diameter (Inch)
6	.0625	0.33
4	.0625	0.38
3	.0625	0.41
2	.0625	0.44

904.3.2.2 Multi-Conductor Signal Cable All signal cable shall be 600 volt, multi-conductor cable, meeting the requirements of the current IMSA Specification 19-1. The conductors shall be No. 14 AWG, stranded copper wire, with color coded polyethylene insulation. The signal cable shall have a black polyvinyl chloride outer jacket and shall be plainly marked on the outside with the manufacturer's name and identification of the type of cable.

904.3.2.3 Ground Wire A ground wire shall be used to ground each signal post, mast arm assembly and controller cabinet to a ground rod inside the nearest concrete pull box and shall be No. 6 AWG, 7 strand, soft drawn bare copper wire.

904.3.2.4 Detector Loop Cable Detector loop cable shall be installed in sawed slots as shown on the plans. The cable shall be 600 volt, single conductor, meeting the requirements of the current IMSA Specification 51-5. The conductor shall be No. 14 AWG, stranded copper wire, with Type THHN polyvinyl chloride thermoplastic insulation and a gasoline and oil resistant nylon jacket. The detector loop cable shall be furnished in a flexible polyethylene tube jacket for the full length of the cable. The tube jacket shall have a nominal ¼ inch outside diameter and a minimum 30 mil wall thickness. The tube jacket shall have a smooth bore, resist abrasion and resist deterioration from oils and solvents. The detector loop cable shall have the manufacturer's name and identification of the type of cable plainly marked on the outside of the tube jacket.

904.3.2.5 Push Button and Detector Loop Lead-In Cable This type of cable shall be 600 volt, two conductor shielded cable, twisted two to three turns per foot, meeting the requirements of the current IMSA Specification 50-2. The conductors shall be No. 18 AWG, stranded tinned copper wire, with color coded polyethylene insulation. The cable shall also be provided with a mylar-backed aluminum foil shield, a stranded tinned copper un-insulated drain wire over the twisted pair, and a polyethylene outer jacket.

904.3.2.6 Communication Cable for Traffic Signal Interconnect Interconnect cable shall consist of multi-conductor, twisted pair, fiber optic, or a combination of these cables.

904.3.2.6.1 Multi-Conductor Cable The multi-conductor interconnect cable shall be 600 volt and meet the requirements of the current IMSA Specification 19-1. The conductors shall be No. 14 AWG, stranded copper wire, with color coded polyethylene insulation, or as shown on construction prints. The interconnect cable shall have a black polyvinyl chloride outer jacket and shall be plainly marked on the outside with the manufacturer's name and identification of the type of cable.

904.3.2.6.2 Twisted Pair Cable This type of cable shall be 600 volts and have three (3) twisted pairs. The conductors in each pair shall be No. 16 AWG, stranded copper wire, with polyvinyl chloride insulation (0.016 inch thick) color and/or number coded with a nylon overcoat. Each twisted pair shall be wrapped with a mylar-backed aluminum foil shield and a No. 16 AWG stranded tinned bare copper drain wire. The three (3) twisted pair shall be wrapped with an overall aluminum foil shield and a No. 16 AWG stranded tinned bare copper drain wire. The communication cable shall have a black polyvinyl chloride outer jacket (0.5 inch thick) and be plainly marked on the outside with the manufacturer's name and identification of the type of cable. The nominal outside diameter of the cable shall be approximately 0.5 inch.

Twisted pair cable will only be allowed for new signal installations within the limits of an existing twisted pair cable interconnected system.

904.3.2.6.3 Fiber Optic Cable The cable shall meet all requirements stated within. It shall be new, unused and of current design and manufacture. The cable shall be equivalent to Corning Cable System 036XU4-T41XXD20, (30 singlemode, 6 multimode) with the first tube being 12 singlemode, followed by one (1) tube of 12 singlemode, followed by one (1) tube of 6 singlemode, followed by one (1) tube of 6 multimode, or as approved by the Engineer. All fibers in the cable must be usable fibers and meet the following specifications.

1) Multimode Fiber: The multimode fiber shall meet EIA/TIA-492AAAA-A-1997 Detail Specification for 62.5 µm Core Diameter/ 125 µm cladding diameter class la graded-index multimode optical fibers.

Core diameter: ..... 62.5 µm

Cladding diameter: ..... 125 µm

Core to cladding offset: ..... <3.0 µm

Coating diameter: ..... 250 µm

Fiber type: .....Graded Index

Operating temperature: .....-40 degrees C to +70 degrees C

Attenuation @ 850 nm: .....≤3.5 db/km

@ 1300 nm: .....≤1 db/km

2) Singlemode Fiber:

Typical core diameter: ..... 8.2 µm

Cladding diameter: ..... 125 ± 1.0 µm

Core to cladding offset: ..... <1.0 µm

Coating diameter: ..... 245 ± 10 µm

Operating temperature: .....-40 degrees C to +70 degrees C

Attenuation uniformity:..... No point discontinuity greater than 0.1 dB at either 1310 nm or 1550 nm

3) The coating shall be a dual layered, UV cured acrylate applied by the fiber manufacturer. The coating shall be mechanically or chemically removable without damaging the fiber.

4) The buffer tube shall be of polypropylene construction and contain up to 12-fiber. The fibers shall be colored with ultraviolet (UV) curable inks. Fillers may be included in the cable core to lend symmetry to the cable cross-section where needed.

5) The central anti-buckling member shall consist of a glass reinforced plastic rod. The purpose of the central member is to prevent buckling of the cable.

6) Each buffer tube shall contain a water-swellable yarn or water blocking element for water-blocking protection. The water-swellable yarn or water blocking element shall be non-nutritive to fungus, electrically non-conductive, and homogeneous. It shall also be free from dirt or foreign matter. This yarn or element will preclude the need for other water-blocking material; the buffer-tube shall be gel-free. The optical fibers shall not require cleaning before placement into a splice tray or fan-out kit.

7) Buffer tubes shall be stranded around a central member using the reverse oscillation stranding process. Water blocking yarn(s) shall be applied longitudinally along the central member during stranding.

8) For single layer cables, a water-swellable tape shall be applied longitudinally around the outside of the stranded tubes/fillers. The tape shall be held in place by a single polyester binder yarn. The water-swellable tape shall be non-nutritive to fungus, electrically non-conductive and homogenous. It shall also be free from dirt and foreign matter.

9) All dielectric cables (with no armoring) shall be sheathed with medium density polyethylene. The minimum nominal jacket thickness shall be 1.4mm. Jacket material shall be applied directly over the tensile strength members and water-swellable tape.

10) The jacket or sheath shall be marked with the manufacturer's name, the words "Optical Cable", the year of manufacture, and sequential feet or meter marks. The markings shall be repeated every two feet. The marking shall be in a contrasting color to the cable jacket.

11) The maximum tensile load for installation shall be 2700 N (608 lb-ft).

12) All optical fibers shall be proof-tested by the fiber manufacturer at a minimum load of 100 kpsi. All optical fibers shall be 100% attenuation tested. The attenuation test results of each fiber shall be provided with each cable reel.

904.3.3 Preformed Pull Box and Cover

1) Each preformed pull box and cover shall be of gray color and be manufactured from reinforced polymer concrete materials. These materials shall consist of sand and gravel aggregates, bound together with a polymer and reinforced with continuous woven glass strands.

2) Each preformed pull box shall have a bolt down cover fastened by two (2) recessed, stainless steel hex head bolts. These bolts shall be aligned with two (2) stainless steel inserts set in the opposite corners of the pull box.

3) Each preformed pull box cover shall have a skid resistant surface with a recessed pull slot for removing the pull box cover.

4) Each preformed pull box shall have the words **ST. LOUIS CO. TRAFFIC** engraved in the cover.

5) The size of the preformed pull box to be installed shall be as specified in the contract or noted on the plans. The design of each size preformed pull box and cover shall be based upon the minimum load rating of the pull box and cover as specified on the following table.

Size of Preformed Pull Box (Nominal Dimensions)	**Min. Load Rating Over 10" Sq. Area**
12"W x 12"L x 12"H	8000 lbs.
13"W x 24"L x 18"H	12000 lbs.
17"W x 30"L x 26"H (Minimum)	12000 lbs.

904.3.4 Concrete Pull Box Frame, Cover and Cable Hooks

1) Each concrete pull box frame and cover shall be cast iron conforming to the requirements of ASTM A 48, Class 30, and of the dimensions shown on the standard detail drawings. The weight of the cover shall range from 65 pounds to 85 pounds. The cover shall be scoriated, web reinforced and have the words TRAFFIC SIGNAL cast on the cover. A ¾ inch diameter lift hole shall be provided in the cover. Each frame and cover shall be given two coats of a good quality commercially available heavy asphalt paint prior to delivery.

2) Cable hooks shall be galvanized steel and have a minimum diameter of ⅜ inch and a minimum length of six inches. The cable hooks provided shall be either pole steps or carriage bolts.

904.3.5 Detector Loop Sealant The detector loop sealant shall be a water-proof, polyester system with excellent adhesion to both concrete and asphalt substrate, whether damp or dry. The sealant shall be a self-leveling polyester system that flows easily into the sawed slots and blends into the surface of the pavement. Once applied, it shall cure to a durable, flexible compound protecting the detector loop against road abuse and seasonal thermal changes. The sealant shall cure at low temperatures and not be affected by freeze-thaw cycles, deicing salts, gasoline or oil. Unless otherwise approved by the Engineer, the loop sealant shall be in conformance with the specific values described below:

1) The loop sealant shall be a polyester compound with excellent adhesion to both concrete and asphalt substrate. The sealant shall be pourable, self leveling and capable of total encapsulation of detector loop wires.

2) The loop sealant shall have the following characteristics:

Property	Specific Value
Shore D Hardness	60
Tensile Elongation	15-25%
Tensile Strength	350 p.s.i. Minimum
Compressive Yield Strength (Ultimate)	2000-3000 p.s.i.
Salt Water Absorption (5% Solution)	0.20% Maximum
Oil Absorption	0.02% Maximum
Gasoline Absorption	0.80% Maximum
Water Absorption	0.20% Maximum
Freeze-Thaw Resistance	Excellent

904.3.6 Concrete Unless otherwise approved by the Engineer, materials, proportioning, mixing, slump, and transporting of portland cement concrete shall be in accordance with the applicable provisions of Section 501 for Class B concrete.

904.3.7 Reinforcing Steel Reinforcing steel for concrete shall be deformed bars in accordance with the applicable provisions of Section 1036.

904.3.8 Signs and Striping Permanent signing and striping materials for each signal installation shall be furnished and installed by St. Louis County, unless otherwise noted on the drawings or specified in the contract.

904.4 Equipment

904.4.1 Signal Head Assemblies Each signal head shall be composed of one or more signal faces with each signal face composed of one or more signal sections. All signal head assemblies shall meet the following general requirements.

904.4.1.1 General Requirements

1) Each signal section shall be a self-contained assembly consisting of a section housing, optical unit, terminal block and all necessary gaskets to insure a weatherproof unit.

2) If new signal sections are to be combined with existing sections, the new signal sections shall be adaptable to the existing.

3) Each signal face's horizontal alignment, arrangement, and location shall be as shown on the drawings.

4) Each signal head shall be assembled in a configuration and mounted in a manner which is in conformance with the standard detail drawings. All doors shall open to a 180 degree position to allow unobstructed access.

904.4.1.2 Signal Head Hardware

1) Unless otherwise approved by the Engineer, all pipe and nipples used for assembling and mounting signal faces shall be Schedule 40 extruded aluminum pipe with a 1½ inch nominal pipe size. The pipe and nipples shall be equal to aluminum alloy 6061-T6 and have a natural aluminum finish. Painting of pipe and nipples will not be permitted.

2) Unless otherwise approved by the Engineer, all terminal compartment housings and fittings, including elbows, tees, crosses, connectors, and hub plates, used for assembling and mounting signal faces, shall be aluminum and have a nominal pipe size of 1½ inches. These fittings and terminal compartment housings shall be equal to either permanent mold castings of aluminum alloy 319.0-F, 356.0-T6, or Almag 35, conforming to the requirements of ASTM B 108, or sand castings of aluminum alloy 319.0-F, 356.0-T6, or Almag 35, conforming to the requirements of ASTM B 26. All fittings and terminal compartment housings shall be free from imperfections and have a natural aluminum finish. Painting of these items will not be permitted.

3) Unless otherwise approved by the Engineer, all pipe, nipples, elbows, tees, crosses, connectors, hub plates and terminal compartments shall have straight threads. One (1) stainless steel square or hex head set screw shall be furnished at each connection point in all elbows, tees, crosses, hub plates, terminal compartments and post top mountings to insure rigid mounting.

4) Fittings which attach to the signal housing shall have either integral serrations or a serrated locking ring, both of which must be compatible with the 72 serrations on the signal housing. Serrated fittings shall be secured to the signal housing by a threaded collared nipple or by a threaded nipple with a hex nut. Upon request, the signal head manufacturer shall submit a sample of their serrated locking ring to the Engineer for his approval.

5) Terminal compartments shall contain a double row barrier type terminal block with not less than twelve (12) points using No. 8-32 NC screws. The door to each terminal compartment shall be either aluminum or aluminum colored plastic and held in place using two (2) ¼ inch - 20 NC, stainless steel screws.

6) Each signal head installed vertically on a mast arm shall be mounted using an astro-bracket with an in-line terminal compartment. The astro-bracket shall be banded onto the mast arm using ⅝ inch by .030 inch stainless steel banding. The astro-bracket should be equivalent to a Pelco Standard Astro-Brac AB-3004-L.

7) Each signal head installed horizontally on a mast arm shall be assembled using two hub plates and one terminal compartment. The two hub plates shall be banded onto the mast arm using ⅝ inch by .030 inch stainless steel banding.

904.4.1.3 Signal Face Types Each signal face shall be of the type designated in the contract or shown on the drawings.

904.4.1.3.1 Conventional Vehicle Signal Face

904.4.1.3.1.1 Basic Construction and Mounting Each 12 inch section housing shall be fabricated from ultraviolet stabilized color impregnated polycarbonate resin having back, sides, top and bottom integrally cast to form a single unit. It shall be clean, smooth, and free from imperfections. The signal housing and the lens door shall be black. Painting of signal sections will not be permitted.

1) The top and bottom ends of each signal section shall be of a ribbed construction so as to produce the strongest possible assembly consistent with light weight.

2) The top and bottom of each housing shall have an opening to accommodate standard 1½ inch pipe fittings and brackets. Each opening shall have 72 integrally cast radial serrations to insure positive locking of the sections. The connection between signal housings shall be weatherproof and capable of being directed at any angle in the horizontal plane in 5 degree increments. Housings shall be rigidly fastened together by a three bolt assembly or other connectors approved by the Engineer.

3) A square housing door shall be suitably hinged and held securely to the body of the housing by corrosion resistant locking devices. Latching of the door shall be achieved without the use of special tools. All door hardware shall be of corrosion resistant material. Gaskets which will exclude dust and moisture shall be used between the lens and the door. Either a gasket or an integral hood recess shall be used between the body of the housing and the lens door.

4) A minimum of two internal bosses shall be provided in each signal section for the mounting of a terminal block.

904.4.1.3.1.2 Optical Unit Features The signal indication module shall consist of a Light Emitting Diode (LED) unit. Installation into existing traffic signal housings built to the Institute of Transportation Engineers (ITE) Vehicle Traffic Signal Head standards shall be without modification to the housing and shall not require special tools.

1) The LED signal module shall have a smooth outside lens surface. The lens shall be uniformly tinted to enhance ON/OFF contrasts in a manner not to affect luminous intensity or chromaticity. The module shall be easily replaceable in the field without the need of any special tools. The module shall be marked to assure proper orientation to the housing. The lens material shall be ultraviolet (UV) stabilized polycarbonate to withstand direct sunlight exposure for a minimum of 5 years without evidence of deterioration.

2) The LED signal module shall be rated for continuous use in the ambient temperature range of -40 degrees C to +74 degrees C and be protected against dust and moisture intrusion.

3) The LEDs shall be indium based AllnGaP technology for red and yellow, and GaN for green. The LED signal module shall conform to ASTM specifications where applicable. Enclosure and lens shall have a minimum UL94-VO grade flame retardant material. Lens shall be made of UV stabilized material.

4) The LED signal module shall meet the minimum initial intensity requirements as defined in the latest edition and revision of the ITE Standards for Adjustable Face Vehicle Traffic Control Signal Heads.

5) The LED signal module shall conform to the chromaticity requirements of the latest edition and revision of the ITE Standard for Adjustable Face Vehicle Traffic Control Signal Heads.

6) Each LED signal module shall be provided with color coded No. 18 AWG stranded copper wire with insulation rated at 104 degrees C. The wiring shall be of sufficient length to extend, without splicing, to the terminal block located within each signal face with the module in a fully open position. The wiring leads shall be terminated with a spade tongue connectors for ease of connection to the terminal block.

7) The LED signal module shall operate from 80V to 135V at 100 Hz without perceptible flicker.

8) Transient voltage protection and fusing shall be provided to withstand high repetition noise transients and low repetition high energy transients per NEMA TS-2 specifications.

9) The LED drive circuitry shall be wired such that a failure of one LED will not result in the loss of more than 20% of the total LED signal illumination. The module shall be designed to sense a loss of light output due to LED failure of between 25% to 40%, upon which the unit shall present an impedance of 500 Kohms to the AC line. The LED signal shall be operationally compatible with traffic controller assemblies meeting the NEMA TS-2 Standards with the exception of dimming.

10) The LED on board circuitry must meet FCC regulations concerning the emission of electronic noise.

11) The warranty period shall be for 60 months of field operation for failure due to workmanship or material defects and minimum of 36 months for loss of more than 40% of the initial rated luminous intensity. Each LED signal module shall be identified on the backside with the manufacturer's name and serial number.

904.4.1.3.1.3 Visors and Backplates

1) A round tunnel visor shall be supplied with each signal section unless otherwise specified. Tunnel visors shall be polycarbonate, not less than 0.060 inches thick. The visors shall be a removable type held in place by either four snap-on tabs or by four fastening screws. The visors shall fit tightly against the door thereby not permitting any perceptible filtration of light between them and the housing doors. Visors shall be at least 10 inches long for all 12 inch signal sections. Visors shall angle downward not less than 3 degrees nor more than 7½ degrees. Visors shall be black and color impregnated, with the underside flat black. Painting of visors will not be permitted.

2) Backplates shall be provided for all signal heads as shown on the drawings or as specified in the contract. Backplates shall be black, color impregnated, weather resistant, and ABS type thermoplastic. They shall be one piece, 0.125 inch thick, vacuum formed with a ⅝ inch flange on all sides for rigidity and structural integrity, and designed to fit each manufacture's signal head precisely. Backplates shall be rigidly secured to each signal face with non-corrodible fasteners, as directed by the manufacturer.

904.4.1.3.2 Optically Limiting Vehicle Signal Face An optically limiting vehicle signal face shall provide an indication to the field of view through the use of an electronic steerable beam providing a visibility zone of red, yellow and green, without requiring louvers or other external blocking devices to achieve the end result. No indication shall result from external illumination nor shall one section illuminate another.

904.4.1.3.2.1 Basic Construction and Mounting Each 12 inch signal section housing shall be one-piece molded and manufactured from Ultra-Violet stabilized Makrolon 9417 or equivalent. It shall be clean, smooth, and free from imperfections.

1) Housings containing electronic components shall be made of ULV94VO flame retardant materials. The housings shall be a minimum of .090 inch thick, and have a 5-inch square maximum opening in the rear. The opening shall accommodate a thermal transfer device that shall dissipate heat to the outside of the housing and physically connected to the LED's within. The housing shall utilize ribbing to enhance the structural strength while reducing weight. The top and bottom exterior of the housing shall be parallel to insure alignment of assembled section, and shall have a common vertical centerline. The top and bottom of the housing shall have an opening to permit the entrance of 1½ inch (38.1) N.P.T fittings and standard traffic signal mounting hardware. The top and bottom opening of each housing section shall have 72 integrally cast radial serrations to allow proper joining of stacked sections to insure positive locking of the sections.

2) The door shall be a single molded piece with an integrated dome that eliminates the need for a lens/door gasket, and shall be manufactured from Ultra-Violet stabilized new polymer resin. The door shall have two evenly spaced latch slots, and shall pivot from the left side on stainless steel hinge

pins. The door shall latch at the right side using stainless steel hardware, and shall have four stainless steel threaded inserts for retaining the visor. The door shall be fitted with a gasket that will form a dust and moisture resistant seal between the door and housing.

3) Each section housing shall be predrilled for backplates.

Each three, four, or five section signal head assembly shall be provided with a terminal block in the yellow indication compartment to provide a connection point for external wiring. The terminal block shall be barrier type, capable of accommodating up to 10 AWG wire on each terminal. The terminal block hardware shall be #8-32 x 5/16 (.3125) inch long binder head stainless steel screws.

4) External color of the housing shall be black, and completely impregnated in the resin material so that scratches will not expose uncolored material.

5) The individual LED light sources shall be wired so that a catastrophic failure of one LED light source will result in the loss of not more than 10 percent of the signal light output.

904.4.1.3.2.2 Optical Unit Features The optical unit for each 12 inch signal section shall consist of an objective lens, lamp, lamp collar, and optical limiter-diffuser. The optical unit shall be designed in conjunction with the visor to eliminate the return of outside rays entering the unit from above the horizontal.

1) The integrated dome shall be clear, circular, convex, scratch resistant, hard coated, and UV stabilized. The 12 inch dome shall have a diameter between 11-15/16 (11.9375) inches and 12-1/32 (12.03125) inches. The lens shall diffuse the light emanating from the LED's to provide light disbursement across the outer dome. In no instance shall individual LED's be visible in the field of vision when the signal section is energized. The optically limiting signal face shall be designed to allow the light output through the lens to be directed or steered into a specific viewing zone. Steering shall be accomplished electronically. The use of mechanical devices, tape, or masking to limit visibility shall not be allowed. The design of the optically limiting signal shall accommodate light output steering in both the vertical and horizontal direction.

2) Ambient light adjustment shall be provided and shall be designed to adjust the intensity of the light output in response to ambient light levels. Adjustments shall be accomplished in a smooth manner in response to ambient light levels and corresponding to two internal levels described as Day and Night.

3) Each signal section shall be installed, and optically aligned in accordance with manufacturer's instructions.

4) Manufacturer shall warrant the Optical Limiting Signal, to be free from defects in material and workmanship for a minimum of seven (7) years from date of shipment from the manufacturer.

904.4.1.3.2.3 Visors and Backplates

1) A round tunnel visor shall be supplied with each signal section unless otherwise specified. Tunnel visors shall be polycarbonate, not less than 0.060 inches thick. The visors shall be a removable type held in place by either four snap-on tabs or by four fastening screws. The visors shall fit tightly against the door thereby prohibiting filtration of light between the visor and the housing doors. Visors shall be at least 10 inches long for all 12 inch signal sections. Visors shall angle downward not less than 3 degrees or more than 7½ degrees. Visors shall be black and color impregnated, with the underside flat black. Painting of visors will not be permitted.

2) Backplates shall be provided for all signal heads as shown on the drawings or as specified in the contract. Backplates shall be black, color impregnated, weather resistant, and ABS type thermoplastic. They shall be one piece, 0.125 inch thick, vacuum formed with a ⅝ inch flange on all sides for rigidity and structural integrity, and designed to fit each manufacture's signal head precisely. Backplates shall be rigidly secured to each signal face with non-corrodible fasteners, as directed by the manufacturer.

904.4.1.3.3 Pedestrian Signal Face

904.4.1.3.3.1 Basic Construction and Mounting In order to facilitate installation and maintenance, the signal housing shall be designed so that all components are readily accessible from the front by merely opening the signal door.

1) Unless otherwise approved by the Engineer, the signal housing shall be fabricated from ultraviolet stabilized color impregnated polycarbonate resin having back, sides, top and bottom integrally cast to form a single unit. It shall be clean, smooth, and free from imperfections. The outside dimensions of the case shall be approximately 16 inches high x 18 inches wide x 9 inches deep. The signal housing, the lens door, and visor shall be black. Painting of the signal head will not be permitted.

2) The signal head shall be suitable for either post top or side mounting. The top and bottom of each housing shall have an opening to accommodate standard 1½ inch pipe fittings and brackets. Each opening shall have 72 integrally cast radial serrations to insure positive locking of the sections. Two corresponding serrated locking ring fittings shall be furnished with each signal case and shall be subject to the approval of the Engineer as specified in Section 904.4.1.2(4). The connection between signal housings shall be weatherproof and capable of being directed at any angle in the horizontal plane in 5 degree increments. Two caps shall be furnished to seal the openings on the top and bottom of each signal housing.

3) The signal housing shall be constructed in a manner that will also allow either right or left side mounting. Whenever side mounting is required, a side bracket shall be fastened to the housing with a watertight seal. Watertight seals shall also be provided on the side(s) of the head not used

for mounting purposes. The side bracket shall have a natural aluminum finish and be designed for banding to either a signal post or a mast arm pole. A barrier type terminal block, furnished with not less than 5 points, shall be installed inside the side bracket on two bosses integrally cast in the bracket. The side bracket shall be designed to protect the terminal block from dust and moisture.

4) The rectangular signal door shall be fabricated from ultraviolet stabilized black color impregnated polycarbonate resin. The door shall be complete with hinge lugs and latch slots. All door hardware shall be of corrosion resistant material. Either a gasket or an integral hood recess shall be used to prevent dust and moisture from entering the signal housing.

5) Internal bosses shall be provided in the signal housing for the mounting of a terminal block and other internal components.

904.4.1.3.3.2 Optical Unit Features The signal indication module shall consist of a Light Emitting Diode (LED) unit. Installation into existing traffic signal pedestrian housings shall be without modification to the housing and shall not require special tools.

1) The LED signal module shall have a smooth outside lens surface. The lens shall be uniformly tinted to enhance ON/OFF contrasts in a manner not to affect luminous intensity or chromaticity. The lens material shall be ultraviolet (UV) stabilized polycarbonate to withstand direct sunlight exposure for a minimum of 5 years without evidence of deterioration.

2) The LED signal module shall have a pedestrian interval countdown display to inform pedestrians of the number of seconds remaining in the pedestrian change interval. Countdown displays shall not be used during the Walk interval nor during the Yellow change interval of a concurrent vehicular phase.

3) The left half of the signal module shall have a Lunar white LED filled Walking Person symbol overlaid on a Portland orange LED filled Upraised Hand symbol, all on a black opaque background. The right half of the signal module shall have 9-inch high countdown numbers filled with Portland orange LEDs, all on a black opaque background.

4) The timing for the countdown pedestrian change interval shall be provided by the timing programmed in the traffic controller. Only two conductors (with ground), from the traffic controller back panel to the pedestrian signal head, shall be required to transmit countdown display timing. No separate timing device, independent of the timing programmed in the traffic controller, shall be required.

5) The LED signal module shall have a fuse and transient suppressor incorporated for line and load protection.

6) The LED signal module shall not have more than 20% harmonic distortion.

7) The LED signal module shall meet FCC Title 47, Subpar B Section 15 Regulations for Electric Noise.

8) The LED signal module shall conform to NEMA moisture resistance STD 250-1991 for Type 4 enclosures (ITE 6.4.6.2 Moisture Resistance)

9) The LED signal module shall be rated for continuous use in the ambient temperature range of -40 degrees C to +74 degrees C and be protected against dust and moisture intrusion.

10) The LED signal module shall operate between 80V to 135V.

11) The warranty period shall be for 60 months of field operation for failure due to workmanship or material defects and minimum of 36 months for loss of more than 40% of the initial rated luminous intensity. Each LED signal module shall be identified on the backside with the manufacturer's name and serial number.

904.4.1.3.3.3 Visors Each signal face shall be provided with a rectangular crate type visor designed to eliminate sun phantom. The material used in construction of the crate visor shall be ultraviolet stabilized black color impregnated polycarbonate plastic. The visor assembly may be either mounted to the signal door or be molded as an integral part of the signal door into a one piece assembly.

904.4.2 Aluminum Post with Square Pedestal Base Assembly

1) The aluminum post shall be straight continuous Schedule 80 extruded aluminum pipe with a 4½ inch nominal outside diameter. The post shall be equal to aluminum alloy 6061-T6 and have a spun finish. The post shall have tapered threads on one end to form a threaded connection with an aluminum base. A removable aluminum post cap, with stainless steel set screws, shall be provided when specified in the contract or noted on the plans.

2) The aluminum square pedestal base shall be free from imperfections and equal to either a permanent mold casting of alloy 319.0-F, conforming to the requirements of ASTM B 108, or a sand casting of alloy 319.0-F, conforming to the requirements of ASTM B 26. The pedestal base shall be approximately 15 inches high x 13½ inches square and weigh a minimum of 20 pounds. The pedestal base shall have a natural aluminum finish. The handhole shall have a minimum 8 inch x 8 inch cover and be either cast aluminum or aluminum colored plastic. Painting of the pedestal base and handhole cover will not be permitted. The pedestal base shall have a 12¾ inch diameter bolt circle with the handhole designed to provide easy access to all wiring and anchor bolt nuts. A ¼ inch x ¾ inch –20 NC stainless steel hex head bolt shall be used to fasten the handhole cover to the pedestal base. The top opening of the pedestal base shall be chamfered and have tapered threads to form a threaded connection with a Schedule 80, 4½ inch nominal outside diameter post.

3) A post to base collar assembly shall be provided and designed to reinforce a pedestal post at the point where the threads enter the pedestal base. The reinforcing collar shall be a two or three-piece cast aluminum unit that clamps around the top of a pedestal base with socket head bolts. The reinforcing collar shall be supplied with a roll pin for holding the collar securely in place. The collar shall have an opening to be used for drilling a pilot hole for the roll pin. Welded connections shall not be allowed between the pedestal base and the post.

4) Anchor bolts shall conform to ASTM A-307 and have a minimum yield strength of 36,000 psi. The bolts shall have a diameter of either ⅝ inches or ¾ inches and be 18 inches long, plus a right angle hook having a minimum length of 2 inches. Minimum top four inches of each bolt shall be threaded. Each bolt shall be furnished with a hex nut and washer. All anchor bolts, nuts and washers shall be hot dipped galvanized and meet the requirements of ASTM A-153.

5) Anchor bolts shall also include an additional aluminum alloy 6061-T6 washer, that shall be a four sided isosceles trapezoid with the following dimensions/characteristics:

a) The washer shall be 5/16 inch thick.

b) The upper base length shall be 1.5 inches.

c) The lower base length shall be 5 inches.

d) The base angle shall be 45 degrees.

e) The height (perpendicular distance between the upper base and the lower base) shall be 2 inches.

f) The corners of the base angle shall have a 3/16 inch radius.

g) The geometric center of this washer shall have a 1⅛ inch hole.

904.4.3 Steel Cantilever Mast Arm Assembly

1) Each steel cantilever mast arm assembly shall consist of a pole and a cantilever mast arm with various accessory items, such as plates, fasteners, end caps, anchor bolts, and a handhole with removable cover. The assembly shall be designed to support rigidly mounted signals and signs without the use of tie rods, guy wires or other supports.

2) The pole shall have a round cross section. Each pole shall be made from not more than two sections of minimum seven (7) gauge, hot rolled steel, with a minimum yield strength of 50,000 psi. Not more than two longitudinal welds and no circumferential welds shall be permitted in the pole's shaft. All poles after being formed and welded shall be "cold worked" to insure roundness and straightness of the shaft. Unless otherwise approved by the Engineer, each pole shall be uniformly tapered from the bottom to top with a maximum taper of one inch in diameter for each seven feet in length (0.14 inches per foot). Unless otherwise indicated on the drawings or specified in the contract, the total height of each standard pole shall be 19 feet and the total height of each extended

height pole shall be 28 feet. A removable corrosion resistant metal pole cap shall be provided on the top of each pole. A minimum four inch by six inch handhole reinforcing frame shall be welded into each pole, complete with a removable corrosion resistant metal cover to facilitate entry. The center of the handhole shall be located approximately 18 inches above the pole's base and at either 90 degrees or 180 degrees with respect to the traffic signal mast arm. The extended height pole shall have an additional, similar sized handhole reinforcing frame welded into each pole at the same height as and at 180 degrees with respect to the traffic signal mast arm, complete with a removable corrosion resistant metal cover attached to the pole by a chain, to facilitate entry. A grounding lug or connector shall be provided inside each pole at a location easily accessible from the lower handhole. The pole assembly shall be galvanized inside and outside and shall meet the requirements of ASTM A-123.

3) The cantilever mast arm shall have the same cross-sectional shape as the supporting pole. Each mast arm shall be made from one section of minimum seven (7) gauge, hot rolled steel, with a minimum yield strength of 50,000 psi. Only one longitudinal weld and no circumferential welds shall be permitted in the mast arm's shaft. All mast arms after being formed and welded shall be "cold worked" to insure roundness and straightness of the shaft. Unless otherwise approved by the Engineer, each mast arm shall be uniformly tapered from the butt to the outer end with a maximum taper of one inch in diameter for each seven feet in length (0.14 inches per foot). Mast arm lengths shall be specified in 2 foot even increments as shown on the drawings or as specified in the contract. Mast arms 10 feet to 40 feet in length shall be one (1) piece arms. Mast arms 42 feet to 44 feet in length may be fabricated as two (2) piece arms, joined by a bolted telescopic connection. The bolted telescopic connection shall be shown in detail on the manufacturer's approved shop drawing. A removable corrosion resistant metal arm cap shall be provided on the outer end of each mast arm. The mast arm assembly shall be galvanized inside and outside and shall meet the requirements of ASTM A-123.

4) The seam welds on the supporting pole and mast arm shall be ultra high frequency resistant or of the submerged arc process. The welds shall insure 60 percent penetration and be rated at not less than 100 per cent of the yield strength of the steel. Each seam weld shall be smooth, straight and centered on its longitudinal axis.

5) The base, pole, arm and gusset plates shall be of adequate thickness, conform to ASTM designation A-36, and have bolt spacing as specified on the County's Standard Detail Drawing C904.30, "Steel Mast Arm Assembly." The pole plate shall be tapped. All plates shall be galvanized and meet the requirements of ASTM A-123. The distance between the center of the mast arm connection and the top of the supporting pole shall be 12 inches.

6) Pole shaft, base plate, anchor bolts, mast arm, and structural connecting hardware, shall be designed in accordance with loading and allowable stress requirements of the 1994 AASHTO "Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals." Loading shall be based on an isotach wind velocity of 80 mph. Calculations and standard detail drawing shall be submitted by the manufacturer for verification of compliance to

these specifications and to the dimensions and design criteria specified on the County's Standard Detail Drawing C904.30, "Steel Mast Arm Assembly." All calculations for mast arms 10 feet to 36 feet in length shall be made with a projected area of 24 square feet and a load of 175 pounds at the end of the arm. All calculations for mast arms 38 feet to 44 feet in length shall be made with a projected area of 24 square feet and a load of 160 pounds at the end of the arm.

7) Projection of the mast arm longitudinal center line, at the outer end of the mast arm, shall not deflect below the horizontal plane. This criteria shall be met when the structure is fully loaded, i.e., 175 pounds at the end of the arm for arms 10 feet to 36 feet in length, and 160 pounds at the end of the arm for arms 38 feet to 44 feet in length. In no case shall the mast arm rise be more than 0.50 inches per foot in an unloaded condition.

8) A luminaire arm of a specified length shall be provided when indicated on the drawings or specified in the contract. The luminaire arm shall be a galvanized steel cantilever arm, with a plastic end cap bushing, and a steel bolted clamp assembly for attachment to an extended height mast arm pole.

9) Anchor bolts shall be fabricated from high strength steel having a minimum yield strength of 55,000 psi. The anchor bolts for mast arms 10 feet to 36 feet in length shall be 1¼ inches in diameter and 48 inches long, including a six inch right angle hook. The anchor bolts for mast arms 38 feet to 44 feet in length shall be 1½ inches in diameter and 60 inches long, including a six inch right angle hook. Minimum top six inches of each bolt shall be threaded. Each bolt shall be furnished with two (2) hex nuts and two (2) washers. A minimum of one foot of the threaded end of each anchor bolt and all nuts and washers shall be hot dipped galvanized and meet the requirements of ASTM A-153. All anchor bolts shall be covered with corrosion resistant metal nut covers or acorn nuts. A ¼ inch thick steel template ring or welded cross member shall be furnished with each mast arm assembly. The template ring or cross member shall have a bolt circle of the same size as the bolt circle for the anchor bolts and it shall rest upon the right angle hooks of the anchor bolts when permanently installed in the mast arm's concrete base. The use of a solid disc or plate as a template for the installation of anchor bolts will <u>not</u> be permitted.

10) Excluding anchor bolts, all fasteners with a bolt diameter of ½ inch or greater shall conform in material to ASTM A-325 and be hot dipped galvanized and meet the requirements of ASTM A-153. All fasteners with a bolt diameter less than ½ inch shall conform in material to ASTM A-307 and be electro zinc plated or conform in material to AISI 300 series and be stainless steel.

11) Each signal head installation on a mast arm shall be by one of the following methods:

a) Each signal head installed vertically on a mast arm shall be mounted using an astro-bracket with an in-line terminal compartment. A hole for wiring access shall be field drilled in the mast arm for each astro-bracket, the location of which shall be determined by the Engineer. The astro-bracket shall be banded onto the mast arm. The area between the astro-

bracket and mast arm shall be sealed with a silicon caulk. A ⅛ inch drain hole shall be drilled into each astro-bracket terminal compartment.

b) Each signal head installed horizontally on a mast arm shall be assembled using one astro-bracket with one terminal compartment. This signal head assembly shall be configured and mounted in accordance with the standard detail drawings. A hole for wiring access shall be field drilled in the mast arm to the astro-bracket providing access to the terminal compartment. The location of the hole shall be determined by the Engineer.

12) The cantilever mast arm assembly shall be handled in a manner to avoid damage to the galvanized surfaces. Any galvanized material on which the coating has been damaged shall be rejected or may, with the approval of the Engineer, be repaired in accordance with Section 712.14.

13) The Contractor shall submit to the Engineer six (6) copies of the manufacturer's steel mast arm assembly shop drawings. The shop drawings shall identify the project name and show all details which are required to adequately control the mast arm assembly fabrication. All shop drawings must be approved by the Engineer prior to fabrication; however, such approval shall not relieve the Contractor of his responsibility under the contract for successful completion of the work in accordance with these specifications. The shop drawings shall be submitted at least two weeks in advance of the Contractor's need for approval. This time requirement for approval does not relieve the Contractor of his responsibility for delivery of each mast arm assembly within the time specified on the bid forms.

904.4.4 Wood Poles, Guys and Span Wire Assembly

1) Wooden poles, as specified in Section 1050, shall be Class II wood poles or better. The length of wood poles shall be as shown on the plans. Guy wires, clamps, guards, stand off pipe, fittings, anchors, rods, concrete embedment and other items used for the installation and support of wood poles shall be included as part of the installation of Class IV wood poles.

a) Guy wire shall be ⅜ inch, high strength, 7 strand, double galvanized wire conforming to the requirements of ASTM A 475.

b) Stand off guys, when specified, shall include a 2½ inch diameter galvanized pipe with galvanized end fittings. The pipe shall be of sufficient length to allow positioning of the guy anchor at the location shown on the plans or at the location spotted in the field by the Engineer.

c) Plastic guy wire guards shall meet the current requirements of the National Electrical Safety Code, Article 282, Para. E. Guy wire guards shall be yellow and made of high density polyethylene or polyvinyl chloride (PVC) material. The material shall have excellent color retention, be ultraviolet stabilized, and have non-brittle properties. Guy wire guards shall be 8 feet long and be a full round design to cover the guy wire all around (360 degrees). The plastic guards shall be designed to resist

upward movement when installed. If clamps are utilized to resist movement, they shall be hot dipped galvanized.

d) Guy wire anchors in soil shall be 4 way, 10 inch diameter, expanding anchors with ¾ inch galvanized thimble eye anchor rods which extend a minimum of 5 feet into the soil. Guy wire anchors in rock shall be 1¾ inch expanding anchors with ¾ inch galvanized thimble eye anchor rods which extend a minimum of 2½ feet into rock.

2) Each span wire assembly shall include a ⅜ inch steel span wire from which signal heads and cable are to be suspended and a ¼ inch steel tether wire for restraining bottom movement of signal heads. Also included shall be all clamps, cable straps, insulators and other items used for a span wire assembly installation, as shown on the standard detail drawings. The span wire and tether wire shall be high strength, 7 strand, double galvanized wire conforming to the requirements of ASTM A 475. All clamps shall be fabricated from low alloy steel.

904.4.5 Power Supply Assemblies Each type of power supply assembly shall consist of a rainproof circuit breaker cabinet/panel, meter socket and all other necessary appurtenances except those furnished by the utility company or those separately listed in the contract. Each assembly shall meet the approval of AmerenUE Company and the electrical code of the Saint Louis County Department of Public Works. All bi-metal connections shall be covered with a non-curing silicon paste used for sealing, lubricating, protecting and insulating against water infiltration and arcing.

904.4.5.1 Type Mounted on Wood Pole The wood pole type power supply assembly shall consist of a circuit breaker cabinet mounted below a meter socket on the side of a wood utility pole or wood span wire pole as shown on the plans or as specified in the contract. The circuit breaker cabinet shall be a 70 ampere minimum, a single phase, three (3) wire, 120/240 volt enclosure, with two (2) single pole 50 ampere circuit breakers. The circuit breaker cabinet shall be a suitably finished type 3R rainproof metal enclosure. The meter socket shall be aluminum, a 120/240 volt, ringless, five (5) terminal, five (5) jaw, 100 ampere minimum, overhead socket with a clamped jaw manual by-pass. The bottom of the meter socket glass shall be a maximum of 5½ feet above finish grade, except over walkways where the bottom of the meter socket shall be 6½ feet above the walkway. The power supply assembly shall also include the 2 inch PVC conduit mounted on the wood pole below the circuit breaker cabinet, ground rod, bare No. 6 AWG ground wire in ¾ inch PVC, No. 6 AWG aluminum service entrance cable of sufficient length to reach utility company secondary and form a drip loop, and all power supply hardware.

904.4.5.2 Type Mounted on Steel Post with Concrete Embedment The steel post type power supply assembly shall consist of a circuit breaker cabinet mounted opposite a meter socket on the web side of a W6x9 galvanized steel post embedded in concrete. The circuit breaker cabinet shall be a 70 ampere minimum, single phase, three (3) wire, 120/240 volt enclosure, with two (2) single pole 50 ampere circuit breakers. The circuit breaker cabinet shall be a suitably finished type 3R rainproof metal enclosure. The meter socket shall be aluminum, a 120/240 volt, ringless, five (5) terminal, five (5) jaw, 100 ampere minimum, overhead socket with a clamped jaw manual by-pass. The bottom of the meter socket glass shall be a maximum of 5½ feet above finish grade,

except over walkways where the bottom of the meter socket shall be 6½ feet above the walkway. The power supply assembly shall also include the 2 inch PVC conduits mounted on the W6x9 galvanized steel post, concrete embedment with ground rod and bare No. 6 AWG ground wire, and all power supply hardware.

904.4.6 Traffic Actuated Controller A traffic actuated controller is defined as the complete assembly of all required equipment and components for actuated control of traffic signal indications for all approaches to an intersection.

904.4.6.1 Controller Cabinet Each controller shall be furnished in a weatherproof cabinet conforming to the following requirements.

904.4.6.1.1 Basic Construction

1) Controller cabinets shall be ⅛ inch reinforced sheet aluminum alloy (5052-H32). All controller cabinets shall be neat in appearance and sufficiently rugged to withstand normal usage.

2) All controller cabinets shall have all exterior and interior surfaces solvent cleaned.

3) A hinged main door shall provide complete access to the interior of the cabinet. A raintight gasket shall provide a tight fit between the door and the cabinet. (Foam Rubber Gaskets will not be accepted) The door shall be provided with a No. 2 cabinet lock. An auxiliary door, positioned on the main cabinet door, equipped with a raintight gasket, shall allow access to a switch panel and shall be equipped with a lock whose key will not unlock the main door. Two keys shall be provided for each type of lock used.

4) The door hinges and pins shall be of corrosion resistant metal. Each pin shall be a solid rod, at least ⅛ inch in diameter. If continuous hinges are furnished, the pins shall be continuous the full length of the hinges and shall not be less than 1/16 inch diameter. Each door hinge shall be rigidly fastened to both the cabinet and the door. Fastening of hinges with sheet metal screws shall not be acceptable.

5) The main cabinet door shall be equipped with at least a two position stop and catch arrangement to hold the door open at positions of 90 degrees and 180 degrees, plus or minus 10 degrees.

6) The cabinet shall contain a minimum of three (3) strong reinforced mounting shelves to adequately accommodate the mounting and weight of the controller unit and all necessary ancillary equipment. The mounting facilities shall permit the controller unit and/or ancillary equipment to be withdrawn from the cabinet for inspection or maintenance without breaking any electrical connections or disrupting operation of the intersection. Screws used for mounting shelves or other mounting purposes (i.e., panels, wiring terminals, etc.) shall not protrude beyond the outside wall of the cabinet.

904.4.6.1.2 Size and Mounting

1) The controller cabinet shall provide space for housing all equipment and components. The size of the controller cabinet shall be as shown on the plans or as specified in the contract.

2) The controller cabinet shall be ground mounted.

a) Mounting flanges for bolting each ground mount cabinet to a Type D concrete base shall be located inside the cabinet along the bottom perimeter. Mounting flanges located outside a ground mount cabinet shall not be acceptable.

b) Anchor bolts for ground mount cabinets shall conform to ASTM A-307 and have a minimum yield strength of 36,000 psi. The bolts shall have a diameter of either ⅝ inches or ¾ inches and be 18 inches long, plus a right angle hook having a minimum length of 2 inches. The bolts shall extend a maximum of 2½ inches above the cabinet base and be threaded. Each bolt shall be furnished with a hex nut and washer. All anchor bolts, nuts and washers shall be hot dipped galvanized and meet the requirements of ASTM A-153.

904.4.6.1.3 Ventilation

1) Each controller cabinet shall have an adjustable thermostatically controlled ventilating fan installed in the top of the cabinet. The fan shall have an exhausting capability, in an enclosure, of at least 100 cubic feet per minute. A ¼ inch mesh screen shall be installed inside the cabinet as a guard covering the vent fan blades. The thermostat controlling the fan shall be manually adjustable to turn on between 90 degrees F (32 degrees C) to 150 degrees F (66 degrees C) with a differential of not more than 10 degrees F (5.5 degrees C) between automatic turn-on and turn-off. An easy to read dial setting calibrated in degrees shall be provided.

2) Each controller cabinet shall be supplied with a replaceable furnace type fiberglass filter mounted behind louvers and in the lower one fourth of the cabinet door or sides. The acceptable standard size filter to be provided shall depend upon the type of controller cabinet mounting and be as described below:

a) In a ground mount controller cabinet, a 12 inch x 16 inch x 1 inch replaceable furnace type fiberglass filter shall be provided.

904.4.6.1.4 Special Switches, Sockets and Outlets All switches shall be permanently marked so that their identity and operation shall be readily apparent.

1) Each cabinet shall have only a two (2) position SIGNAL - FLASH switch mounted on the switch panel behind the auxiliary door to the main cabinet door. The switch shall be labeled as SIGNAL and FLASH. The two (2) positions of the switch and their functions are described below:

a) **SIGNAL** - Power is supplied to the signal lights and their operation is controlled by the controller unit.

b) **FLASH** - Signal lights are controlled by the flasher unit. The controller unit is operating with stop timing introduced. This stop timing shall be removed by either setting this switch back in the SIGNAL position or as specified below in Section 904.4.6.1.4(2). An input shall be put into the controller unit through the "D" harness, to show a local flash alarm.

2) Each cabinet shall have a switch provided inside the cabinet to put the signal lights into flashing operation with the controller unit remaining in operation without stop timing being introduced. Access to this switch shall be attainable only by opening the main cabinet door. This switch shall remove stop timing if it was previously introduced by the FLASH switch behind the auxiliary door.

3) Each cabinet shall have a switch provided inside the cabinet in an unobstructed area to remove power from the controller unit and conflict monitor unit only without interrupting power to other controller features. Access to this switch shall be attainable only by opening the main cabinet door.

4) Separate push button momentary switches, with normally open contacts, shall be provided inside the cabinet in an unobstructed area to put calls into the controller unit for each actuated vehicle and pedestrian phase. If preemption phasing is shown on the plans or purchase order then a push button shall be provided for each preemption sequence. The test push buttons shall feed a logic ground to the controller unit.

5) Each controller cabinet shall have a ground fault circuit interrupter (GFCI) duplex outlet in an unobstructed area inside the cabinet. An 18 inch fluorescent light fixture with a cold weather ballast and a lamp rated at 15 watts and 120 volts shall be provided inside the front of the ground mounted cabinet above the main door with a switch mounted so that the light will be turned off when the main door is closed. Two (2) heat lamp sockets controlled by a thermostat which turns the lamps on at 40 degrees F (4 degrees C) and off at 60 degrees F (16 degrees C) shall be provided. A lamp rated at 150 watts, 120 volts shall be supplied with each socket.

904.4.6.2 Panel Wiring, Circuit Breakers and Relays

1) All wiring inside the cabinet shall be stranded and shall be neatly bundled and secured with plastic cable ties. Copper barrel lugs shall be provided for all field connections inside the controller cabinet. Insulated crimped-on connectors, one per wire, of an approved type shall be used for all other panel connections. The outgoing signal circuits shall be the same polarity as the line side of the power supply, and the common return of the signal circuits shall be the same polarity as the ground side of the power supply. The power supplied shall be provided through two single conductor cables unless otherwise indicated. 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. Sufficient terminals shall also be provided on the ground bus bar for the common return of all field and panel connections.

2) Each cabinet shall be furnished with easily accessible wiring panel(s) of all metal construction sufficiently rugged to withstand normal usage. Unless otherwise approved by the Engineer, the back panel shall be so constructed, mounted, and wired so as to allow the panel to be swung forward and down to facilitate access to back wiring, without removing equipment or shelves. The back panel shall be mounted a minimum of 4 inches from the bottom of the cabinet. As a minimum, the following barrier type terminal strips shall be provided on the panel(s):

a) Terminals for all incoming power lines.

b) Terminals and bases for signal load switches and outgoing field circuits. The following minimum number of load switch bases with sufficient terminals shall be provided:

Size by Phase Designation	**Min. No. of Load Switch Bases**
Two Phase	4
Four Phase	8
Eight Phase	12

c) Terminals and bases for all flash transfer relay(s) and outgoing signal field circuits.

d) Terminals for all sensor and detector cables.

e) Terminals for all required auxiliary equipment.

f) Terminals for all special circuits which may be required to provide the operation shown on the signal plans.

3) All terminals shall be permanently marked so that their identity may be readily apparent.

4) A surge arrestor shall be provided to block high speed transients and remove high energy surges from the incoming AC lines. The arrestor shall be designed for a peak current of 20 KA and a clamping voltage not to exceed 340 volts during surge. The arrestor shall provide protection from main neutral to ground as well as main line to ground. The surge arrestor shall be equal to EDCO #SHP 300-10.

5) A minimum 30 ampere line filter shall be installed on the incoming power line after the 30 ampere circuit breaker.

6) An eight position outlet power strip including three (3) positions for transformers that are spaced far enough apart as to not block or cover the remaining outlets positions shall be provided, and installed. The outlet strip shall be mounted on

the side of the cabinet where the power panel is located. The outlet strip shall be hard wired to a two position terminal block. The outlet strip shall also be hard wired to the load side of the line filter using 14 AWG wires. The outlet strip shall have the following specifications:

a) Shall have a minimum of 1900 joules AC surge suppression

b) 15 amp circuit breaker

c) Diagnostic LED confirming outlet grounding and surge suppression status

7) The following minimum number of flashing field circuits complete with flash transfer relays shall be provided:

Size by Phase Designation	**Min. No. of Flashing Field Circuits**
Two Phase	2
Four Phase	6
Eight Phase	8

All indications that are to be flashed on any single approach shall flash simultaneously. The load shall be equally distributed between the two outputs of the flasher whenever feasible. An unbalanced flashing load shall be subject to the approval of the Engineer.

8) The transfer relays that control the switching operation between the control mechanism and the flasher unit shall be designed to carry 10 amperes (tungsten filament load) per contact set. The socket for each flash transfer relay shall be equal to BEAU 5400 Series socket or TRW Cinch 2400 Series socket. All wiring must be soldered to sockets; push on terminal lugs are not allowed.

9) The signal bus shall be connected to the incoming AC+ through a signal bus mercury contactor and be designed to carry a 30 ampere load. The current ratings specified are computed with a tungsten filament load. The signal bus mercury contactor shall be energized to provide power to the signal bus.

10) Signal circuits shall not be controlled by relays. However, other circuits which require control by relays shall have relays which plug into an octal socket composed of high dielectric phenolic insulator material and cadmium plated brass contact material. The pin configuration of each socket shall be as follows:

Pin 1 ..... Moveable Contact	Pin 5 ..... N. C. Contact
Pin 2 ..... Relay Coil	Pin 6 ..... N. O. Contact
Pin 3 ..... N. O. Contact	Pin 7 ..... Relay Coil
Pin 4 ..... N. C. Contact	Pin 8 ..... Moveable Contact

Pins 1, 3, and 4 shall constitute one contact set, and pins 5,6, and 8 shall constitute the other set. The relay contacts shall have a current rating of 1200 watts minimum per contact set, computed with a tungsten filament load.

11) The electrical connection(s) to the controller unit i.e. connectors A, B, and C, shall be made with quarter turn MS connector(s) as specified in the latest edition and revision of NEMA Standards Publication No. TS 2 Type 2, Traffic Control Systems.

12) The wiring harness(es) and harness connector(s) to the controller unit shall be complete, thereby including wiring for every pin in each connector.

13) A 15 ampere circuit breaker shall be provided to remove power from the cabinet light and ground fault circuit interrupter (GFCI) duplex outlet. A 30 ampere circuit breaker, with input in parallel with the above 15 ampere circuit breaker, shall be provided to remove all other incoming power. Each circuit breaker shall have an "On-Off" switch.

14) Original mylar drawing(s) of the controller wiring diagrams for each signal installation and/or signal system, or a computer disc with this information stored in a format compatible with MicroStation software shall be provided. The controller wiring diagrams shall be prepared on neat and clean 24 inch x 36 inch mylar sheet(s) or on a computer disc. The diagrams shall be easy to read and match the cabinet wiring. All controller wiring diagrams shall be double referenced.

904.4.6.3 Controller Phase Requirements The phasing and interval sequence to be provided shall be as shown on the plans or as specified in the purchase order.

1) When the plans or purchase order specify a two phase actuated controller, an eight phase actuated controller unit shall be provided in the size cabinet specified and be completely wired for two phases.

2) When the plans or purchase order specify a four phase actuated controller, an eight phase actuated controller unit shall be provided in the size cabinet specified and be completely wired for four phases.

3) When the plans or purchase order specify an eight phase actuated controller, an eight phase actuated controller unit shall be provided in the size cabinet specified and be completely wired for eight phases.

904.4.6.4 Actuated Controller Unit Features The controller unit shall be a fully actuated controller unit with a full complement of operational, programming, and diagnostics capabilities. The controller unit shall meet or exceed both NEMA TS-1 1989 and TS-2 2003 Actuated Controller Unit Standards. The controller unit shall have a LCD alphanumeric backlit display unit (8-line 40 character/line). Programming shall use English language menus. The Controller can also be utilized as a master control unit using master software. An external 10 base-T Ethernet port with configurable IP shall be built in. 8MB of flash memory shall be required to retain all timing and control parameters even during power outages. The controller unit shall be capable of 16 vehicle phases, 16 pedestrian phases, 4 timing rings, 16 overlaps, 80 detectors, adaptive maximum routines, adaptive protected/permissive routines, coordination virtual split routine, diagnostics & status displays, and reports.

904.4.6.4.1 Controller Unit Functional Standards The following controller unit functional standards are required in addition to those specified in the latest edition and revision of NEMA Standards Publication No. TS 2 Type 2, Traffic Control Systems.

1) Each vehicle phase provided shall have volume-density capability.

2) Dual ring controller units shall have the capability of dual entry operation without the use of external logic.

904.4.6.4.2 Controller Unit Connector Pin Designations Unless otherwise specified, all designated pins of the controller unit connectors shall be internally wired. The manufacturer shall not be allowed to internally wire the Reserved, Spare, and Test Input pins for any special use, unless otherwise approved by the Engineer.

904.4.6.4.3 Controller Unit Assembly Requirements The actuated controller unit shall conform to the physical standards, as specified in the latest edition and revision of NEMA Standards Publication No. TS 2 Type 2, Traffic Control Systems, and to the assembly design requirements specified herein:

1) The controller unit shall be designed for placement on a shelf.

2) The front panel(s) of the controller unit shall be permanently marked to identify the fuses, indicators, switches, controls, etc., so that the operation of each shall be readily apparent.

3) The controller unit shall be designed utilizing microprocessor based technology.

4) The controller unit shall be modular by design. Modules shall be positively fastened to the frame and easily removed and replaced without the use of any special tools. An upper and lower guide or track shall be provided for each module assembly in the controller unit chassis. All modules of unlike function shall be mechanically keyed to prevent insertion into the wrong opening and subsequent damage to the controller unit.

5) All connectors shall be front panel mounted.

6) All switching functions shall be accomplished by fully solid state electronic circuitry.

7) The controller unit shall utilize MOS integrated circuits for all logic functions, unless otherwise approved by the Engineer.

8) Timing shall be entered by a front panel keyboard and by computer. Easy to read keys shall provide either tactile or audio feedback.

9) Menu driven programming shall be provided utilizing traffic engineering terminology prompts. Within a menu, each parameter shall be viewed for simple cursor control of data entries. Adding or changing data entries and instructions shall be accomplished without the use of an access code.

10) During a power failure, no batteries shall be required to retain memory.

11) A minimum 8 line by 40 character, alpha-numeric, liquid crystal display shall be provided on the front panel of the controller unit. The display shall have adjustable contrast settings providing easy to read displays under all lighting conditions. The display shall provide comprehensive visibility of program entries, operational parameters, controller units, and the status of intersection operation.

12) All component parts and terminals shall be readily accessible when the boards are removed from the enclosure for adjustments, testing or maintenance.

13) All wiring for input and output functions shall be terminated on panel terminal strips.

14) Controller units shall have the capability to log and display critical alarms on the unit display.

904.4.6.4.4 Coordination

1) Coordination shall be an internal controller unit function which shall make it possible to incorporate actuated controllers into a coordinated system without seriously impairing individual controller flexibility.

2) The controller unit of each actuated secondary controller shall have internal coordination which, if interconnected, shall respond to the individual cycle, reset, and mode of operation imposed by centrally located direct connect system or local Master Controller. The internal coordination of each actuated secondary controller shall impose control only upon the intersection where it is located.

3) The controller unit of each actuated Master Controller shall have internal coordination which, if interconnected, shall supervise all pretimed and actuated secondary controllers within the system. The internal coordination of each actuated master controller shall also impose control upon the intersection where it is located.

4) Coordination settings shall be entered and adjusted by the controller unit front panel keyboard without the use of an access code.

5) Actuated controller units shall have internal coordination with the capability of being interconnected by the following methods:

a) Time base coordination.

b) Fiber Optic

c) Ethernet

6) Unless otherwise approved by the Engineer, internal coordination in actuated controller units shall have, as a minimum, the following functional features:

a) Four (4) adjustable cycle lengths.

b) Three (3) offsets per cycle.

c) Four (4) splits per cycle.

d) Sync. monitor.

e) Shortway offset seeking.

f) Automatic permissives/force-offs.

7) Unless otherwise approved by the Engineer, internal coordination in actuated controller units shall have, as a minimum, the following capabilities:

a) Cycle length transfer.

b) Reset transfer.

c) Fully actuated operation.

d) Semi-actuated operation.

e) Fixed cycle length operation.

f) Free operation.

g) Permissive Mode

h) Yield Mode

i) Permissive Yield Mode

j) Permissive Omit Mode

k) Sequential Omit Mode

l) Full Actuated Mode

8) Manually selecting any individual cycle, reset, or mode of operation in either actuated secondary or master controllers shall be achieved by utilizing the controller unit front panel keyboard.

904.4.6.4.5 Time Base Programming

1) Time base programming shall include 250 Events for the control of Pattern Selection, Free, Flash, Dimming, Detector Diagnostic Parameters, System Detector Logging, 3 Auxillary Functions, 8 Special Functions, 16 Traffic Functions, 99 Day Programs, and 10 Week Programs.

2) Time base programming shall be an internal controller unit function which shall provide coordination in a signal system by establishing an extremely accurate time base that is uniform with all other time base coordinators in the system.

3) All time base programming instructions, including time of day, day of week, and the operation of each output function, shall be entered and adjusted by the controller unit front panel keyboard without the use of an access code.

4) Changeover from standard time to daylight saving time, or vice versa, shall be accomplished automatically. Once the current year and week of year are entered, the changeover shall be accomplished at 2:00 a.m. on the Sunday morning specified by the present law.

5) Automatic leap year adjustment shall be provided.

6) A capacitor back-up system shall be provided for maintaining timekeeping when 120 volts AC power is not available. This back-up system shall maintain timekeeping intact for not less than 48 hours when fully charged, and shall go on line automatically upon failure of the primary power. When operating on the back-up system, the timing accuracy shall be plus or minus 4 seconds per 24 hours at worst case. Upon resumption of the primary power, the time base coordinator outputs shall immediately assume the configuration in which they would have been had power not been interrupted.

7) The controller unit shall display the following as a minimum:

- **a)** Time of day, either on a 24-hour format or a 12-hour (am/pm) format.
- **b)** Day of week.
- **c)** Status of each output (active or inactive).
- **d)** Cycle length in effect in seconds.
- **e)** All data required to verify programming prior to entry of an instruction.

8) During operation on the back-up system, the display shall be dark to conserve back-up power. The display shall be clearly illuminated during operation from the AC power line.

904.4.6.4.6 Preemption

1) Preemption shall be an internal controller unit function. The controller unit shall be capable of providing a minimum of six (6) preemption sequences.

2) All controllers shall be wired for preemption input and output functions from the controller unit to the back panel terminal strips.

3) Preemption field wiring, relay(s), and a test push button for each preemption sequence shall be provided when preemption phasing is shown on the plans or purchase order.

4) Upon actuation of preemption, the color sequence(s) specified shall be provided. After the preemption phase(s) have been released and cleared, normal operation shall be automatically resumed to the phase specified.

5) Each interval of preemption shall be entered and adjusted by the controller unit front panel keyboard without the use of an access code.

6) The controller unit shall display when a preemption sequence is actuated and when a preemption sequence has been released and cleared. The controller unit shall also display the status and value of each preemption phase and interval.

904.4.6.5 Conflict Monitor An external solid state conflict monitor shall be provided as a standard cabinet feature and be capable of handling the total circuits provided. The conflict monitor shall comply with the latest edition and revision of NEMA Standards Publication No. TS 2 Type 2, Traffic Control Systems. The monitor shall include a full intersection Liquid Crystal Display (LCD) along with the ability to communicate with a computer. Monitor status, event logs, and signal sequence history logs shall be stored in nonvolatile memory for diagnostic and archival purposes. In the event of any incompatibility, the NEMA Standards shall be superseded by the provisions described herein.

1) Unless otherwise approved by the Engineer, only Type 6 and Type 12 conflict monitors shall be acceptable. As a minimum, the following type conflict monitors shall be provided:

Size by Phase Designation	Minimum Acceptable Type Conflict Monitor
Two and four phase *	Type 6 (6 input channels)
Eight phase	Type 12 (12 input channels)

* If special sequencing is used, a Type 12 conflict monitor may be required.

2) The conflict monitor shall utilize MOS integrated circuits for all logic functions, unless otherwise approved by the Engineer.

3) If a conflict exists, the conflict monitor shall cause the signals to go into emergency flash operation with stop timing applied simultaneously to the controller unit and an input shall be put into the controller unit through the "D" harness to show a conflict flash alarm. When the actual conflict has been cleared, a reset switch (front mounted) in the conflict monitor shall return the controller to normal operation when depressed.

4) The conflict monitor shall be programmed by soldering jumpers on a printed circuit board for those inputs which are considered compatible. Unless otherwise approved by the Engineer, this programming board shall be interchangeable among manufacturers and be as described in the latest edition and revision of NEMA Standards Publication No. TS 2 Type 2, Traffic Control Systems.

5) Unless otherwise approved by the Engineer, the conflict monitor must be capable of providing a visual indication of the following:

a) Unsatisfactory operating voltages.

b) Conflict.

c) Red failure.

d) Channels involved in conflicting signal indications.

e) Channel(s) involved in red failure.

f) LCD display of field indications.

6) Additional connector(s) on the conflict monitor (i.e., other than the standard NEMA connectors and communications ports for the controller unit or computer) shall not be allowed, unless otherwise approved by the Engineer.

7) The conflict monitor shall be enclosed in a suitable finished case, be located on a shelf or partial shelf within the controller cabinet, and have an integral power supply capable of handling the monitor's requirements.

8) All unused conflict monitor unit wires shall be terminated on an easily accessible terminal block located on the back panel and all unused red inputs shall be tied to the signal buss power.

904.4.6.6 Solid State Load Switches

1) Provide a separate load switch for each vehicular phase, overlap, and pedestrian phase to switch power to all signal lamps required for the signal phasing shown on the drawings or as specified in the purchase order, including phases specified for future controller expansion. All load switches shall comply with the triple-signal solid state type load switch as specified in the latest edition and revision of NEMA Standards Publication No. TS 2 Type 2, Traffic Control Systems. The load switches shall be capable of handling a tungsten-lamp load of 10 amperes per circuit. All load switches shall have optically isolated solid state relay outputs. Dual signal type load switches shall not be allowed.

2) The number of load switch bases to be provided shall be as specified in Section 904.4.6.2(2).

3) Light emitting diode indicators shall be provided on the load switches to monitor the load switch inputs.

904.4.6.7 Flash Operation

1) Each controller shall be capable of dual flash operation. Dual flash is defined as follows:

a) Internal time base or interconnect flash operation, which flashes Yellow-Red.

b) Emergency flash operation (conflict monitor, police door, etc.), which flashes as follows:

Intersection Signal .....Flashes Red-Red

Pedestrian Signal ..... Flashes Yellow

Fire Station Signal .....Flashes Yellow-Red

Emergency flash operation shall override time base or interconnect flash operation.

2) Each controller shall be capable of being placed in flash operation by either an interconnect line or an internal time base.

3) The transition from normal operation to interconnect or internal time base flashing operation, and vice versa, shall be in accordance with the current edition and latest revisions of the Manual on Uniform Traffic Control Devices.

4) In each controller the above transitions to and from interconnect line or internal time base flash operation shall be accomplished internally to the controller unit. Programmed flash is Yellow-Red.

5) Flash operation shall also be obtained manually by utilizing either one of the two switches specified in Section 904.4.6.1.4. The flash transfer shall occur immediately and override interconnect line or internal time base flash.

904.4.6.8 Solid State Flasher Unit The flasher unit shall be provided as a standard cabinet feature and be completely solid state and utilize digital design techniques. The flasher shall comply with the latest edition and revision of NEMA Standards Publication No. TS 2 Type 2, Traffic Control Systems.

1) Each flasher shall be a Type 3 dual circuit flasher, capable of handling a tungsten-lamp load of 15 amperes per circuit at a temperature of 165 degrees F (74 degrees C).

2) The design shall be such as to simplify repair, utilizing only standard electronic components.

904.4.6.9 Traffic Signal Battery Backup Flash System The battery backup unit (BBU) shall be provided as a standard cabinet feature at all intersection signals. It shall be capable of providing power for signal operation for two hours or when 40% battery capacity is reached before putting the signal into emergency flash operation. The system shall be compatible with LED signal heads from different manufacturers.

1) The BBU shall have a minimum output rating of 1000 VA at 700 watts. The output voltage shall be no less than 115 VAC and no more than 120 VAC and the output frequency shall be a regulated 60-hertz sine wave. The BBU shall operate in a temperature range of -22 degrees F to 165 degrees F.

2) The minimum battery voltage will be 48 VDC using four 12VDC 33 amp hour batteries in plastic battery boxes, two batteries to a box. The battery charger shall be temperature compensated.

3) When the AC line has failed, the BBU will supply power to keep the signal in operation for two hours or when 40% battery capacity is reached before putting the signal into emergency flash by breaking the controller voltage monitor input to the conflict monitor unit. The two-hour set point and the 40% battery power set point shall be user settable through the serial communications port. When the unit is running on battery operation, power will still be supplied to all equipment in the controller cabinet powered by the 30 amp circuit breaker.

4) The front panel shall display battery charging, low battery or battery fault, unit processor fault, and unit running on battery. There will be dry contact outputs that mimic the front panel display. The output for running on battery will be wired to put an alarm into the controller unit when installed in a system cabinet.

5) The unit shall have an RS232 serial port that allows a technician to connect to and monitor the BBU. All of the information available on the local displays will also be available on the serial port. The serial port will also be used to make adjustments to operating parameters of the unit as needed. The serial port connections and terminal set up shall be included in the Operators Manual.

6) A manual bypass switch shall be installed to keep power supplied to all equipment should the unit require service. Power to the bypass shall come from the output of the 30 amp circuit breaker.

904.4.6.10 Unmanaged Switch An environmentally hardened, extreme environment, unmanaged network switch with internal power supply shall be provided as a standard cabinet feature at all traffic signals. The switch will have a minimum of two SLC-type 100mb ports, and four 10/100 RJ45 switch ports, with the ability to support auto-cross, and auto negotiation. The printed circuit board will have a 5 mil thick silicone coating for protection against moisture.

904.4.6.11 Single Mode Fiber Optic Patchcord Singlemode patchcord(s) shall be Communication Supply Corporation part number 478727 or equivalent as approved by the engineer with the following characteristics:

1)	Nominal Diameter:	8.2 µm
2)	Number of Fibers:	2 (ZIPO)
3)	Connectors:	Ceramic ST Connectors to Ceramic LC Connectors
4)	Length:	≤ 2 meters

904.4.6.12 Approval of Controller Equipment In order for manufacturers' controller equipment, including panel wiring, to be approved, the following requirements must be fulfilled, unless otherwise approved by the Engineer.

1) The manufacturers' equipment within the controller cabinet, including panel wiring, must satisfactorily meet the specifications as described herein.

2) The manufacturers' equipment within the controller cabinet must have been previously tested with satisfactory results by the St. Louis County Department of Highways & Traffic. It shall be the prerogative of the St. Louis County Department of Highways & Traffic to determine whether a new model of previously approved equipment will be accepted without retest.

3) Prior to approval of equipment within the controller cabinet, the Engineer shall be provided with a certification(s) by an independent testing laboratory stating that the equipment complies with the latest edition and revision of NEMA Standards Publication No. TS 2 Type2, Traffic Control Systems.

4) The manufacturers' equipment within the controller cabinet, including panel wiring, must meet the subjective approval of the St. Louis County Department of Highways & Traffic concerning the following:

a) Appearance (suitable size of equipment, ease of reading functions and displays, neat arrangement of wiring panels).

b) User friendly (ease of programming, accessibility for monitoring).

c) Technician compatibility (ease of maintenance, convenient board testing and removal, state of the art board layout and design, accessible wiring panels).

904.4.7 Auxiliary Equipment for Controllers Auxiliary equipment shall consist of separate devices used to add supplementary features to a controller assembly. Each auxiliary unit mounted inside the controller cabinet shall be enclosed in a suitable finished case that is neat in appearance and sufficiently rugged to withstand normal usage. The function of each auxiliary unit shall be permanently marked by an identification plate on the case. All auxiliary equipment shall be designed to operate satisfactorily between 95 volts AC and 135 volts AC and -30 degrees F (-34 degrees C) to 165 degrees F (74 degrees C) ambient temperature. Approval of auxiliary equipment shall be in accordance with the requirements of Section 904.4.6.12.

904.4.8 Detectors

904.4.8.1 Pedestrian Push Button Detector The pedestrian push button detector shall be vandal resistant, pressure activated piezo type, with momentary LED and audible alert using existing 2 conductor switch wires. The detector shall be a removable contact assembly mounted in an aluminum rectangular case. The operating voltage shall not exceed 24 volts. The back of each case shall be designed for mounting to a round pole. A ½ inch opening for cable shall also be provided in the back of each case. Holes shall be formed in the assembly case for mounting the push button unit. The operating button shall be sturdy, secure against electrical shock to the user, and of such construction as to withstand continuous hard usage. The push button case shall have a natural aluminum finish. Push buttons shall be mounted forty-two (42) inches above the ground.

904.4.8.2 Vehicle Inductive Loop Detection System

904.4.8.2.1 Card Rack Mounted Type This type of vehicle inductive loop detection system shall have two (2) channels per card, be rack mounted, and be designed to employ digital techniques to the fullest extent. Card rack mounted inductive loop detectors shall be Type 7T detectors with relay outputs and comply with the latest edition and revision of the NEMA Standards Publication No. TS 2 Type 2, Traffic Control Systems. In the event of any incompatibility, the NEMA Standards shall be superseded by the provisions described herein.

1) The number of detector cards to be provided shall be as specified in the contract or shown on the plans.

2) When card rack mounted type inductive loop detectors are shown on the plans, the following minimum number of two-channel detector card positions shall be provided in the detector rack(s):

Size by Phase Designation	Min. No. of Detector Card Positions Provided in Detector Rack(s)
Two Phase	2
Four Phase	4
Eight Phase	8

Unless otherwise shown on the plans, detector card rack(s) shall not be required in controller cabinets used exclusively for fire station signals.

3) The following number of integral detector power supplies shall be provided in the detector rack(s):

Size by Phase Designation	**No. of Integral Power Supplies in Detector Rack(s)**
Two Phase	1
Four Phase	1
Eight Phase	2

Each power supply shall be mounted on the left side of the detector cards it powers (front view) and be capable of supplying the power requirements of the detector card units.

4) The rack(s) shall be neat in appearance, and sufficiently rugged to withstand normal usage with each opening properly labeled. All hardware functions shall be permanently marked so that their identity and operation is readily apparent. The card rack shall be permanently and neatly wired in the cabinet (no removable connectors from the card rack to the back panel). There shall be enough slack in the wiring so the rack can be removed from the shelf and the back accessed without having to remove any wiring from the card rack or the back panel. Printed circuit boards shall not be accepted as part of the card rack assembly.

5) The detector card units shall utilize MOS integrated circuits for all logic functions, unless otherwise approved by the Engineer.

6) Adjustable, digital timed delay capability with delay override and call extension shall be incorporated on each channel of each detector card.

7) Each channel on each detector card shall be self-tuning.

8) Each channel on each detector card shall have a relay output with the relay coil energized for the "no call" condition.

904.4.8.3 Overhead Vehicle Video Detection Systems

904.4.8.3.1. Camera System with Internal Processor The number of cameras to be provided for each intersection overhead vehicle video detection system shall be as specified in the contract or shown on the plans. The camera system shall include fixed video camera(s), each with an internal Machine Vision Processor (MVP) sensor, a MVP cable and a universal mounting bracket. The camera system shall also include a communications interface panel(s), a power transformer panel(s), a detector port master, and a color monitor with a four-channel video switching unit, all of which shall be placed in the controller cabinet. The system shall be capable of producing accurate adjustable detection zones for individual lanes in all weather and lighting conditions. The system shall be equivalent to the Solo Terra manufactured by Autoscope, as approved by the Engineer.

1) Each camera shall be weatherproof and designed for outdoor use. The MVP sensor video camera shall combine an integrated high-speed, color imaging CCD array with zoom lens optics, image-processing hardware and a general-purpose CPU bundled into a sealed enclosure. The sensor shall be equipped with a sunshield to reflect solar heat and to shield the CCD array and faceplate from direct exposure to the sun. The sensor shall also be equipped with a faceplate heater to melt accumulated ice, snow, or condensation from obscuring the view of the camera.

2) The MVP sensor shall be an integrated imaging color CCD array with zoom lens optics, high-speed, dual-core image processing hardware bundled into a sealed enclosure. The CCD array shall be directly controlled by the dual-core processor, thus providing high-quality video for detection that has virtually no noise to degrade detection performance. It shall provide JPEG video compression as well as standard MPEG-4 digital streaming video with flashing detector overlay. The MVP shall provide direct real-time iris and shutter speed control. The MVP image sensor shall be equipped with an integrated 22x zoom lens that can be changed using either configuration computer software. The digital streaming video output and all data communications shall be transmitted over the three-wire power cable.

3) Each communications interface panel shall support up to eight MVPs. The communications interface panel shall accept 110/220 VAC, 50/60 Hz power and provide predefined wire termination blocks for MVP power connections, a Broadband-over-Power-Line (BPL) transceiver to support up to 10MB/s interdevice communications, electrical surge protectors to isolate the modular cabinet interface unit and MVP sensors, and an interface connector to cable directly to the modular cabinet interface unit.

4) One transformer to supply 24 VAC power to four MVP sensor video cameras shall be provided on an external panel as part of the communications interface equipment.

5) The detector port master provides a simple, reliable interface between any standard traffic controller and up to eight MVP sensors. It monitors phase colors and gathers detection information. The detector port master is a single-card device that can stand alone or slide easily into a detector rack. Its advanced microcontroller-based communication circuitry passes real time detection states or traffic alarms as discreet detector outputs to a traffic controller. The real time detector outputs from the rear edge connector or front connector shall be fully compatible with existing loop detector systems. A 25 pin I/O harness shall also be furnished with each unit and be compatible with the front connector on the unit. The detector port master may also be inserted into a detector rack solely for power.

6) A 10-inch color monitor shall be provided to observe the operation of the vehicle video detection zones. The monitor shall have a minimum of 280 TV lines of resolution. The monitor must incorporate a universal power supply, allowing it to be compatible with a voltage range of 90 - 260 VAC (50/60 Hz). The power supply must be regulated to maintain excellent performance during fluctuations in line voltage. Power consumption must not exceed 50 watts. The monitor

must have two looping composite video. The video inputs must have auto termination circuitry. All user controls shall be conveniently located on the front panel and must include sharpness, tint, color, bright, contrast, volume +/-, input selection, and power on/off. The monitor must also have an indicator light for power. The monitor must have a heavy duty metal cabinet to protect the CRT and circuitry. The monitor must be able to operate to full specifications within the normal temperature range of 0 degrees to 40 degrees C (32 to 104 degrees F).

7) A four channel video switching unit with quad output shall be provided to allow video from four cameras to be shown on the color monitor either individually or simultaneously.

904.4.9 Closed Loop System Equipment

1) The closed loop master controller shall manage, control, monitor and collect data for up to 32 intersections. It shall be able to compute, control and supervise the program selection for two independent groups. It shall provide monitoring and reporting of conditions for each new and/or existing local controller and be compatible with said local controllers. It shall allow for master and local programming from remote locations. It shall be capable of handling 64 system detectors, 48 coordination patterns, and 16 timing plans with 3 offsets per timing plan. It shall be capable of providing traffic responsive plan selection. It shall be Ethernet compatible and include one internal fiber optic modem, or FSK modem, as specified. The use of two or more masters to accomplish these features shall not be allowed.

2) Each closed loop local controller shall be Ethernet compatible and include one internal fiber optic modem, or FSK modem, as specified.

3) The closed loop master monitor shall be capable of monitoring multiple systems. It shall receive and log data reports. It shall receive reports of critical alarms via modems from system masters. It shall interpret and relay to a paging system the master location, local intersection location, type of alarm and time of alarm. It shall be capable of printing the alarms at a central location.

4) An external modem shall be provided. This modem shall be equivalent to a U.S. Robotics 56K Faxmodem, Model No. USR5686E. The modem shall be compatible with Windows: XP, NT 4.0, 2000, ME, 98, and 95B, Standards and Protocols Supported: V.92 ITU, V.90 ITU, V.34 33.6 Kbps ITU.

904.4.10 Fiber Optic Termination Housing The housing shall be suitable for under shelf mounting (to be mounted between the top of the back panel, and the bottom shelf) and be capable of mounting a minimum of 24 hub ST type connectors. A minimum of 24 multimode ST type connectors shall be installed in the housing. The housing shall have a splice tray kit capable of a minimum of 30 splices. It shall be capable of housing up to 48 fibers and provide for the stacking of fibers. It shall also have ample room for feed through cable and provide strain relief for multiple cables within the unit.

904.4.11 Vehicle Video Detection Camera Mounts

904.4.11.1 Camera Mount on Luminaire Arm Each steel luminaire arm assembly for mounting a camera out from an extended height mast arm pole shall consist of a galvanized steel cantilever arm of a specified length. This assembly shall include a plastic end cap bushing and a steel bolted clamp for attachment to an extended height mast arm pole. A universal mounting bracket, for mounting a camera to the luminaire arm, shall be furnished with each camera.

904.4.11.2 Camera Mount on Post Extension Each post extension assembly for mounting a camera higher than a mast arm pole shall consist of a 14 foot straight continuous Schedule 80 extruded aluminum pipe, with a 4½ inch nominal outside diameter. The post shall be equal to aluminum alloy 6061-T6 and have a spun finish. This assembly shall include a removable aluminum post cap, with stainless steel set screws and mounting brackets for attachment to a mast arm pole. A universal mounting bracket, for mounting a camera to the post extension, shall be furnished with each camera.

904.4.11.3 Camera Mount on Mast Arm Each pipe assembly for mounting a camera to a mast arm shall consist of a 6-foot straight continuous Schedule 40 extruded aluminum pipe, having a 1½ inch nominal pipe size. The pipe shall be equal to aluminum alloy 6061-T6 and have a natural aluminum finish. This assembly shall include a plastic end cap, an astro-bracket for attachment to a mast arm, and a bracket for mounting a camera to the top of the pipe assembly.

904.4.12 Pan Tilt Zoom (PTZ) Internet Protocol Video Surveillance Camera

904.4.12.1 PTZ Surveillance Camera A PTZ camera shall be provided and installed on all new intersection traffic signals, unless specified otherwise on plans. The PTZ camera shall meet the following specifications:

Imager	¼ inch CCD
Shutter	1 to 1/10,000 Seconds
Exposure	Auto
Min. Illumination	0.7 Lux (Color) 0.005 Lux (B/W)
White Balance	Auto
Iris	Auto
Gain	Auto and Manual
Focus	Auto
Zoom Ratio	18x Optical; 4x Multiplier
View Angle	2.7° - 48°
Focal Length	4.1 - 73.8mm
F-Number	1.4
Pan Angle	360°
Pan Speed	170° per Second
Tilt Angle	-90° to +5°
Ethernet	100Base-TX/10BaseT (RJ-45)
I/O Terminals	4 inputs, 4 outputs
Resolution	640x480, 320x240
Compression	MPEG4, MJPEG

Frame Rate	30FPS (320x240) 30FPS (640x480)
Protocols	TCP/IP, HTTP, FTP, SMTP
Power Req.	110VAC
Operating Temp.	-20° to +122° Fahrenheit

1) The PTZ Camera must be compatible with the current software utilized by St. Louis County at the time of installation. The contractor shall be responsible for contacting the St. Louis County Signal Shop at (314) 615-0213 to inquire as what software is currently utilized by St. Louis County. The PTZ camera shall be accessed and controlled by a Web Browser. Confirmation of Compliance with software shall be provided before construction begins.

904.4.12.2 PTZ Camera Mount on Post Extension. Each post extension assembly for mounting a camera higher than a mast arm pole shall consist of a 14-foot straight continuous Schedule 80 extruded aluminum pipe, with a 4½ inch nominal outside diameter. The post shall be equal to aluminum alloy 6061-T6 and have a spun finish. This assembly shall include a removable aluminum post cap, with stainless steel set screws and mounting brackets for attachment to a mast arm pole. A mounting bracket, for mounting a PTZ IP camera to the post extension, shall be furnished with each camera.

904.4.12.3 10/100 Base-T CAT5 Lightning Surge Protector The Lightning Surge Protector shall be provided and mounted in the intersection traffic signal cabinet. The surge protector shall meet the following specifications:

1) Three Stage Protection

2) Failsafe architecture

3) 10/100 Base-T CAT5 protection

4) Cisco® Reverse Polarity PoE compatible

5) Shielded RJ-45 jacks and metal housing for EMI noise suppression

6) Two (2) Shielded RJ45 Jack Ethernet Connectors

7) Data Clamping Voltage of 18 volts

8) PoE Clamping Voltage of 58 volts

9) Data Lines:

- **a)** Pair 1: Pins 1 and 2
- **b)** Pair 2: Pins 3 and 6

10) CAT 5 Power Pinouts supporting normal and reverse polarity:

- **a)** +/- VDC: Pins 4 and 5
- **b)** +/- VDC: Pins 7 and 8

904.4.12.4 Special Cables and Connections Needed For PTZ Camera

1) **Twisted Pair Video Communication Cable** Cameras shall be provided with a Video Communication Cable. The Cable shall meet the following specifications:

Number of pairs	4
Total Number of Conductors	8
AWG	24
Stranding	Solid
Insulation Material	PO – Polyolefin
Insulation Wall Thickness	≥ .010 in.
Outer Shield Material	Aluminum Foil-Polyester Tape
Outer Shield % Coverage	100%
Outer Shield Drain Wire AWG	24
Outer Shield Drain Wire Stranding	7x32
Outer Jacket Material	PVC – Polyvinyl Chloride
Outer Jacket Ripcord	Yes
Overall Diameter	≥ .265 in.
Operating Temperature Range	- 40°C to +75°C
Suitability – Outdoor	Yes
Sunlight Resistance	Yes
Oil Resistance	Yes
Other Specification	NEMA WC-63.1 Category 5e, UL verified to Category 5e

2) **RJ45 Connectors** The Video Communication Cable shall have a RJ45 connector attached to each end. The RJ45 connector shall then be connected to the Camera and Lightning Surge Protector. The RJ45 connector shall be installed according to the following wiring configuration:

Wire 1	W/O
Wire 2	O
Wire 3	W/G
Wire 4	BL
Wire 5	W/BL
Wire 6	G
Wire 7	W/BR
Wire 8	BR

3) **14/3 Stranded SJTOW Flexible Power Cable** Cameras shall be provided with a Power cable. The power cable shall be equipped with a 110 vac plug inserted into the power strip, and hard wired to the cameras. The cable shall meet the following specifications:

Application	300 Volt Outdoor and Oil Portable
Conductor	14 AWG Bare Copper
Stranding	41/30
Insulation Material	PVC
Insulation Thickness	≥ 0.031"
Insulation Conductor Diameter	≥ 0.136"
Number of Conductors	3

Jacket Material	PVC
Jacket Thickness	≥ 0.036"
Overall Cable Diameter	≥ 0.365"
Temperature Rating	-20°C to 60°C
Insulation Colors	Black White Green

904.4.12.5 Managed Ethernet Switch When a PTZ camera is installed at a traffic signal. The cabinet shall be supplied with a Managed Ethernet switch, in lieu of unmanaged switch, as described in Section 904.4.6.10 and shall meet the following specifications.

1) Powered by an external 24vdc supply.

2) Environmentally hardened for harsh conditions per IEC 61850 and IEEE1613 standards.

3) Manages redundant rings with the Spanning Tree protocol.

4) The circuit board shall be coated for high humidity, coating shall be of 5 mil thickness.

5) There shall be 4 - 10/100 RJ45 electrical ports.

6) There shall be 4 - 100mb 15km singlemode LC fiber ports.

7) There shall be 4 - 100mb 2km multimode LC fiber ports.

8) There shall be 2 - 1000mb LX ports capable of accepting standard 1310nm wavelength, 25km SFP transceivers.

9) There shall be 2 - 1000mb SFP modules of 1310nm wavelength capable of transmitting 25km included.

904.5 Construction Requirements.

904.5.1 Location of Existing Underground Facilities, Structures and Utilities. Existing underground facilities, structures and utilities, if shown on the plans, shall be considered approximate only. Verification of the locations of all existing underground facilities, structures and utilities, either shown or not shown on the plans, shall be the responsibility of the Contractor, and shall be verified prior to any grading, excavation or construction of improvements. The Contractor/Developer shall contact St. Louis County Department of Highways & Traffic, Traffic Operations personnel, at (314) 615-0215, a minimum of 48 hours in advance of construction work for locating and spotting existing traffic signal conduit. In the event the Contractor/Developer damages the conduit and/or cable, repairs shall be made at their cost, by an Electrical Contractor within 72 hours, as directed by St. Louis County.

904.5.2 Location of New Concrete Bases, Pull Boxes and Detector Loops The Contractor shall notify the St. Louis County Department of Highways & Traffic, Traffic Operations personnel, at (314) 615-0226, when ready for the construction/installation of new concrete bases, pull boxes, and detector loops. This notice shall be a minimum of 48 hours

in advance of construction work. The Contractor shall stake the locations of improvements, easements, and/or rights of way on the ground to facilitate the placement of the new traffic signal items. The Contractor shall not proceed with construction until Traffic Operations personnel have completed verifying the proposed location of the new traffic signal items.

904.5.3 Traffic Signal Construction in Solid Rock If solid rock is encountered, all conduit, pull boxes, concrete bases and other roadway improvement items requiring excavation shall be installed, as directed by the Engineer. All costs for installing these items in solid rock shall be considered incidental to the contract prices bid for these items.

904.5.4 Construction of Concrete Bases Concrete bases for pedestal posts, mast arm poles, and controller cabinets shall be located in accordance with Section 904.5.2 and conform to dimensions shown on the standard detail drawings.

1) The top surfaces of Type B and Type C concrete bases shall be flush with adjacent surfaced areas and be constructed to the elevations shown on the standard detail drawings in seeded or sodded areas. The height above sidewalk or a concrete pad of each Type D concrete base shall be as shown on the standard detail drawings.

2) Excavation for bases shall be made in a neat and workmanlike manner. Each base shall be formed from the top of the base to a minimum of 12 inches below grade. Forms shall be sufficiently rigid to prevent warping or deflection. The forms shall be level and held rigidly in place before and during the placement of concrete.

3) Concrete shall be Class B concrete in accordance with Section 501, or concrete of a commercial mixture as approved by the Engineer. Concrete shall be placed, finished and cured in accordance with the applicable provisions of Section 703. Anchor bolts and conduit shall be carefully inspected and held rigidly in place before and during the placement of concrete. The placement of anchor bolts and conduit shall be in accordance with the dimensions shown on the standard detail drawings. Vibration of concrete may be necessary to fill all voids. The Contractor shall be required to protect anchor bolt threads during the concrete operation. All concrete shall be removed from the threads immediately after finishing has been completed. The tops of all bases shall be finished level in a workmanlike manner. Backfill material shall be compacted around each base in layers not exceeding six (6) inches in depth.

4) Type B concrete bases shall be cured at least 72 hours prior to installing mast arms. Type C and Type D concrete bases shall be cured at least 48 hours prior to installing pedestal posts and ground mount controller cabinets.

904.5.5 Construction of Concrete Pads A four (4) inch concrete pad shall be constructed in front of each Type D concrete base or preformed type slip over controller cabinet base, when sidewalk is not provided. The size of the concrete pads shall conform to dimensions shown on the standard detail drawings. The top surface of each concrete pad shall be flush with adjacent surfaced areas and be approximately one (1) inch above seeded or sodded areas. Concrete pads shall be Class B concrete in accordance with Section 501, or concrete of a commercial mixture as approved by the Engineer. Concrete shall be placed, finished and cured in accordance with the applicable provisions of Section 608.

904.5.6 Installation of Preformed Pull Boxes Preformed pull boxes shall be located in accordance with Section 904.5.2 and conform to dimensions shown on the standard detail drawings.

1) A stone drain, consisting of one (1) inch clean gravel or crushed stone, shall conform to dimensions shown on the standard detail drawings and be constructed below each preformed pull box. Backfill material shall be compacted around each preformed pull box in layers not exceeding six (6) inches in depth.

2) The top surface of each preformed pull box shall be flush with adjacent surfaced areas. In seeded or sodded areas a four (4) inch thick concrete apron twelve (12) inches wide shall be constructed flush around the perimeter of each preformed pull box. The concrete apron shall be approximately one (1) inch above adjacent seeded or sodded areas. Concrete aprons shall be Class B concrete in accordance with Section 501, or concrete of a commercial mixture as approved by the Engineer. Concrete shall be placed, finished and cured in accordance with the applicable provisions of Section 608.

904.5.7 Construction of Concrete Pull Boxes Pull boxes shall be located in accordance with Section 904.5.2 and conform to dimensions shown on the standard detail drawings.

1) Each concrete pull box shall be cast in place in a neat and workmanlike manner. Inside surfaces of the pull box walls shall be formed. If the excavation is irregular, outside surfaces of the walls shall also be formed. An outside form shall be installed across trenches leading into the excavation for the pull box. The ends of all conduit through the walls of the pull box shall fit tightly against the inside form. Concrete shall be Class B concrete in accordance with Section 501, or concrete of a commercial mixture as approved by the Engineer. Concrete shall be placed, finished and cured in accordance with the applicable provisions of Section 703.

2) The frame, cover and cable hooks shall be installed conforming to dimensions shown on the standard detail drawings.

3) A stone drain, consisting of one (1) inch clean gravel or crushed stone, shall conform to dimensions shown on the standard detail drawings and be constructed below each pull box. Backfill material shall be compacted around each concrete pull box in layers not exceeding six (6) inches in depth.

4) The top surface of each concrete pull box shall be flush with adjacent surfaced areas and be approximately one (1) inch above seeded or sodded areas.

5) A ground rod shall be placed inside each concrete pull box. The top of the ground rod shall be one (1) foot above the top of the stone drain.

904.5.8 Adjustment of Existing Concrete Pull Boxes This work shall consist of adjusting an existing concrete pull box to finish grade. The existing cast iron frame(s) and cover(s) shall be removed in such a manner so as not to damage the concrete walls of the pull box below the existing frame(s). A concrete collar shall be formed and placed atop the existing pull box walls in a neat and workmanlike manner using Class B concrete in accordance with Section 501, or concrete of a commercial mixture as approved by the Engineer. Concrete shall be placed, finished and cured in accordance with the applicable provisions of Section 703. Unless otherwise approved by the Engineer, the concrete collar shall be tied to the existing pull box walls with #3 tie bars equally spaced as directed by the Engineer. The existing cast iron frame(s) and cover(s) shall be placed in the new concrete collar and shall be flush with adjacent surfaced areas and approximately one (1) inch above seeded or sodded areas. Any portion of the existing pull box that is damaged shall be repaired or replaced with new materials at the Contractor's expense.

904.5.9 Installation of Conduit It shall be the Contractor's option to install traffic signal conduit by the directional boring method, conventional trenching method, or conventional pushing method. The size of conduit to be installed shall be as specified in the contract or noted on the plans. The top surface of underground conduit shall be placed from a minimum of 18 inches to a maximum of 36 inches below finish grade, or a minimum of 12 inches below subgrade, unless otherwise shown on the plans or approved by the engineer. A change in direction of conduit shall be accomplished by bending the conduit uniformly to a radius which will fit the location or by the use of standard bends or elbows, with approval of the Engineer. All conduit and fittings shall be free from burrs and irregularities. All conduit shall be cleaned and swabbed before cables are installed. All fittings shall be tightly connected to the conduit. Open ends of conduit placed for future use shall be capped or plugged. Conduit placed for future interconnect or future traffic signal cable shall contain an insulated, No. 16 AWG, stranded copper pull wire. All costs for the pull wire shall be considered incidental with no separate payment being made. Payment for furnishing and installing conduit will be based upon the unit price bid for the size of conduit and quantities shown on the Itemized Bid, regardless of the installation method chosen by the Contractor.

904.5.9.1 Conduit in Trench All trenches shall be excavated to the width and depth necessary for conduit installation. No dirt or debris shall be placed in the street nor shall it be placed on the sidewalk so as to leave less than three (3) feet of walkway available. Materials which might cause mechanical damage to the conduit shall not be used for backfilling below an elevation six (6) inches above the conduit. The bottom of the trench shall be free of such materials before the conduit is placed. No conduit shall be placed without approval of the trench by the Engineer. All trenches shall be backfilled as soon as practicable. Backfill material shall be deposited in the trench in layers not exceeding six (6) inches in depth. Each layer shall be compacted to the approximate density of the adjacent material before the next layer is placed. Where excavation is made in parkways, tree lawns or other turfed areas, topsoil shall be replaced as nearly as practicable to its former condition with seeding and strawing operations, unless otherwise shown on the plans. Where excavation is made across planting beds, stabilized shoulders, or rocked areas, these materials shall be replaced in kind so as to restore the areas to their former condition. Where excavation is made in proposed sidewalk, roadway, or shoulder areas, or wherever prevention of backfill settlement is considered essential by the Engineer, the trench shall be backfilled with granular fill from a level of 6 inches above the conduit to finish subgrade. Granular backfill shall consist of ¾ inch minus crusher-run limestone (Designation MSD 3 Backfill). The entire area involved in trenching operations shall be left in a neat and presentable condition. All

restoration costs shall be included in the unit price bid for the size of conduit installed, unless otherwise provided for as a separate pay item. All couplings, connectors and elbows necessary for installing conduit in trench shall also be included in the unit price bid for the size of conduit installed.

904.5.9.2 Pushed Conduit All pushed conduit shall be installed without disturbing the existing surface, unless otherwise approved by the Engineer. Pushed conduit may be placed by jacking, pushing, boring, or other approved means. Push pits and receiving pits shall be backfilled in the same manner as described for "Conduit in Trench" in Section 904.5.9.1. If any existing pavement, shoulders, sidewalk, or curbing is removed and replaced for installing pushed conduit, all restoration costs shall be included in the unit price bid for the size of conduit installed, unless otherwise provided for as a separate pay item. If concrete sidewalk or pavement is broken or removed, full slab replacement will be required. All couplings, connectors and elbows necessary for installing pushed conduit shall also be included in the unit price bid for the size of conduit installed.

904.5.9.3 Directional Boring Directional boring shall be used to install polyethylene (PE) duct and limit the disturbance of the existing ground surface. The boring machine shall be set up at locations which will minimize damage to existing improvements. An output signal shall be supplied inside the housing of the boring machine drill bit. The output signal shall be constant to allow a person to track the location of the drill bit at all times. The directional head shall be capable of accepting a variety of cutting bits for varied soil conditions. The operators of the boring machine shall check the bore path and make the necessary corrections to stay along the intended alignment. The boring machine shall be equipped with either water or a drilling fluid to facilitate drilling operations and the lubrication of the PE duct during pull-back. The Contractor shall make the necessary provisions to keep water and soil out of the new PE duct. Agents may be added to the water or drilling fluid to assist in holding the hole open during duct pull-back. If any existing pavement, shoulders, sidewalk, or curbing is removed and replaced to bore conduit, all restoration costs shall be included in the unit price bid for the size of conduit installed, unless otherwise provided for as a separate pay item. If concrete sidewalk or pavement is broken or removed, full slab replacement will be required.

904.5.9.4 Conduit in Doweled-On Concrete Median When ¾ inch conduit in a doweled-on concrete median is specified for detector loop installations, the conduit shall be installed in conformance with the standard detail drawings. Most of the conduit shall be laid on the surface of the pavement prior to construction of the concrete median. One end of the ¾ inch conduit shall be connected to a pull box in the proposed median. The other end of the conduit shall be installed by embedding a minimum 12 inches of conduit in the pavement below the edge of the proposed median. After constructing the median and removing concrete forms, cut the conduit flush with the face of the median below finish grade and remove the excess conduit. The open end of the conduit located below finish grade at the face of the median shall be cleaned and temporarily sealed with "duct" seal or an equivalent removable sealant.

904.5.9.5 Conduit on Wood Pole If conduit on wood pole is specified, the conduit shall be PVC and installed in a straight, neat, and workmanlike manner. The conduit shall be supported by conduit clamps at a maximum spacing of four (4) feet. Conduit extended to near the top of a wood pole shall be capped with an approved entrance

head fitting and positioned to allow for formation of a drip loop in the entering cable. Conduit extended to the base of a wood pole for either one (1) or two (2) detector loops shall include a 6 inch x 6 inch x 4 inch weatherproof PVC junction box with a screw down cover. This box shall be mounted to the wood pole approximately 18 inches above finish grade. All couplings, connectors, elbows, tees, hubs, clamps and access fittings necessary for installing conduit on a wood pole, including the above referenced PVC junction box with a screw down cover, shall be included in the unit price bid for the size of PVC conduit on a wood pole.

904.5.9.6 Conduit Repair The Contractor shall locate broken conduit (PVC, steel, or PE duct), excavate, remove existing cable, repair/replace conduit, reinstall/replace cable, backfill and restore area. Payment for this work will be as specified in the contract or noted on the plans. If existing pavement, shoulders, sidewalk, or curbing is removed and replaced for a conduit repair, the cost for this work shall be provided for as a separate pay item(s). If concrete sidewalk or pavement is broken or removed, full slab replacement will be required.

904.5.10 Connecting Conduit to Existing Concrete Pull Boxes This work shall consist of connecting new conduit to an existing concrete pull box as indicated on the plans. An opening for the new conduit shall be drilled through the wall of the existing concrete pull box at a minimum of 18 inches below finish grade. The new conduit shall be properly fitted in place, and extend a minimum of two (2) inches from the inner face of the pull box. After the conduit is in place, the opening around the conduit shall be sealed watertight in an approved manner. Any portion of the existing pull box that is damaged shall be repaired or replaced with new materials, at the Contractor's expense.

904.5.11 Installation of Signal Posts and Mast Arm Assemblies Each steel mast arm pole and aluminum post with a square pedestal base shall be securely fastened to a concrete base with anchor bolts.

1) Aluminum posts with square pedestal bases shall be erected vertically without the use of leveling nuts, and washers as specified in Section 904.4.2.5. Each square pedestal base shall be positioned so the handhole cover is located adjacent to a sidewalk or walkway where such paved areas exist.

2) Steel poles for cantilever mast arms shall be installed plumb by adjustment of leveling nuts. Poles for cantilever mast arms may be raked only when approved or directed by the Engineer.

3) All signal posts and mast arm assemblies shall be grounded by a No. 6 AWG, 7 strand, bare copper wire from a grounding lug inside each signal post or mast arm assembly to a common ground provided by a ground rod in the nearest concrete pull box.

904.5.12 Installation of Wood Poles, Guys and Span Wire Assemblies Wood poles, guys and span wire assemblies shall be installed as shown on the plans and in accordance with the standard detail drawings.

1) Wood poles shall be Class II or better and installed a minimum of 7 feet below finish grade. The depth shall be increased one (1) foot for each five (5) foot increase in length above 35 feet.

2) Upon installation of guy wires, a yellow plastic guy wire guard, as specified in Section 904.4.4(1.c.), shall be installed on each down guy.

3) Stand off guys, when specified, shall be installed with the stand off pipe a minimum of ten (10) feet above finish grade. The stand off pipe shall be of sufficient length to allow positioning of the guy anchor at the location shown on the plans or at a location spotted in the field by the Engineer.

4) When a wood pole in concrete embedment is required, a three (3) foot diameter hole shall be drilled. Loose material at the bottom of the hole shall be either removed or compacted to the approximate density of the adjacent material. A masonry block shall be placed at the bottom of the hole upon which the pole shall be set. Concrete embedment shall be poured around the pole up to a level 24 inches below finish grade. The concrete shall be Class B concrete in accordance with Section 501, or concrete of a commercial mixture as approved by the Engineer. Concrete embedment around the wood pole shall be cured at least 72 hours prior to the wood pole being subjected to concentrated loads. The remaining 24 inches below finish grade shall be backfilled and compacted in layers not exceeding six (6) inches in depth.

5) Guy wires, clamps, guards, stand off pipe, fittings, anchors, rods, concrete embedment and other items used for the installation and support of wood poles shall be included in the unit price bid for Class II wood poles.

6) The span wire assembly shall be installed at a sufficient height to provide a minimum clearance of 16' and a maximum clearance of 19' to each signal head assembly.

7) Span wire, tether wire, clamps, cable straps, insulators and other items used for installation of a span wire assembly shall be included in the lump sum price bid for span wire assembly.

904.5.13 Installation of Power Supply Assemblies Each power supply assembly shall be installed in accordance with the standard detail drawings. The location of each power supply installation shall be coordinated with AmerenUE Company and other utilities as required.

904.5.13.1 Type Mounted on Utility Pole Each power supply mounted on a utility pole shall be installed within the pole quadrant specified by AmerenUE Company and in accordance with the standard detail drawings. The bottom of the meter socket glass shall be a maximum of 5½ feet above finish grade, except over walkways where the bottom of the meter socket shall be 6½ feet above the walkway.

904.5.13.2 Type Mounted on Steel Post with Concrete Embedment The location of each power supply base shall be determined by the location of the underground service provided by AmerenUE. The top of the embedded concrete base with steel post shall be flush with adjacent surface areas and be constructed to the elevations shown on the standard detail drawings. The bottom of the meter socket glass shall be a maximum of 5½ feet above finish grade, except over walkways where the bottom of the meter socket shall be 6½ feet above the walkway.

904.5.14 Installation of Signal Heads All signal head assemblies shall be constructed and installed in accordance with the standard detail drawings, unless otherwise approved by the Engineer.

1) The vertical clearance to the bottom of an overhead signal head assembly shall be at least 16 feet but not more than 19 feet above the roadway.

2) Within the limits of normal vertical clearance, signal heads shall have a horizontal clearance of not less than 2 feet from the face of a vertical curb or from the outside edge of a shoulder. In a median, the above 2 foot minimum clearance should be obtained where possible.

3) Each signal head installation on a mast arm shall be by one of the following methods:

a) Each signal head installed vertically on a mast arm shall be mounted using an astro-bracket with an in-line terminal compartment. A hole for wiring access shall be field drilled in the mast arm for each astro-bracket, the location of which shall be determined by the Engineer. The astro-bracket shall be banded onto the mast arm. The area between the astro-bracket and mast arm shall be sealed with a silicon caulk. A ⅛ inch drain hole shall be drilled into each astro-bracket terminal compartment.

b) Each signal head installed horizontally on a mast arm shall be assembled using one astro-bracket with one terminal compartment. This signal head assembly shall be configured and mounted in accordance with the standard detail drawings. A hole for wiring access shall be field drilled in the mast arm to the astro-bracket providing access to the terminal compartment. The location of the hole shall be determined by the Engineer.

4) Signal head fittings, brackets, terminal compartments and hardware shall be securely tightened and fastened in position. When banding is used to attach a signal head, a ⅝ inch by .030 inch stainless steel band shall be used. Prior to placing signal heads in operation, all signal faces shall be covered or turned away from approaching traffic.

5) When ready for operation, the signal heads shall be securely fastened in position and face approaching traffic. Signal faces shall be aimed laterally at the approximate center of the lane or lanes they control, unless otherwise directed by the engineer. They shall be aimed at a point back of the stop line a distance corresponding to the following requirements:

Approach Speed (M.P.H.)	Distance (Feet)
30	160
40	240
50	330

904.5.15 Installation of Controller Cabinets Each cabinet shall be installed in accordance with the standard detail drawings. The controller cabinet size and type of mounting shall be as shown on the plans or as specified in the contract.

1) Each cabinet shall be mounted on a Type D concrete base. The height of each Type D concrete base shall be as specified on the standard detail drawings. The anchor bolt spacing shall be as specified by the manufacturer of each cabinet. After the controller cabinet is bolted using washers, specified in Section 904.4.2.5, to the concrete base, the outside perimeter of the cabinet shall be sealed with silicone caulk.

904.5.16 Installation of Detector Loops

1) Detector loops will be marked on the pavement by Division of Traffic personnel after receiving a minimum 24 hours notice from the Contractor in accordance with Section 904.5.2.

2) Prior to sawing the detector loops, traffic control protection shall be provided to detour traffic around the work area.

3) Slots for the installation of detector loop cable shall be sawed in the pavement with a power concrete saw. Newly constructed concrete pavement shall not be sawed for 72 hours, unless directed otherwise by the Engineer. All sawed slots shall be thoroughly cleaned using compressed air to blow out dirt and all free water.

4) Each sawed slot for detector loops shall be ⅜ inch wide and 2 inches deep regardless of the number of detector loop cables to be installed. The intersection of slots shall overlap enough to maintain full 2 inch depth. Where slots intersect, a 1¼ inch diameter hole shall be drilled to full 2 inch depth. The practice of sawing diagonal cuts across the corners of a loop shall not be permitted.

5) One slot for loop leads, ⅜ inch wide and 2 inches deep, shall be sawed from each detector loop to a separate ¾ inch conduit. The lateral distance between each of the loop lead slots shall be 1 foot minimum. The lateral distance between transverse pavement joints and the nearest loop lead slot shall also be 1 foot minimum.

6) The ¾ inch conduits for loop leads shall be located near the edge of pavement or near the face of a curb, median or island. These conduits shall be installed in accordance with the standard detail drawings.

7) After ¾ inch conduit is installed for detector loop leads, the face of each median, island or curb above each conduit shall be marked and scored with a concrete saw. If the pavement is ever overlayed, this scoring of concrete faces will provide a permanent mark to aid in locating the end of each ¾ inch conduit in the event the detector loops must ever be replaced.

8) Detector loop cable shall be pushed into the sawed slots with blunt tools without damaging the tube jacket. The number of loop turns required shall be as shown on the plans. The loop leads shall be pushed into the slot leading to a ¾ inch conduit and pulled through the conduit to a pull box for connection to a shielded lead-in cable. The detector loop wire and outer tube jacket for each detector loop shall be continuous without splice.

9) Detector loop leads shall be connected to shielded lead-in cable in a pull box as shown on the plans and in accordance with Section 904.5.17(4).

10) Prior to pouring the detector loop sealant, each ¾ inch conduit opening shall be sealed with "duct" seal or an equivalent removable sealant. This "duct" seal will keep the detector loop sealant from running into the ¾ inch conduit to prevent future maintenance problems if a loop must ever be replaced.

11) Prior to pouring the detector loop sealant, wedges shall be inserted into the sawed slots on 3 foot centers to prevent the air space in the tube jacket from causing the detector loop cable to float in the slot when the loop sealant is poured. The wedges shall be 1 inch sections of plastic tubing which are folded before insertion.

12) After the detector loop cable is connected to a shielded lead-in cable and before the slot is sealed, the resistance of the detector loop and lead-in cable to ground shall be checked. After a satisfactory test, which shows resistance of not less than ten (10) megohms, the slot shall be sealed with detector loop sealant.

13) The placement of the detector loop sealant shall be in strict accordance with the directions of the manufacturer regarding the preparation of the sealant mix, its application, and the proper curing procedures subsequent to reopening of the road to traffic.

14) Where a ¾ inch conduit joins a loop lead slot, loop sealant shall be poured into the space between the pavement and the ¾ inch conduit causing the conduit to be bonded to the pavement.

15) Where future detector loops are to be installed, ¾ inch conduit shall be installed for the future detector loop leads. The ends of the ¾ inch conduit shall be sealed with "duct" seal or an equivalent removable sealant. This will keep dirt and debris out of the unused ¾ inch conduit. The face of each median, island or curb above each ¾ inch conduit shall be marked and scored with a concrete saw to aid in the future locating of each conduit.

904.5.17 Installation of Wiring

1) All signal cable runs shall be continuous without splice from the terminal block of each signal head to a terminal strip in the controller cabinet, or from the terminal block of one signal head to the terminal block of another signal head when a jumper is shown on the plans or directed by the Engineer. All conductor cable combinations to signal heads shall be as shown on the plans or as directed by the Engineer.

2) Power cable runs shall be continuous without splice from the power supply circuit breaker panel to the traffic signal controller cabinet. Energized power cables shall be black and terminated on circuit breakers inside the power supply circuit breaker panel and the controller cabinet. The neutral cable shall be white and terminated on the ground bus bar inside the power supply circuit breaker panel and the controller cabinet.

3) Pedestrian push button detectors and vehicle detector loops shall be connected to the controller by separate No. 18 AWG, 2 conductor, shielded lead-in cables which shall be continuous without splice.

4) Detector loop leads shall be connected in series to shielded lead-in cable. These connections shall be made in a pull box near the loops as shown on the plans. All connections between detector loop leads and shielded lead-in cable shall be made by using a 3M direct bury splice kit #DBY or compatible connection approved by the engineer. Shielded lead-in cable runs shall be continuous without splice from a pull box near the loops to the controller cabinet. If more than one shielded lead-in cable is wired to the same loop detector channel, the lead-in cables shall be wired in series in the controller cabinet, not connected together in series in a pull box.

5) All signal posts, mast arm assemblies and controller cabinets shall be grounded by a No. 6 AWG, 7 strand, bare copper wire from a grounding lug inside each signal post, mast arm assembly and controller cabinet to a ground provided by a ground rod inside the nearest concrete pull box.

6) 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 conduits into pull boxes. Lubricants may be used to facilitate pulling cable. Slack in each cable run shall be provided by coiling six (6) feet of cable in each pull box.

7) All wiring connections shall be securely tightened. Copper barrel lugs shall be used for all field connections inside the controller cabinet. Insulated crimped-on connectors of an approved type shall be used for all other terminal connections. All spare field wires shall be capped with closed end insulated terminals of an approved type.

8) Signal interconnect cable shall be continuous without splice between the terminal strips of interconnected controllers, except when the distance between controllers exceeds 2,000 feet or when otherwise approved by the Engineer. This exception is not applicable to fiber optic cable installations which shall be continuous without splice between controllers.

9) Color codes shall be followed so that the red insulated conductor connects to the red indication terminal, yellow to yellow, green to green, and white to neutral. The power cables shall be color coded so that black connects to AC(+) and white to neutral.

10) At an existing traffic signal installation, where new/existing cable is to be installed/relocated into an existing conduit, all existing cable and wire not used shall be removed from the conduit. All costs for relocating/removing existing cable and wire shall be considered incidental with no separate payment being made.

11) When existing conduit needs to be repaired/replaced, the existing cable needs to be removed and then reinstalled/replaced through the repaired/new conduit, or as directed by the engineer.

12) When existing conduit is to be intercepted with a new pull box, existing cable shall be removed from the intercepted location and replaced after the pull box is installed and conduits are properly angled within the pull box.

904.5.18 Fiber Optic Cable The fiber optic cable installation shall be supervised by trained and experienced personnel. The Contractor shall, upon request of the Engineer, provide documentation of qualifications and experience for fiber optic installations. The Engineer shall determine if the Contractor is qualified to perform this work.

904.5.18.1 Installation of Fiber Optic Cable

1) All fiber optic signal interconnect cable shall be continuous without splice between interconnected controllers.

2) A suitable cable feeder guide shall be used between the cable reel and the face of the duct or conduit to protect and guide the cable off the reel into the duct or conduit. It shall be carefully inspected for jacket defects. If defects are noticed, the pulling operation shall be stopped immediately and the Engineer notified.

3) Precautions shall be taken during installation to prevent the cable from being kinked or crushed. A pulling eye shall be attached to the cable and used to pull the cable through the conduit system. A pulling swivel shall be used to eliminate twisting of the cable.

4) As the cable is played off the reel into the cable feeder guide, it shall be sufficiently lubricated with a type of lubricant recommended by the cable manufacturer. Dynamometers or break away pulling swings shall be used to ensure that the pulling line tension does not exceed the installation tension value specified by the cable manufacturer. The mechanical stress placed on a cable during installation shall not be such that the cable is twisted or stretched.

5) The pulling of cable shall be hand-assisted at each controller cabinet, pull box, and junction box. The cable shall not be crushed, kinked or forced around a sharp corner. If a lubricant is used it shall be of water-based type and approved by the cable manufacturer. Sufficient slack shall be left at each end of the cable to allow proper cable termination.

6) Additional slack cable shall be left in each pull box and junction box. The minimum slack amounts shall be as follows:

Pull box, junction box..... 10 feet

Double pull box..... 30 feet

7) After cable connections are made inside the controller cabinet, the unused additional slack cable in the cabinet shall be pulled back, coiled and stored with the additional slack cable in the pull box next to the controller cabinet. Storage of additional slack cable shall be coiled and bound at a minimum of three points around the coil perimeter and supported in the static storage positions. At each controller cabinet and pull box the cable shall be visibly marked or tagged as "**CAUTION FIBER OPTIC CABLE**".

8) Maximum length of cable pulling tensions shall not exceed the cable manufacturer's recommendations.

9) Existing cable shall remain in place; however, it may be pulled out to assist in pulling the fiber optic cable. Existing cable shall always be returned to the conduit system before the end of work each day and connected in each controller cabinet. The Engineer shall be notified before the existing cable is disconnected.

10) When existing cable is not present or when plans call for its removal, an insulated, No. 16 AWG, stranded copper wire shall be pulled in with the fiber optic cable to facilitate future locating of the conduit. All costs for this wire shall be considered incidental with no separate payment being made.

11) For static storage, the cable shall not be bent at any location to less than ten times the diameter of the cable outside diameter or as recommended by the manufacturer. During installation, the cable shall not be bent at any location to less than twenty times the diameter of the cable outside diameter or as recommended by the manufacturer.

904.5.18.2 Fiber Optic Cable Terminations

1) All multimode fiber ends shall be fusion spliced and/or terminated per the Engineer. The cost of which is incidental to the cost of the cable.

2) The above referenced ST connectors shall be fusion spliced using a kit with 6 each FPC MM 62 1F 900um ST/00 1 meter, blue, orange, green, brown, slate, and white with ST connectors with ceramic ferrule, part number S212580-1M.

3) The termination housing shall be suitable for wall mounting and be capable of mounting a minimum of 30 singlemode and 6 multimode hub ST type connectors. A minimum of 36 multimode ST type connectors shall be installed in the housing. The housing shall have a splice tray kit capable of a minimum of 30 splices. It shall be capable of housing up to 48 fibers and provide for the stacking of fibers. It shall have ample room for feed through cable and provide strain relief for multiple cables within the unit.

4) Patch cords shall be terminated through ST connectors mounted on the termination housing and plug into the internally provided controller unit fiber optic modem. The patch cord assemblies shall be fully compatible with the fiber optic interconnect cable and connecting modems and modules. The patch cords shall be no longer than four (4) feet.

5) All singlemode fiber ends shall be fusion spliced and/or terminated per the Engineer. The cost of which is incidental to the cost of the cable.

904.5.18.3 Testing of Fiber Optic Cable and Terminations Each section of cable shall be tested for continuity and attenuation. The contractor shall provide all personnel, equipment, instrumentation and supplies necessary to perform all testing. All testing shall be performed in an accepted manner and in accordance with the testing equipment manufacturer's recommendations. All data shall be recorded and submitted to the Engineer.

904.5.18.3.1 Optical Time Domain Reflectometer The optical time domain reflectometer (OTDR) shall be used to test each section of cable. A LED light source with an 850 µm wavelength shall be used. The LED shall be stable within 0.1 db in intensity over a time period sufficiently long to perform the measurement. The output of the LED shall overfill the input end of the launch fiber/cable in both numerical aperture and core diameter.

1) OTDR shall be used to evaluate the quality and length of cable reels prior to their use on the project. The fiber loss in db/km and the length of each reel shall be recorded in the documentation. The maximum attenuation of the cable shall be 3.5 db/km nominal, measured at room temperature at 850 nm. A copy of OTDR signature traces for all system links shall be made and provided in the documentation.

904.5.18.3.2 Documentation The results of all testing shall be recorded, along with date of test, name of person performing test, brand name, model number, serial number of equipment used during test, and any other pertinent information and data. All test results and other information must be given to the engineer for verification of fiber cable work.

904.5.19 Removal of Existing Concrete Pull Boxes Unless otherwise noted on the drawings, existing concrete pull boxes to be removed shall be removed twelve (12) inches below finish grade and backfilled to finish grade with material of the same grade and type as the adjacent surface.

904.5.20 Removal of Existing Concrete Bases Unless otherwise noted on the drawings, existing bases to be removed shall be removed twelve (12) inches below finish grade and backfilled to finish grade with material of the same grade and type as the adjacent surface.

904.5.21 Relocation or Removal of Existing Signal Equipment

1) Traffic signal equipment shall be relocated or removed only with the approval of the Engineer. The Contractor shall exercise care in his dismantling operations so as not to damage traffic signal equipment to be relocated or removed. All traffic signal equipment to be relocated or removed shall be assumed to be in good condition unless indicated otherwise by a previous inspection by the Engineer. It will be the Contractor's responsibility to request and set up an inspection appointment with the Engineer prior to the relocation or removal of equipment to determine the extent of any damage to equipment.

2) County maintained traffic signal equipment to be removed shall be delivered to the Department of Highways and Traffic Operations Building, Signal Shop, 2688 Adie Road, Maryland Heights, Missouri 63043, Phone (314) 615-0200.

3) State maintained traffic signal equipment to be removed shall be delivered to the Missouri Highway and Transportation Department (MoDOT) Signal Shop, 2309 Barrett Station Road, Ballwin, Missouri, 63021, Phone (314) 340-4100.

904.5.22 Modification of Existing Traffic Signals

1) Existing traffic signals, including detectors and interconnect, shall remain in effective operation, except during the period of time when the traffic signal must be shut down for alterations or changeover to new traffic signal equipment. The Contractor shall notify Division of Traffic personnel 48 hours in advance of any traffic signal shutdown. During the time traffic signals are turned off, "Stop" signs shall be installed by the Contractor adjacent to each lane approaching the intersection as directed by the Engineer. The length of time existing traffic signals are turned off for alterations or changeover to new equipment shall be held to a minimum. The times of day and days of week existing traffic signals may be shutdown shall be as specified on the plans or as directed by the Engineer.

2) Any portion of an existing traffic signal installation or system that is modified shall be maintained by the Contractor in accordance with Sec 904.5.23. In addition, any portion of an existing traffic signal installation that is damaged by construction operations shall be repaired at the Contractor's expense, including portions of an existing signal not modified by the Contractor.

904.5.23 Signal Maintenance During Construction

1) This maintenance shall include all repairs and/or adjustments to signal materials and equipment, furnished and installed by the Contractor, which the Engineer has determined are necessary due to malfunctions, construction operations, vandalism, knockdowns, and/or acts of God. The Contractor shall be responsible for obtaining recovery of all damages, including replacement of any signal equipment.

2) In any event, if in the opinion of the Director and at his/her sole discretion, immediate repairs and/or adjustments are determined to be necessary to provide for the safe and efficient movement of traffic, and the Contractor is not capable of

making such repairs and/or adjustments to the satisfaction of the Director; the Director will order County personnel or other qualified Engineers or technicians to make immediate repairs and/or adjustments. The Contractor will be charged the entire cost of the work performed by County or other qualified personnel (if paid by the County). The Contractor will be charged for all labor (including benefits and indirect overhead), materials, and equipment furnished by the County in making immediate repairs and/or adjustments. There will be a three (3) hour minimum call-up time for overtime. The work performed by County or other qualified personnel will in no way jeopardize any part of the guarantee as specified in Sec 904.10.

904.5.23.1 Daily Cleanup During Construction All dirt, trash, and other related construction debris shall be removed from the right-of-way before the end of the work day. If in the opinion of the Engineer, the construction site is unclean and presents a hazard to vehicular and/or pedestrian traffic, the Engineer may order County personnel to provide cleanup efforts with the entire cost of the work performed by the County to be deducted from monies due to the Contractor from forthcoming payments.

904.5.23.2 Traffic Handling During Construction Signal construction should be accomplished with as little interruption to traffic as possible. When interruptions to traffic become inevitable, it will be the Contractor's responsibility to furnish, place, and maintain, standard traffic control devices in accordance with the current edition and latest revisions of the Manual on Uniform Traffic Control Devices (Part VI) or as directed by the Engineer. All costs for traffic handling shall be considered incidental with no direct payment being made, unless otherwise provided for as a separate pay item. The traveled portion of the roadway must be clear of all equipment and materials from 3:30 PM to 9:00 AM, unless determined otherwise by the Engineer.

904.5.24 Restoration All pavement, shoulders, sidewalk, curbing, embankments, planting beds, and turfed areas disturbed by construction shall be restored as directed by the Engineer. All costs for restoration shall be considered incidental with no direct payment being made, unless otherwise provided for as a separate pay item.

904.5.25 Final Clean Up All signal equipment shall be cleaned in such a manner so as to be free of grease, oil and excess dust. The lens and reflector of each signal indication shall be wiped clean. All debris or scrap material shall be removed from the inside of each pull box, handhole, signal head and controller cabinet. The final cleaning up of the right-of-way shall meet the requirements of Section 104.8.

904.6 Temporary Traffic Signals

1) When specified, temporary traffic signals shall be provided for the handling of traffic during construction. The operation period of temporary traffic signals shall be held to a minimum. Unless otherwise provided, a plan of each proposed temporary signal shall be submitted to the Engineer for approval prior to the installation of the signal. When temporary traffic signals are installed, the signal heads shall be covered until the installation is placed in operation. Temporary traffic signals, when required, shall be kept in effective and continuous operation except for shutdowns required for changeover to new equipment.

2) If an existing traffic signal is to be replaced with a temporary traffic signal installation, the existing traffic signal shall not be taken out of operation until such time as approval is received from the Engineer for a changeover. The downtime for this changeover shall be kept to an absolute minimum. Existing traffic signals taken out of operation shall be covered until removed.

3) Unless otherwise noted, the Contractor shall be required to furnish and install the necessary materials and equipment for the operation of temporary traffic signals. The maintenance of temporary traffic signals shall be in accordance with Section 904.5.23. The Contractor shall remove each temporary traffic signal installation when its use is no longer deemed necessary by the Engineer. No direct payment will be made for the removal of the temporary signal; and the temporary signal equipment will remain the property of the Contractor. The Contractor shall comply with all existing electrical codes, ordinances and regulations of Saint Louis County and municipalities involved. The Contractor shall also comply with the requirements of AmerenUE Company to obtain power for the operation of each temporary traffic signal installation.

904.7 Signal Acceptance Procedures.

904.7.1 Signal Inspection When the Contractor is certain all traffic signal equipment that was furnished and installed by the Contractor for a new or modified traffic signal installation, is operating properly, he shall make an inspection appointment with the Engineer. After a thorough inspection of the signal equipment and installation, the Engineer may authorize the Contractor to put the signal into permanent operation. This authorization will be given if all signal equipment is working properly, or if public safety and convenience warrants the operation of the signal before all corrections have been made. If the inspection reveals signal deficiencies, the Contractor shall correct them expeditiously and within the time allowed for the completion of the project. If the signal must be put into flashing operation or completely shutdown to make the necessary corrections, the Contractor must receive approval from the Engineer before this action is taken. This inspection procedure shall be repeated until all corrections have been made.

904.7.2 Signal Test Period

1) After all deficiencies to signal equipment furnished and installed by the Contractor have been corrected, the signal shall remain in operation for a 30 consecutive day test period. Any failure or malfunction of equipment during the test period shall be corrected by the Contractor. The signal shall then be tested for an additional 30 consecutive day period. This procedure shall be repeated until the signal equipment has operated to the Engineer's satisfaction for 30 consecutive days. However, it should be noted that if the signal is part of a system within the project, that portion of the signal installation associated with systems operation shall not be tested until all signals in the system within the project are ready to be tested.

2) After a signal and/or signal system that was furnished and installed by the Contractor has been satisfactorily tested for 30 consecutive days, the County will make emergency repairs and/or adjustments determined to be necessary due to malfunctions. However, prior to final acceptance, the Contractor shall still be responsible for any repairs and/or adjustments which the Engineer has

determined are necessary due to construction operations, vandalism, knockdowns and/or acts of God. The Contractor shall be responsible for obtaining recovery of all damages.

904.7.3 Signal Maintenance Information Before final acceptance of the work, the Contractor shall furnish the Engineer the following information for signal equipment furnished and installed by the Contractor.

1) Three (3) copies of the manufacturers' instructions for the maintenance and operation of all signal equipment.

2) Original mylar drawing(s) of controller wiring diagrams for each signal installation and/or signal system, or a computer disc with this information stored in a format compatible with MicroStation software. The controller wiring diagrams shall be prepared on neat and clean 24 inch x 36 inch mylar sheet(s) or on a computer disc. The diagrams shall be easy to read and match the cabinet wiring. All controller wiring diagrams shall be double referenced.

904.7.4 Final Acceptance Upon presumptive completion of the entire project, including completion of the signal test period, the Director will make an inspection. If all construction contemplated by the contract has been completed to his satisfaction that inspection will constitute the final inspection. The Director will make the final acceptance and notify the Contractor in writing of this acceptance as of the date of the final inspection.

904.8 Method of Measurement

1) Measurement of conduit will be made to the nearest linear foot as indicated on the plans. Contract quantities will be used in final payment except as provided in Section 904.8(3).

2) Measurement of cable and wire will be made to the nearest ten (10) linear feet as indicated on the plans. Contract quantities will be used in final payment except as provided in Section 904.8(3).

3) Field measurements will be made only for authorized changes during construction, or where appreciable errors are found in the contract quantity. Each revision or correction will be computed and added to or deducted from the contract quantity.

904.9 Basis of Payment Accepted traffic signals will be paid for at the unit bid price for each of the pay items included in the contract. No separate payment will be made for any incidental items necessary to complete the work unless specifically provided as a pay item in the contract.

904.10 Guarantee

1) The Contractor shall guarantee satisfactory in-service operation of all Contractor supplied and installed electrical equipment and related components for a period of one (1) year from date of the final acceptance of the entire project.

2) Upon notice from the Engineer of unsatisfactory in-service operation of Contractor supplied and installed electrical equipment and/or related components, the Contractor shall immediately begin the correction, repair or replacement process. This notice from the Engineer may be given anytime within the guarantee period specified in Section 904.10(1). The Contractor shall be responsible for having the defective work, materials or equipment either corrected, repaired or replaced within three (3) working days after notification by the Engineer. Unless otherwise approved by the Engineer, if defective materials or equipment cannot be repaired or replaced within this time, the Contractor shall make arrangements for their temporary replacement with similar materials or equipment. In any event, if in the opinion of the Director and at his sole discretion, immediate repairs and/or adjustments are determined to be necessary to provide for the safe and efficient movement of traffic, and the Contractor is not capable of making such repairs and/or adjustments to the satisfaction of the Director; the Director will order County personnel or other qualified Engineers or technicians to make immediate repairs and/or adjustments. The Contractor will be charged the entire cost of the work performed by County or other qualified personnel (if paid by the County). The Contractor will be charged for all labor (including benefits and indirect overhead), materials, and equipment furnished by the County in making immediate repairs and/or adjustments. There will be a three (3) hour minimum call-up time for overtime. The work performed by County or other qualified personnel will in no way jeopardize any part of this guarantee.