

SECTION 622 - BLANK

SECTION 623

TRAFFIC SIGNALS AND STREET LIGHTING

01DESCRIPTION

623 G.01.01 GENERAL

- A. Electrical work shall consist of furnishing and installing, modifying or removing traffic signals, school flashers, flashing beacon systems, street and highway lighting systems, Intelligent Transportation Systems (ITS) facilities, sign illumination systems, traffic count stations, electrical equipment in structures, falsework lighting, partial installations for future systems, or combinations thereof, all as shown on the Drawings and as specified in these specifications and the Special Provisions.
- B. The standards for street lighting and traffic signal installation and construction shall be the "Uniform Standard Drawings, Volumes I and II" and these specifications as adopted and approved by the Regional Transportation Commission of Southern Nevada (RTC).
- C. For the purposes of this section, the Maintaining Agency of identified portions of the work described herein shall be the entity specified in the Contract Documents as being responsible for the operation and maintenance of those portions of the completed work. Unless otherwise specified, the Contracting Agency shall be considered the Maintaining Agency for all items of work.
- D. Unless otherwise indicated on the Drawings or specified in the Special Provisions, all materials shall be new.
- E. The locations of traffic signals, flashing beacons, street light and traffic signal poles, roadway lighting fixtures, traffic signs, traffic controller cabinets, electrical services, school flashers, and appurtenances shown on the Drawings are approximate and the exact locations will be established by the Engineer in the field.
- F. All materials furnished and used shall conform to the provisions in **Section 106, "Control of Materials."** The materials shall be manufactured, handled, and used in a manner to ensure completed work with undamaged equipment and materials in accordance with the Drawings, specifications, and Special Provisions.
- G. All systems shall be complete and in satisfactory operating condition at the time of acceptance of the contract.
- H. Where an existing system is to be modified, the existing material shall be reused, salvaged and stockpiled, or abandoned as shown on the Drawings, as specified in the Special Provisions, or as directed by the Engineer.

623 G.01.02 REGULATIONS AND CODE

- A. All electrical equipment shall conform to the standards of the National Electrical Manufacturers Association (NEMA), and listed by Underwriters Laboratories, Inc. (UL), or the Electronic Industries Association (EIA), wherever applicable.
- B. In addition to the requirements of the Drawings, these specifications, and the Special Provisions, all materials and workmanship shall conform to the requirements of:
 - 1. *National Electrical Code (NEC).*

2. National Electrical Testing Association (NETA).
 3. *National Electrical Safety Code* (NESC).
 4. Standards of ASTM International.
 5. American National Standards Institute (ANSI) manuals.
 6. International Municipal Signal Association (IMSA) cable specifications.
 7. Institute of Electronic and Electrical Engineers (IEEE).
 8. Illumination Engineering Society (IES).
 9. Rural Electrification Association (REA).
 10. Nevada Occupational Safety and Hazard Act (NOSHA).
 11. National Board of Fire Underwriters (NBFU).
 12. *Manual on Uniform Traffic Control Devices* (MUTCD).
 13. *Uniform Standard Drawings*.
 14. Any local ordinance which may apply.
- C. Wire sizes shall be indicated in American Wire Gauge (AWG).
- D. All work performed on any traffic signal component shall be under the direct on-site supervision of technician or electrician certified by IMSA for Level II Traffic Signals.
1. Actual trenching and foundation excavation activities are not considered construction labor involving traffic signal components until conduits or other electrical components are installed.
 2. At a minimum, a supervisor with the IMSA Level II Traffic Signal certification shall oversee the installation of conduits and other electrical raceways.
 3. Traffic signals are defined as all electrical equipment constructed in public right-of-way that are intended to provide control of traffic and shall include but not be limited to school flasher assemblies, advance warning beacons, traffic signal indications assigning right-of-way, school and other crosswalk signals, advance signal flashers, and intersection flashing beacons.
- E. All work performed on any component of any electrical street lighting or traffic signal system shall be supervised by an electrician that is certified as a Journeyman Electrician. The company shall hold a valid state of Nevada recognized C-2 Electrical Contractor's license.

623 G.01.03 EQUIPMENT LIST AND DRAWINGS

- A. Unless otherwise permitted in writing by the Engineer, the Contractor shall, within 15 days following approval of the contract, submit to the Engineer for approval a list of equipment and materials which the Contractor proposes to install.
1. The list shall be complete as to name of manufacturer, size, and identifying number of each item.
 2. The list shall be supplemented by such other data as may be required, including scale drawings of cabinets showing location and spacing of shelves, terminal blocks, and equipment, including dimensioning.

- B. All submittal information shall be submitted for review, in quadruplicate. A minimum of 10 working days will be allowed for the review and return of the submittal documents.
- C. When the Contractor provides a traffic signal controller cabinet, the circuit diagrams for detector plug connections, the peripheral equipment, and all external solid-state logic shall be provided.
 - 1. The Contractor shall furnish traffic signal cabinet drawings and electrical schematics on CD in AutoCAD format, and 2 copies 24 inches by 36 inches in size.
 - 2. The diagrams shall show the location of the installation and shall list all equipment installed in the cabinet.
- D. The Contractor shall furnish a redlined set of the Drawings and revised Special Provisions to the Engineer prior to inspection showing actual conduit, pull box, and signal/lighting pole locations.
 - 1. The redlined Drawings shall indicate any changes in the detector location, field wiring, signal phasing, and all other technical information for each traffic signal and street lighting installation.
 - 2. The Contractor shall also furnish operation and maintenance manuals with each controller and all other electronic equipment furnished by the Contractor.
 - 3. The manuals shall include any and all peripheral equipment specified herein or in the Special Provisions to be installed with the controller, including but not limited to preempt system, video detection system, loop detection amplifiers, conflict monitors, and modems.
 - 4. As-built Drawings shall be required, and the final submittal requirements shall be as specified in the Contract Documents or directed by the Engineer.
- E. All schematic wiring diagrams of the controllers and auxiliary equipment, all cabinet diagrams, and all operation manuals shall be submitted at the time the controllers are delivered for testing, or, if ordered by the Engineer, previous to purchase.
 - 1. This diagram shall show in detail all circuits and parts.
 - 2. Such parts shown thereon shall be identified by name or number and in such manner as to be readily interpreted.

623 G.01.04 WARRANTIES, GUARANTEES, AND INSTRUCTION SHEETS

- A. Manufacturers' warranties, guarantees, and certifications for materials used in the work and instruction sheets and parts list shall be supplied with materials and shall be delivered to the Engineer prior to acceptance of the project.

623 G.01.05 GLOBAL POSITIONING SYSTEM (GPS) COORDINATES

- A. GPS coordinates shall be determined for all new and relocated traffic signal system, ITS, and street lighting facilities that are connected via the underground conduit system(s) and are visible at ground level, including but not limited to poles, pull boxes, splice vaults, cabinets, and service pedestals.
- B. The GPS coordinates shall be submitted to the Engineer in a format specified in the Contract Documents or by the Maintaining Agency, at the end of the project prior to final acceptance. The Engineer will forward the data to the Maintaining Agency.

02MATERIALS

623 G.02.01 CONDUIT

- A. Underground conductors shall be installed in polyvinylchloride (PVC) conduit unless otherwise specified in the Special Provisions or the Drawings.
- B. Conduit shall be listed by the Underwriters Laboratories, Inc., and shall bear the UL label on each length.
- C. Signal conductors and low voltage conductors shall not be installed in high voltage light standards.
- D. The conduit sizes to be used shall be as indicated in the Contract Documents.
 - 1. Conduit sizes shall be 1-1/4 inches minimum nominal diameter for street light conduit, and 2 inches or larger minimum nominal diameter for all other conduit, unless the proposed raceway is attaching to an existing raceway that is smaller or as directed by the Engineer.
 - 2. The size of the existing conduit shall always be matched when connecting conduit to an existing raceway.
 - 3. Conduit reducers shall not be installed.
- E. The Contractor may, at no additional cost to the Contracting Agency and with Engineer approval, use larger size conduit, and where used, it shall be for the entire length of the run from outlet to outlet with no reducing couplings permitted.
- F. PVC coated rigid steel conduit shall consist of galvanized rigid steel conduit conforming to applicable federal specifications and Underwriters Laboratories.
 - 1. The exterior surface of the conduit shall be acid-treated to provide an acceptable surface for plastic coating with a heat polymerizing lacquer with a thickness not to exceed 0.0005-inch thick.
 - 2. A polyvinyl chloride compound shall then be bonded to the prepared conduit with a thickness not less than 0.035 inch for the full length of the conduit except the threads.
 - 3. The bond between the metal and the plastic shall be equal to or greater than the tensile strength of the plastic coating.
 - 4. In addition, the PVC compound shall have the following physical characteristics:
 - a. Hardness: 85+ Shore A Durometer
 - b. Dielectric Strength: 400 (Volts/mil @ 60 cycles)
 - c. Tensile Strength: 3,500 psi
- G. All 90-degree elbows and all other conduit bends of 45 degrees or more installed as part of electrical raceways exceeding 300 feet in length and that are to be used as traffic signal or traffic signal interconnect components shall be PVC coated rigid steel, unless otherwise specified in the Contract Documents or directed by the Engineer. The minimum radius for 90-degree elbows (or equivalent combination of smaller bends) for traffic signal cables shall be 18 inches.
- H. Bell end fittings shall be provided on PVC extensions to rigid steel conduit bends installed in traffic signal cabinets.

- I. End caps with "J" hooks in place to secure the bonding ground wire shall be installed on all spare conduits as directed and to the satisfaction of the Engineer.
 1. All traffic signal and street lighting conduits shall have at least one Green No. 8 AWG wire installed, as tracer wire.
 2. ITS conduit shall have a 6-pair, REA Specification PE-39, No. 22 AWG Twisted Wire Pair cable installed, in lieu of the Green No. 8 AWG Bond Grounding conductor.

623 G.02.02 PULL BOXES

- A. Pull boxes shall be precast reinforced concrete or composite boxes of the sizes and details shown on the Drawings and Standard Drawings.
 1. Reinforcement shall have an H-20 rating.
 2. Sides and/or ends of pull boxes shall not be tapered for additional strength.
 3. Pull box dimensions shall be constant for the full depth of the pull box.
- B. Steel, cast iron, or non-conductive lids shall be used as specified in the Contract Documents or directed by the Engineer.
 1. Concrete pull box covers are not allowed.
 2. Pull box covers shall be inscribed "TRAFFIC SIGNAL," "STREET LIGHTING," or "FIBER OPTIC" as appropriate, unless otherwise specified in the Contract Documents or directed by the Engineer.
 3. Pull boxes intended for voltages over 600 volts shall be inscribed "HIGH VOLTAGE."
 4. Pull box covers inscribed "ELECTRICAL" shall not be permitted.
 5. Pull boxes for installation in bridges and bridge parapets shall conform to the dimensions and locations shown on the Drawings.
 6. Boxes or vaults formed in concrete shall have metal frames and covers.
- C. The dimensions of all pull boxes and covers shall be manufactured and delivered as shown in the Uniform Standard Drawings within a tolerance of 1/8 inch.
- D. All ITS communication facilities shall be installed in accordance with **Sections [680](#), "Fiber Optic Cable," and [681](#), "Fiber Optic Splice and Distribution Equipment."**
- E. Enclosures for termination of traffic signal electrical raceways that cross under all roadways shall be a bottomless 24-inch deep P-30 with a nonconductive lid, or a double stacked No. 7 pull box with grounded steel covers with the legend "TRAFFIC SIGNAL," as specified in the Contract Documents or as directed by the Engineer.
- F. All metal parts shall have provisions for attaching a grounding conductor.
- G. All metal pull box lids shall be connected to the bonding ground using bare 7-strand No. 4 AWG copper conductor.
 1. The grounding conductor shall be welded to the underside of the metal pull box cover by the Contractor or manufacturer using an exothermal welding process unless otherwise specified in the Contract Documents.
 2. The grounding conductor shall have a length of 24 inches above the surrounding grade line.

- H. Existing soils may be used for pull box bedding, unless otherwise specified in the Contract Documents or directed by the Engineer.
- I. Pull boxes installed in undeveloped areas shall have a minimum of an 8-inch concrete collar installed at the top of the pull box, at the final grade, as noted in the Uniform Standard Drawings.
- J. Conduit ends shall be sealed with fittings, caps, or conduit sealant to prevent conduits from being filled with sand and gravel. Conduit ends, fittings, and duct seal to be used shall be reviewed and approved by the Engineer prior to installation.
- K. The Contractor shall not modify pull boxes.

623 G.02.03 EXPANSION FITTINGS

- A. Expansion fittings shall be installed where the conduit crosses an expansion joint in a structure.
- B. Each expansion fitting shall be provided with a bonding jumper of No. 6 AWG copper wire, or equal, if the expansion fittings are attached to metal conduits that are grounded.
- C. Expansion fittings to be used where the conduits exit a structure or bridge abutment shall be reviewed and approved by the Engineer prior to installation.

623 G.02.04 CONDUCTORS AND CABLE

- A. Conductors and cable shall conform to the following specifications:
 - 1. Copper wire shall conform to the applicable portions of ASTM D2220, ASTM B3, and ASTM B8.
 - 2. Insulation for multiple circuit lighting conductors shall be rated at 600 volts, 194 degrees F minimum. Lighting conductors shall be 7-strand No. 4 AWG copper wire with THW-2 or XHHW-2 insulation, unless otherwise shown in the Drawings or indicated herein.
 - 3. Conductors for series lighting shall be No. 6 AWG or No. 8 AWG stranded copper wire insulated with 10/64-inch FAA approved polyethylene compound and rated at 5,000 volts for underground circuits. Conductors for overhead series lighting shall be No. 6 AWG or No. 8 AWG solid, hard-drawn copper.
 - 4. Electrical cable for traffic signals shall be IMSA 20-1 approved signal cable of proper size for the required installation unless otherwise specified in the Contract Documents. All traffic signal cable shall be 25-conductor, No. 12 AWG stranded or No. 14 AWG solid copper wire traffic signal cable as specified in the Contract Documents or directed by the Engineer.
 - 5. All traffic signal field cables and conductors entering the traffic controller cabinet shall be permanently labeled in the cabinet with their purpose or function and which pole is being serviced.
 - a. The wires shall be identified using 1-inch wide UV resistant marking tape and a black marker recommended by the tape manufacturer.
 - b. The tape shall be secured in place using a clear heat-shrink tubing that extends 1 inch past the marking tape along the cable to prevent moisture and dirt penetration.

6. Interconnect cable shall be 6-pair, 22 AWG filled telephone cable in accordance with REA Specification PE-39, current edition, unless otherwise specified in the Contract Documents or directed by the Engineer.
 - a. Splices in the interconnect cable are prohibited.
 - b. The cable shall be terminated only in the traffic signal controller cabinet or separate interconnect pull box unless otherwise approved and directed by the Engineer.
 - c. Intersection street light conductors shall be wired in accordance with the Contract Documents or directed by the Engineer.
7. Insulation for service feeds between the transformer and the service pedestal or pole shall be rated at 600 volts, 194 degrees F minimum.
 - a. Conductors shall be a minimum stranded No. 3/0 AWG copper wire with THW-2 or XHHW-2 insulation, unless otherwise specified in the Contract Documents or directed by the Engineer.
 - b. Copper wire shall conform to the applicable portions of ASTM D2220, ASTM B3, and ASTM B8.
8. Loop lead-in cable shall be IMSA 50-2, 12 AWG stranded tinned copper in accordance with ASTM B33.
 - a. The insulation shall be high molecular weight polyethylene in accordance with ASTM D1248.
 - b. One conductor shall have black insulation and the other shall have clear insulation.
 - c. The shield shall be helically applied with stranded, tinned copper drain wire.
 - d. The overall jacket shall be polyethylene with a 600-volt, 140 degrees F rating.
 - e. The wires shall be twisted a minimum of once every foot of length in accordance with IMSA 50-2.
9. Loop wire other than preformed loops for installation in saw cuts shall meet IMSA 51-5.
 - a. Loop wire shall be single conductor No. 14 AWG, copper wire with 19 strands.
 - b. The insulation shall be 15 mils of black PVC complying with UL 62 with an overall jacket of clear nylon in accordance with ASTM D4066.
 - c. The wire shall be rated for 600 volts and have a nominal OD of 0.25 inch.
 - d. The cable-in-duct system shall meet the performance tests as specified in NEMA standards.

623 G.02.05 SERIES STREET LIGHTING

- A. Overhead wire shall be No. 6 AWG Medium Hard Drawn (MHD) solid bare copper continuous from standard to standard with no splices.
- B. Double wire circuits shall have pressed steel conductor arms at 45 degrees from the pole and 180 degrees from the direction of service.

- C. Where overhead lines change direction, up to 45 degrees, the lines shall be bisected by rotating feeder arms; for angles of change greater than 45 degrees, an additional set of feeder arms shall be provided to maintain proper wire separation.
- D. Underground series wires shall be No. 6 AWG stranded copper with 10/64-inch FAA approved polyethylene compound rated for 5,000 volts.

623 G.02.06 COLOR CODING

- A. For traffic signals and signs, insulation shall be of solid color, or of basic colors with a permanent colored stripe, to identify conductors as detailed below, unless otherwise specified.

CONDUCTORS COLORS AND SEQUENCE I.M.S.A. SPECIFICATIONS 19-2 OR 19-1

Conductor	Base Color	First Tracer
1	Black	
2	White	
3	Red	
4	Green	
5	Orange	
6	Blue	
7	White	Black
8	Red	Black
9	Green	Black
10	Orange	Black
11	Blue	Black
12	Black	White
13	Red	White
14	Green	White
15	Blue	White
16	Black	Red
17	White	Red
18	Orange	Red
19	Blue	Red
20	Red	Green
21	Orange	Green
22	Black	
23	White	
24	Red	
25	Green	

623 G.02.07 ELECTRICAL SERVICE PEDESTALS

- A. Electrical service pedestals to be installed for traffic signals or street lighting systems shall be 120/240-volt, 200-amp, 3-wire, single phase with a 4-jaw meter socket, unless otherwise specified in the Contract Documents.
- B. The main breaker shall be rated for 200 amps, unless otherwise specified in the Contract Documents, or as directed by the Engineer.

- C. The main enclosure of the pedestal shall be a rainproof NEMA Type 3R cabinet with construction complying with UL 50 requirements.
- D. The main body of the pedestal shall be fabricated of 12 gauge metal, corrosion resistant, zinc plated steel with a vandal resistant main door to provide interior access to the breaker compartment and vandal-resistant hood door for access to the meter.
 - 1. A dead-front door shall be provided behind the main door to enclose the internal wiring compartment.
 - 2. Both the main and dead-front doors shall be connected to the main body or frame of the service pedestal by use of stainless steel piano hinges.
 - 3. A twisting lock mechanism shall be provided to secure the dead-front door to the main frame.
 - 4. The hood door protecting the service meter shall be hinged to the main body of the pedestal with a stainless steel piano hinge and include an exterior handle to assist in lifting the hood.
 - 5. The hood door and both hinged doors shall be constructed from 14 gauge, corrosion resistant, galvanized steel.
 - 6. A padlock hasp shall be provided for securing the hood door and the main door.
- E. The overall dimensions of the enclosure shall be 16-1/2 inches wide, 48 inches high, and 17-1/2 inches deep.
- F. A removable utility door shall be provided in the back of the pedestal to allow service to the utility landing lugs. A padlock hasp shall be provided to lock the door in place.
- G. The overall exterior dimensions of the service pedestal shall be 48 inches tall, 16 inches wide, and 18 inches deep.
 - 1. The dimensions of the pedestal shall be within a tolerance of 15 percent.
 - 2. The anchor bolt pattern shall be 14-1/2 inches wide and 12-1/2 inches deep with a 1/2-inch tolerance.
- H. A photocell window shall be provided on the side of the main section of the service pedestal with a clear plastic window material. A protective cover or louvered vents shall be provided for the photocell window to protect the window from vandalism yet allow the PEC to function properly.
- I. All fasteners including rivets, screws, nuts, and bolts shall be stainless steel.
 - 1. Pedestal anchor bolts shall be hot dip galvanized 3/8 inch by 18 inches by 2 inches with corrosion resistant washers and nuts.
 - 2. Anchor bolts shall be interior to the main body of the pedestal.
- J. The main body of the pedestal, the hood, and the main door shall be as specified in the Contract Documents or as directed by the Engineer.
 - 1. The dead-front door shall be polyurethane powder coated inside and out with a gloss white coating.
 - 2. All finishes shall consist of Federal specification 595 polyurethane, industrial grade powder paint with 1.7-mil thickness minimum.
- K. The internal wiring shall be completed with copper conductors rated for 194 degrees F, THW-2 or XHHW-2 insulation, and rated for 600 volts. The wire shall be sized in

accordance with the *National Electrical Code* and Underwriters Laboratories, Inc., except that wire to the street light contactors shall be No. 4 AWG stranded copper with THW-2 or XHHW-2 insulation and wired at the factory.

- L. The pedestals shall be assembled by a manufacturer recognized and endorsed by Underwriters Laboratories, Inc. and shall be marked with the UL stamp of approval on the inside of the main door.
- M. The pedestals shall incorporate a copper main load center, which may be raw copper or tinned.
 - 1. Bus bars for grounding and neutral connections shall be raw copper or aluminum, with facilities for landing a minimum of two No. 1/0 AWG conductors, six No. 2 AWG to No. 12 AWG conductors, and twelve No. 4 AWG to No. 14 AWG conductors.
- N. The pedestal shall be designed to accept GE type THQL or equivalent breakers and shall be equipped as specified in the Contract Documents or directed by the Engineer.
- O. The pedestal shall incorporate a single photocell for controlling both 2-pole, 60-amp lighting circuits.
 - 1. Each lighting circuit shall have a separate test toggle switch (or toggle switch position) rated for 15 amps with sealed leads for testing the circuit during maintenance activities.
 - 2. The test switch shall be affixed to the frame of the pedestal and extend through the dead-front door to be accessible by opening only the main door.
 - 3. The photocell shall be Area Research Lighting model SST-VP-IES, or approved equal.
- P. The utility landing lugs shall be raw copper, aluminum, or zinc coated, as specified in the Contract Documents or directed by the Engineer, and shall be capable of receiving the appropriate sized wire from the transformer as noted on the Drawings.
- Q. When specified, double meter service pedestals shall conform to all requirements of the standard pedestals for each side of the metered section. The overall dimensions of the enclosure shall be 24 inches wide, 48 inches high, and 17 inches deep.
- R. Appropriate labels shall be attached to the inside of the main door including a listing of circuit breakers from various manufacturers that are interchangeable with those supplied in the cabinet. A circuit diagram shall be attached to the front door.
- S. An instruction manual shall be provided with the service pedestal.
 - 1. The manual shall include installation and maintenance instructions and shall contain a wiring diagram of the pedestal and a listing of available circuit breakers to be used in the pedestal.
 - 2. A holding compartment shall be provided on the inside of the door to contain the manual and other plans.
 - 3. A resealable plastic storage bag to hold the manual safe from the environment shall be provided.

03CONSTRUCTION

623 G.03.01 MAINTENANCE OF EXISTING AND TEMPORARY ELECTRICAL SYSTEMS

- A. Existing electrical systems including but not limited to traffic signals, ramp metering, highway and street lighting, flashing beacons, school flashers, ITS communications facilities, and sign illumination, or approved temporary replacements thereof, shall be kept

in effective operation for the benefit of the traveling public during the progress of the work, unless prior written authorization is provided by the Engineer to allow for alterations or final removal of the systems.

1. Traffic signal shutdown shall be as directed by Engineer and in the presence of the Maintaining Agency representative.
 2. Lighting system shutdowns shall not interfere with the regular lighting schedule, unless prior authorization is provided by the Engineer.
 3. The Contractor shall request permission from the Engineer and notify the Maintaining Agency in writing 5 normal working days, excluding legal holidays, prior to performing any work on existing electrical systems, including traffic signals and street light systems.
 4. Contractors shall not access traffic signal control cabinets without obtaining permission from the Maintaining Agency.
- B. The Contractor shall submit three 24-hour telephone numbers of responsible Contractor personnel to be contacted in the event there are conflicts while the electrical system is being modified.
- C. The Contractor shall repair or replace any damages caused by Contractor's construction activities to the existing electrical systems and to other public owned facilities in the area, at the direction of the Engineer.
1. These damaged facilities shall be repaired promptly and at the expense of the Contractor in accordance with the Contract Documents, and as directed by the Engineer.
 2. Should the Contractor fail to perform the required repairs or replacements, the cost of performing such repairs or replacements will be deducted from any monies due or to become due the Contractor or related performance bond.
 3. The cost of repairs may include reimbursement of Contracting and Maintaining Agency personnel wages and materials and/or the cost of other contractors hired by the Contracting Agency to repair the damages caused by the Contractor.
- D. The exact location of existing conduits and pull boxes shall be ascertained by the Contractor before using equipment that may damage such facilities or interfere with any system.
- E. Where roadways are to remain open to traffic and existing lighting systems are to be modified, the lighting systems shall remain in operation and the final connection to the modified circuit shall be made so that the modified circuit will be in operation by nightfall of the same day.
- F. Temporary electrical installations shall be kept in effective operation until the temporary installations are no longer required for the traveling public.
- G. These provisions will not relieve the Contractor in any manner of Contractor's responsibilities as provided in ***Subsections 107.11, "Responsibility for Damage Claims," and 107.16, "Contractor's Responsibility for the Work and Materials."***
- H. A temporary overhead cable system may be used for the existing signal system circuitry in lieu of maintaining the underground installations during construction, if authorized in writing by the Engineer.
- I. Where an existing system is being modified, work not shown on the Drawings or specified in the Special Provisions and which is determined by the Engineer as extra work

necessary to keep all or any part of the existing system in effective operation and safe to the public and maintenance personnel shall be measured and paid for in accordance with ***Subsection 109.03, "Extra and Force Account Work."***

623 G.03.02 MAINTAINING EXISTING INTELLIGENT TRANSPORTATION SYSTEM (ITS) FACILITIES

- A. ITS communications facilities including, but not limited to, copper wire, fiber optic, microwave, radio systems and the electrical services supplying power to same shall be maintained at all times.
 - 1. Any damage to the ITS system of communication cable is considered to be an emergency and liquidated damages of \$2,500 per day for copper cable and \$7,500 per day for fiber optic breaks shall be assessed to the Contractor by the Contracting Agency beginning 24 hours after the conduit or cable damage.
 - 2. The outer jacket of cable insulation shall remain intact without nicks or scrapes or other damage that may compromise the insulating qualities to avoid replacement of the entire interconnect cable.
- B. A conduit break may be considered the same as a cable break.
 - 1. Conduit breaks shall be repaired by first removing the entire length of interconnect cable before repairing the conduit as directed by the Engineer.
 - 2. The interconnect conduit may then be replaced in the electrical raceway after proven to be undamaged by testing as specified herein for new line installations.
- C. The exact location of existing ITS communications system conduits and pull boxes shall be determined by the Contractor before using any equipment that may damage ITS facilities or interfere with Contracting Agency, Maintaining Agency, or FAST operations. Any damage to any ITS communications cable is considered by the Contracting Agency to constitute an emergency.
- D. Where damage to ITS facilities is caused by the Contractor's operations, the Contractor shall, at no additional cost to the Contracting Agency, begin temporary repairs immediately after the damage occurs and shall proceed with repairs expeditiously until complete.
 - 1. All fiber optic repairs shall be performed in accordance with ***Sections 680, "Fiber Optic Cable,"*** and ***681, "Fiber Optic Splice and Distribution Equipment."***
 - 2. Damaged ITS communications infrastructure shall be repaired by the Contractor within 24 hours of discovery.
 - 3. If the Contracting Agency or the Regional Transportation Commission of Southern Nevada (RTC) determines that the need for repairs are critical, the Contracting Agency or the RTC may begin the work of repairing any damage to the ITS communications facilities within the 24 hours of discovery. The Contracting Agency or the RTC may seek direct reimbursement from the Contractor causing the damage to recover the costs in repairing the damaged ITS communications infrastructure.
- E. Should the Contractor fail to perform the required repairs or replacements to ITS communications infrastructure within the 24-hour period, the Contracting Agency or the RTC may elect to repair the damage using any means possible and the cost of performing such repairs or replacements will be deducted from any monies due or to become due the Contractor, including performance bonds. The Contracting Agency or the RTC may seek

direct reimbursement from the Contractor to recover the costs in repairing the damaged ITS infrastructure.

- F. No splices shall be permitted, unless otherwise permitted in writing by the Engineer in consultation with the FAST Director or designee.
- G. The No. 22 AWG copper interconnect cable shall meet the FAST Specification with a DC resistance of 17.4 ohms/1,000 feet at 68 degrees F. Any cable exhibiting a DC resistance in excess of 18.3 ohms/1,000 feet at 68 degrees F in more than 1 pair of conductors shall be deemed to be damaged when tested and shall be replaced.
- H. Temporary repairs of damage to an extended length of ITS cable or damage at more than a single discrete point may consist of placing cable overhead until permanent replacement is completed.
 - 1. The Contractor shall provide temporary overhead interconnect if necessary while the permanent cable is being relocated or replaced.
 - 2. All temporary aerial installations shall be approved by the Maintaining Agency and FAST and shall be installed as directed by the Engineer.
- I. Permanent restoration of a damaged ITS copper wire interconnect shall be made by removing the damaged cable and replacing with a new cable conforming to REA Specification PE-39, 22 AWG, between the nearest existing terminal boards housed in traffic signal controller cabinets, junction cabinets, or an engineering office at each end of the damaged cable run as determined by the Engineer. The new cable shall be tested after installation for acceptable conductance and continuity to ensure no insulation damage occurred during the installation process.
- J. All damaged ITS cable removed from the system under any of the restoration methods shall be removed from the conduit in continuous lengths, wound on a reel, and returned to the Maintaining Agency.
- K. All cable repairs or restoration to ITS facilities shall be made under inspection by FAST or personnel from the Maintaining Agency in whose jurisdiction the repair is being made.
- L. All materials, equipment, and workmanship incorporated into any cable repair or restoration of ITS facilities shall be guaranteed for a period of 1 year after the final acceptance of the work or equipment.
 - 1. If during the guarantee period any defects or faulty materials are found, the Contractor shall immediately, upon notification by the Engineer, proceed at Contractor's own expense to replace and repair the defective materials and faults.
 - 2. The Contractor shall also be responsible for complete repair to damage of all finishes, fixtures, equipment, and furnishings that may be damaged as a result of this defective equipment and/or workmanship including but not limited to removal and replacement of sidewalks, curb and gutter, and roadway pavement.

623 G.03.03 SCHEDULING OF WORK

- A. Traffic signals shall not be placed in operation for use by public traffic without the energizing of street lighting at the intersection to be controlled if street lighting exists or is being installed in conjunction with the traffic signals.
- B. Traffic signals shall not be placed in operation until all discrepancies are corrected, all appropriate roadway pavement markings and signs are in place, and the roadways to be controlled are open to public traffic, unless otherwise directed by the Engineer.

- C. Roadway lighting and traffic signals shall not be placed in operation, including flashing operation, prior to delivery of a full set of redlined drawings to and the successful completion of required tests performed in the presence of the Maintaining Agency's authorized representative. This does not preclude the preparation and submittal of as-built Drawings.
- D. Any fault in any material or in any part of the installation revealed by these tests shall be replaced or repaired by the Contractor or vendor immediately.
 - 1. Electrical equipment and components shall not be energized until properly grounded as shown in the Contract Documents or directed by the Engineer.
 - 2. All repairs and material replacements shall be completed as directed by the Engineer.
- E. Conductors shall not be pulled into conduit until pull boxes are set to grade, conduit trenches backfilled and compacted, crushed rock sumps installed, and metallic conduits properly grounded.
- F. Under-Deck Lighting and Lighting for Pedestrian Structures:
 - 1. Under-deck lighting for vehicular under-crossings shall be placed in operation as soon as practicable after false work has been removed from the structure.
 - 2. Lighting for pedestrian structures shall be placed in operation prior to opening the structure to pedestrian traffic.
 - 3. If the Engineer orders under-deck lighting or lighting for pedestrian structures placed in operation before permanent electrical service is available, the cost of installing and removing temporary electrical service will be paid for as extra work as provided in **Subsection 104.03, "Extra Work."**
- G. Traffic and pedestrian signals that have been installed and have not yet been energized shall be covered with durable, reusable bright orange traffic and pedestrian head covers, unless otherwise specified in the Contract Documents or directed by the Engineer.
 - 1. Plastic bags shall at no time be used to cover traffic or pedestrian heads.
 - 2. At no time shall traffic and/or pedestrian signals that have been installed and are not in operation remain uncovered.
 - 3. Emergency signals that have not been energized shall also be covered.
 - 4. The color of the signal section shall be visible when energized for testing.
 - 5. Covers shall be mechanically fastened; however, Velcro is not acceptable.
 - 6. The temporary coverings remain the property of the Contractor until the signal is energized and accepted by the Maintaining Agency, at which time the coverings become the property of the Maintaining Agency.
 - 7. The Contractor shall maintain the coverings in proper condition at all times until final acceptance.
 - 8. Coverings that are ripped, torn, shredded, or otherwise allowing any portion of the signal lens to be seen by the public shall be immediately replaced.
 - 9. Coverings that are not replaced immediately shall be replaced by the Contracting Agency and the cost of the covering replacement shall be deducted from any unpaid invoices that have been or will be submitted to the Contracting Agency by the Contractor.

623 G.03.04 HIGH VOLTAGE SAFETY PRECAUTIONS

- A. Before starting work on existing series street lighting circuits, the Contractor shall obtain a daily safety circuit clearance from the Maintaining Agency.
- B. The electrical bypass control shall be switched to the "off" position, fuses shall be removed, and signs posted at the switch box before any work is done.
- C. The Occupational Safety and Health Administration (OSHA) procedure for "lock-out, tag-out" shall be followed in strict compliance for all series street lighting circuits.

623 G.03.05 EXCAVATING AND BACKFILLING

- A. Excavations required for the installation of conduit, foundations, and other facilities shall be performed in a manner to cause the least possible damage to the streets, sidewalks, and other improvements, including private property.
 - 1. Excavations shall not be larger than necessary for the proper installation of conduit, electrical facilities, and foundations.
 - 2. Excavating shall not be performed until immediately before installation of conduit, facilities, and foundations.
- B. Excavations shall not remain open overnight except as approved by the Engineer and only when adequate protection for the public, including pedestrians, is provided.
- C. The material from the excavation shall be placed in a position where the least disruption and obstruction to vehicular and pedestrian traffic will be realized and the least interference with surface drainage will occur.
- D. Surplus excavated material shall be removed and disposed of by the Contractor outside of the right-of-way.
- E. At the end of each day's work, and at other times when construction operations are suspended, equipment and other obstructions shall be removed from the right-of-way.
- F. Structural excavation and backfill shall conform to the requirements of **Sections 206, "Structure Excavation,"** and **207, "Structure Backfill."**
- G. Trench excavations shall be backfilled in conformance with the requirements of **Section 208, "Trench Excavation and Backfill."**
- H. Backfilled excavations shall be kept well filled and maintained in a smooth and well-drained condition, until permanent resurfacing is completed as specified in **Subsection 208.03.21, "Cutting and Restoring Street Surfacing."**
- I. Unless otherwise specified in the Contract Documents, excavation in the street and highway shall be performed in such a manner that not more than 1 lane of traffic is restricted in either direction at any time, or as approved by the Engineer.
- J. All streets upon or within which any work is being done shall be kept open to all traffic by the Contractor, as specified in **Subsection 104.04, "Maintenance of Traffic,"** unless otherwise provided in the Special Provisions, or as approved by the Engineer.
- K. Surface and underground materials, irrigation systems, utilities, and other constructions shall be restored in kind to or exceeding the original conditions by the Contractor as part of the excavation and backfilling operations.
- L. Barricading shall conform to the latest editions of the Traffic Control Plans for Highway Work Zones for the Clark County Area and the *Manual on Uniform Traffic Control Devices*.

623 G.03.06 REMOVING AND REPLACING IMPROVEMENTS

- A. Improvements, such as sidewalks, curbs, gutters, Portland cement concrete and asphalt concrete pavement, bituminous surfacing, base material, and other improvements removed, broken, or damaged by the Contractor, shall be replaced or reconstructed in compliance with the applicable sections of these specifications.
- B. Whenever a part of a square or slab of existing concrete sidewalk or driveway is broken or damaged, it shall be repaired in accordance with **Subsection 202.03.02, "Removal."**
- C. The outline of all areas to be removed in Portland cement concrete sidewalks and in pavements shall be cut to a minimum depth of 1-1/2 inches with an abrasive type saw prior to removing the sidewalk and pavement material.
 - 1. Cut for the remainder of the required depth may be made by any method satisfactory to the Engineer.
 - 2. Cuts shall be neat and true with no shatter outside the removal area.

623 G.03.07 FOUNDATIONS

- A. Foundations for traffic signal and lighting poles, traffic signal cabinets, and service pedestals shall be concrete conforming to **Section 501, "Portland Cement Concrete."**
- B. For posts, poles, and pedestals, a 4-inch minimum foundation cap or crash cap consisting of grout or concrete as specified in the Contract Documents or directed by the Engineer shall be poured after the post, pole, or pedestal is in proper position.
 - 1. Grout shall not contain coarse aggregate and shall conform to **Subsection 501.03.12, "Mortar."**
 - 2. Grouting material to be used for the crash cap may be mixed by the Contractor on-site as directed by the Engineer.
- C. The bottom of concrete foundations shall rest on firm, undisturbed ground.
 - 1. In addition, for traffic signal foundation installations, the bottom 2/3 of the concrete foundation shall be poured against undisturbed soil.
 - 2. If the signal foundation is to be placed in an area which has been filled, the fill shall be compacted to 95 percent of the original compaction as specified elsewhere in these specifications and the bottom 2/3 of the foundation shall be poured in drilled 95 percent compacted fill.
 - 3. Forms shall be true to line and grade.
 - 4. Tops of footings for posts and poles, except special foundations, shall be finished 1 inch above grade of curb or sidewalk or as directed by the Engineer.
 - 5. The exposed portions of the foundations shall be formed to present a neat appearance.
- D. Forms shall be rigid and securely braced in place.
 - 1. Conduit ends and anchor bolts shall be held in place by means of a template until the concrete sets.
 - 2. Both forms and soil which will be in contact with the concrete shall be thoroughly moistened before placing concrete.
 - 3. Forms shall not be removed until the concrete has thoroughly set.

- E. Standard surface finish shall be applied to exposed surfaces of concrete. All top surface areas of traffic signal cabinet bases and service pedestals shall be smoothed finished with a trowel.
- F. Where the edge of a concrete foundation extends within 18 inches of any existing concrete improvement, a slab with a minimum thickness of 4 inches shall be extended to meet the existing improvement.
- G. Traffic signal cabinets shall have a 4-inch thick concrete slab installed in front of the cabinet.
 - 1. The concrete slab shall be as wide as the signal cabinet foundation and a minimum of 4 feet in length from the cabinet base.
 - 2. The cost of this concrete slab shall be incidental to the cost of the foundation.
- H. Electrical service pedestals installed in remote locations where sidewalk does not exist shall also have a concrete slab.
 - 1. The concrete pad shall be a minimum of 2 feet on each side of the pedestal foundation and 4 feet in front of the electrical service pedestal.
 - 2. The concrete slab shall be 4 inches thick.
 - 3. The cost of the concrete pad shall be incidental to the cost of the pedestal foundation.
- I. Concrete for Type XX poles, XX-A poles, and XX-B poles shall set for a minimum of 10 days unless otherwise approved by the Engineer. Concrete for smaller bases shall set for a minimum time of 72 hours.
- J. Concrete foundations shall be installed in accordance with all pertinent sections of these specifications and the Uniform Standard Drawings. Minimum concrete curing times before live loads can be set on the foundation shall be as specified therein and as directed by the Engineer.
- K. Traffic signal and luminaire arms shall be considered live load and may be mounted on the poles only after the concrete foundations have set for the minimum curing times as prescribed in **Sections 501, "Portland Cement Concrete,"** and **502, "Concrete Structures."**

623 G.03.08 WIRING AND CONDUIT

- A. Wiring shall conform to appropriate articles of the latest version of the *National Electrical Code* (NEC).
 - 1. Wiring within cabinets, junction boxes, and so forth shall be neatly arranged.
 - 2. Powdered soapstone, talc, or other approved lubricant shall be used when installing conductors in conduit.
 - 3. Any excess lubricant shall be removed as directed by the Engineer.
 - 4. All conduits shall be PVC unless otherwise specified in the Contract Documents.
- B. Each conductor shall have a minimum of 18 inches of slack coiled within each standard and at least 2 feet of slack coiled in each pull box. The length of slack shall be that amount of extra conductor that is available to be pulled completely out of the pole shaft or pull box.
- C. Series lighting cable shall be installed without splices from luminaire to luminaire and from service to luminaire unless otherwise specified.

1. Multiple lighting conductors may be spliced in the base of standards or in pull boxes adjacent thereto.
 2. Signal cable shall run from terminal to terminal without splices unless otherwise indicated on the Drawings.
- D. Splices for street light cables shall be split bolt or "gel-cap" type unless otherwise specified in the Contract Documents or directed by the Engineer.
1. The gel-cap type shall consist of a kit containing a high abrasive and impact resistant clear elastomer cap factory-filled with cross-linked silicon gel for environmental sealing.
 2. The silicon gel shall not become hard or brittle and shall have a temperature tolerance of -40 degrees F to +221 degrees F.
 3. The cap, clamp, and gel used for the gel-type splice kit shall be UV-resistant.
 4. Kits shall contain a split bolt connector and shall accommodate range of cable sizes specified in the Contract Documents or directed by the Engineer.
 5. Gel-cap-type connection shall also permit removal and re-entry of wiring for maintenance purposes without damage to the splice kit.
- E. Conductor connector types to be used shall be approved by the Engineer prior to installation.
- F. When conductors and cables are pulled into the conduit, all ends of the conductors and cables shall be taped to exclude moisture. Ends of spare conductors shall be taped.
- G. All new traffic signal and street lighting conduit for future use shall have a 8 AWG stranded copper conductor with green THW-2 or XHHW-2 insulation which is secured at both ends by a conduit cap with a J-hook.
1. A yellow polyethylene pull string shall also be installed in the conduits for future use.
 2. The 8 AWG green conductor shall remain in the conduit at all times for locating and grounding purposes.
 3. All splices shall be performed using waterproof methods.
- H. The outer jacket of insulation for all multi-conductor traffic signal cable shall be removed from the cable that is interior to the signal poles beginning at the base handhole, unless otherwise directed by the Engineer.
1. The Contractor shall ensure that the proper length of each color of wire is available to route to the appropriate terminal.
 2. Splices and/or wire jumpers between adapter terminals shall not be permitted.
 3. Wiring shall be installed as specified in the Contract Documents or directed by the Engineer.
- I. The Contractor shall always install wire between the pole-mounted "J" box and all spare traffic signal tenons on traffic signal mast arms.
1. These conductors shall be 14 AWG UF wire, and shall be uniquely identified in the J-box.
 2. A minimum of 6 conductors shall be installed for the 2 end spare tenons and 4 conductors for tenons elsewhere on traffic signal mast arms.
 3. All unused tenons shall be sealed with 10 mil tape.

- J. Conductors shall run from terminal to terminal without splices unless otherwise indicated in the Contract Documents or directed by the Engineer.
 - 1. The ends of all conduits shall be well reamed to remove burrs and rough edges.
 - 2. Field conduit cuts shall be made square and true so that the ends will butt or come together for the full circumference in the couplings or adapters.
 - 3. Slip joints or running threads shall not be permitted for coupling metal conduit.
- K. Couplings for steel conduit shall be tightened until the ends of the conduits are brought together, so that a good electrical connection will be made throughout the entire length of the conduit run.
- L. Conduit ends shall be threaded and capped with standard pipe caps until wiring is installed. Approved conduit bushings shall be installed when the caps are removed.
- M. Manual or power-operated equipment normally used for cutting rigid steel conduit is acceptable for use in cutting PVC coated rigid steel conduit.
 - 1. PVC shall not be peeled back before cutting and all cuts shall be reamed.
 - 2. Threading shall be the same as for non-coated rigid conduit.
 - 3. All scarred and grip marked areas shall be touched up with approved heavy consistency coating compound approved by the Engineer.
- N. All couplings and threaded fittings for PVC coated rigid steel shall be hand tightened prior to using a wrench.
 - 1. All wrench marks and scores shall be recoated and joints shall be sealed with heavy consistency PVC compound.
 - 2. The Contractor shall ensure that the final installation does not have exposed metal areas.
- O. Standard field bending techniques shall be used which typically use a shoe 1 size larger to accommodate the larger pipe diameter.
 - 1. Rigid steel conduits shall be bent without crimping or flattening.
 - 2. No single run shall include more than two 45-degree bends and two 90-degree bends without prior approval by the Engineer.
- P. PVC coated rigid steel conduit, 2 inches in diameter or larger, shall be used for all bends, except for 90-degree bends at street light pole and service pedestal foundations where separation to the intended pull box, cabinet, service pedestal, or traffic signal pole is more than 50 feet. The radius of all 90-degree elbows for traffic signal and ITS conduits shall be a minimum of 24 inches.
- Q. Conduit terminating in pedestals, cabinets, traffic signal poles, and lighting poles shall be a minimum of 2 inches in diameter, unless otherwise specified on the Drawings, and shall extend 2 to 3 inches above the foundation or crash cap, whichever is higher.
 - 1. The conduits shall be straight.
 - 2. Conduits shall not extend above the lower handhole rim or grounding connection, whichever is lowest.
- R. Traffic signal and roadway lighting conduit shall enter concrete pull boxes from the bottom and shall terminate at least 2 inches inside the box wall and 4 to 6 inches above the bottom of the pull box.

1. There shall be at least 6 inches of clearance between the top of the conduits and the bottom of the pull box cover.
 2. The conduits shall be installed to facilitate pulling of conductors.
 3. Conduit entering the bottom of a pull box shall be located near the end walls to leave the major portion of the box clear.
 4. At all outlets, conduit shall enter from the direction of the run.
 5. ITS communications installations may allow entry in the side of the pull box or communications vault.
- S. Conduits shall be lowered as necessary in the vicinity of poles, posts, pull boxes, electrical vaults, and other electrical enclosures for the conduits to facilitate entrance into the enclosure.
1. The Contractor shall not modify traffic signal/roadway lighting pull boxes, electrical vaults, signal or lighting poles or posts, cabinets, pedestals, or any other electrical device for the purpose of entering the device with the conduits without written approval of the Engineer.
 2. ITS communications installations may be field modified only with the approval of and as directed by the Engineer.
 3. All entry points shall be sealed and form fitted with grout or other acceptable material approved by the Engineer.
- T. Existing underground conduit to be incorporated into a new system shall be cleaned by blowing out with compressed air, or by other methods required by the Engineer.
- U. Conduit runs shown on the Drawings are for bidding purposes only and may be changed with the approval of the Engineer to avoid underground obstructions.

623 G.03.09 ELECTRICAL SERVICE

- A. Electrical service points, when required for street lighting, traffic signals, and other electrical constructions in the road right-of-way, shall be as indicated on the Drawings.
- B. Electrical service points for electrical systems, including but not limited to traffic signals, street lighting, school flashers, pedestrian crossing flashers, emergency signals, sign lighting, and high mast lighting, shall be coordinated with the power company by the Contractor and constructed where indicated on the Drawings.
1. Alternate service locations approved by the power company may be adopted as directed by the Engineer.
 2. Traffic signal electrical services shall be as shown on the Drawings unless otherwise approved and directed by the Engineer.
 3. Street lighting electrical services shall be as close to the center of the circuit or system as possible.
- C. Pad-mount services, when called for, shall conform to the Uniform Standard Drawings as applicable.
- D. The Contractor shall furnish and install conduit and conductors to the service point as shown on the Drawings or as required to complete the installation, but under no circumstances shall the conduit and conductor sizes be less than the minimum sizes shown in the Uniform Standard Drawings. A No. 5 pull box shall be installed directly in front of the service pedestal with conduit stubbed from the load side of the pedestal.

- E. Electrical conductors for service shall have THW-2 or XHHW-2 insulation and shall be 3/0 AWG, stranded, copper wire unless otherwise specified in the Contract Documents or directed by the Engineer.
- F. Electrical service shall be inspected, approved, and "tagged" by a representative of the Agency authorized to order electrical service.
 - 1. The Contractor shall complete all utility connections, wiring, crash cap, grounding, and bonding within the service pedestal prior to calling for inspection.
 - 2. The Contractor shall conform to the inspection process of the Agency authorized to order electrical service.

623 G.03.10 PULL BOXES

- A. A minimum of 6 inches of clearance shall be maintained between the top of the conduits and the bottom of the pull box cover.
- B. A minimum of 4 inches of conduit shall extend into the pull box.
- C. Conduit caps shall be installed to help prevent the entry of foreign material into the electrical raceway.
- D. Traffic signal and roadway lighting pull boxes shall not be modified by the Contractor.
 - 1. Entry holes into pull boxes and electrical vaults shall be cut or "knock-outs" provided by the manufacturer as designated in the Drawings.
 - 2. ITS communications pull boxes and vaults may be field modified only with the approval of and as directed by the Engineer.
 - 3. All entry points shall be sealed and form fitted with grout or other acceptable material approved by the Engineer.

623 G.03.11 SIGNS ON TRAFFIC SIGNALS

- A. All 24-inch by 30-inch or larger traffic signs mounted on traffic signal mast arms shall include a wind brace, unless otherwise specified in the Contract Documents or directed by the Engineer.
- B. The wind brace shall be equal to a minimum of 1-inch wide by 3/16-inch thick aluminum sheeting material connected to the top and bottom of the sign and wrapped around the mast arm.
- C. There shall be a wind brace installed every 12 inches on the sign panel.

623 G.03.12 ITS COMMUNICATIONS INFRASTRUCTURE

- A. Communications infrastructure installed for the use of the FAST shall meet the following specifications:
 - 1. The communications conduit shall run straight through the pull box, entering the side of the box near the bottom, to allow for a continuous fiber optic pull of no more than 6,000 feet.
 - 2. The cover depth from the finish grade of all conduits shall be a minimum of 30 inches with allowances for conduit to rise near pull boxes for entry points. If conduit exists adjacent to the proposed conduit installation, the depth and location of the end of the new conduit shall be required to match the existing conduit.

3. The installation of a Type 200 Splice Vault as shown in the Uniform Standard Drawings with the letters "FIBER OPTIC" inscribed on the lid shall be as shown on the Drawings. At these splice point locations, a "sweep" with radius of 24 inches minimum shall be installed with the angle of entry/exit conducive to pulling fiber optic cable directly out the lid of the vault without the use of pulleys inside the vault.
4. Innerduct shall not be used unless specifically required in the Contract Documents. If innerduct is proposed, the specific use of each innerduct cavity shall be as identified in the Contract Documents or approved by the Engineer.
5. All buried conduits shall have underground marking tape placed 12 inches above the installed conduit and marked with the letters "FIBER OPTIC." GPS coordinates shall be determined for all new and relocated traffic signal system and street lighting facilities that are connected via the underground conduit system and are visible at ground level as specified in **Subsection 623 G.01.05, "Global Positioning System (GPS) Coordinates."**
6. For roadway projects where the sidewalk, curb, and gutter are already installed and communications facilities are required, the appropriate size conduit may be installed at the lip of gutter as shown on the drawings or as approved by the Engineer.
7. Installation of fiber optic cable shall conform to **Section 680, "Fiber Optic Cable."**
8. Conduit caps with J-hooks to support the interconnect cable shall be installed for all spare conduit openings to prevent the entrance of debris into the electrical raceway.
9. A 6-pair, 22 AWG interconnect cable, complying with REA Specification PE-39, current edition, interconnect cable shall be installed in all ITS conduit runs.

TRAFFIC SIGNAL SECTION

01DESCRIPTION

623 T.01.01 GENERAL

- A. Traffic signal construction shall consist of furnishing, installing, modifying, or removing traffic signals, school flashers, flashing beacons, changeable message signs, traffic count stations, conduits for future traffic signals, and other electrical installations in the roadway right-of-way as shown and specified in the Contract Documents.
- B. The locations of traffic signal poles, controller cabinets, electrical services, and other associated equipment shown on the Drawings are approximate. The Engineer will confirm exact locations of these items in the field.
- C. All materials furnished and used shall be manufactured, handled, and used in a manner to ensure completed work with undamaged equipment and materials in accordance with the Drawings, specifications, and Special Provisions. Engineer approval of all materials shall be required prior to installation.
- D. All systems shall be complete and in satisfactory operating condition at the time of acceptance including successful completion of all testing required by these specifications.
- E. All work performed on any traffic signal component shall be under the direct on-site supervision of an electrician or technician certified by IMSA for Level II Traffic Signals.
 1. Actual trenching and foundation excavation activities are not considered construction labor involving traffic signal components until conduits or other electrical components are installed.

2. An electrician with IMSA Level II Traffic Signal certification shall supervise the installation of electrical raceways.
 3. Traffic signals are defined as all electrical equipment constructed in public right-of-way or easements that are intended to provide control of traffic and shall include but not be limited to school flasher assemblies, advance warning beacons, traffic signal indications assigning right-of-way, school and other crosswalk signals, advance signal flashers, and intersection flashing beacons.
- F. The Contractor is responsible for locating and protecting all underground and aerial utilities and constructions.
1. The exclusion of utilities and other structures on the Drawings or in the Special Provisions does not limit the Contractor's responsibility for these construction elements.

02MATERIAL

623 T.02.01 TRAFFIC SIGNAL CONTROLLER CABINETS

- A. The type of traffic signal controller cabinet to be furnished shall be a Type VIII cabinet, and shall conform to Drawing No. 803 of the Uniform Standard Drawings.
1. This is commonly referred to as an "R" cabinet.
 2. The cabinet shall be fabricated of sheet aluminum.
 3. All external seams exposed to the outside shall be 100 percent welded (no gaps).
- B. All cabinets shall be provided as a complete unit to include all shelves, foundations, anchor bolts with template, a standard number 2 traffic signal cabinet lock, interior cabinet lights, termination strips, cable harnesses, convenience outlets, circuit breakers, load switches, transfer relays, jumpers, completely wired back panel, video and loop detection interface panel and harnesses, loop detector amplifiers, and emergency vehicle detection equipment and interfaces, as a minimum.
- C. Each cabinet shall be weatherproof, properly ventilated, and have at least two 110 CFM ventilation fans, with each fan having an independent thermostat.
- D. The Contract Documents shall specify whether the cabinet finish is painted or polished aluminum.
1. If a painted finish is required, the cabinet finish shall consist of Federal Specification 595 polyurethane, industrial grade pure white powder paint with 1.7 mil thickness minimum or approved equal.
 2. The cabinet shall be finished both inside and out.
- E. Lifting tabs shall be provided on the center and top of both side panels to assist in the placement of the cabinet by overhead supports. The lifting tabs shall not be fillet welded permanently in place.
- F. Cabinets shall be designed to use fully adjustable shelf-mounting rails of uni-strut design.
1. The rails shall be mounted on the interior of each side panel of the cabinet and shall use spring nuts in the rail channels to tighten the bolts that support the shelves.
 2. Cabinets that use carriage bolt assemblies are not acceptable.
 3. There shall be 3 shelves provided with all cabinets.

4. Each shelf shall be 12 inches deep and the full width of the cabinet.
 5. The middle shelf of the cabinet shall have a 30-inch wide, pullout shelf mounted below for use as a laptop computer table.
 6. The pullout shelf shall be manufactured of the same material and shall be the same depth as the supporting shelf.
 7. The pullout computer shelf shall have a compartment for storing cabinet prints that is accessed by lifting the shelf top.
 8. The compartment shall be the full depth of the pullout computer shelf and shall be a minimum of 1-1/2 inches and a maximum of 2 inches in height.
- G. An emergency access shall be provided in the front of the door to allow police personnel to place the signal indications in the red flashing mode of operation. The police panel door shall be hinged to the main door using a stainless steel piano hinge and shall be keyed with a standard police key lock.
- H. All cabinets shall have the door mounted with a stainless steel piano hinge welded or bolted to door and jamb.
1. There shall be a standard multi-point door stop to lock the door open at 45, 90, and 180 degrees and a supplemental, single-arm door stop to add stability to the door when locked open.
 2. The 3-position doorstop shall be mounted at the bottom of the cabinet door and the single-arm door support shall be mounted at the top of the cabinet.
 3. Each doorstop shall be fully retractable so as not to interfere with the door's closing and opening operation.
 4. When specified, a rear access door shall be provided.
- I. Anchor bolt holes in each cabinet shall conform to the anchor bolt pattern specified in Drawing No. 725 of the Uniform Standard Drawings.
1. All cabinets shall be supplied with completely galvanized anchor bolts and foundation/bolt template in accordance therewith.
 2. Modification of the controller cabinet to fit alternate anchor bolt patterns shall not be allowed without prior approval by the Engineer.
- J. Cabinets shall have 2 fluorescent light fixtures with lamps mounted in the cabinet interior.
1. One light shall be mounted over the door, at a location least likely to be damaged, and shall be a minimum of 20 inches in length.
 2. The second fluorescent fixture shall be 15 watt and shall be attached to the bottom of the lowest shelf above the back-panel and field terminals.
 3. Both fixtures shall be switched automatically by the door to illuminate the lights when the door is opened, and de-energize them when the door is closed.
- K. The back panel in each cabinet shall be wired to the NEMA TS 2 Type 2 standard inputs and outputs.
1. Standard NEMA A, B, and C connectors shall be provided for connection to the controller.
 2. The wiring harness for each connector shall provide a termination point onto the back panel for all pins of each connector, including spares or unassigned pins.

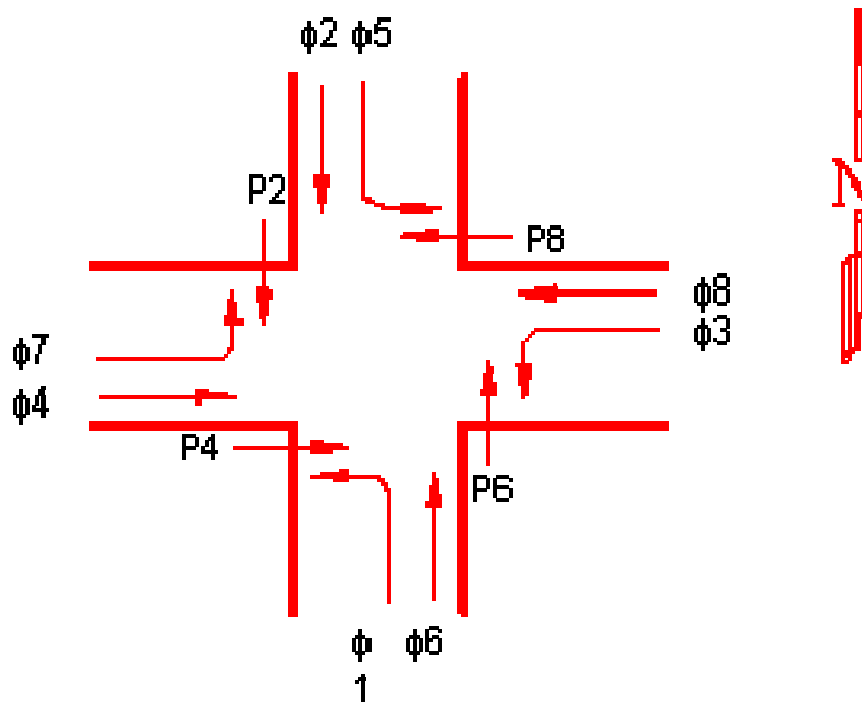
3. The terminals shall be clearly marked as to their associated function, with silk-screened letters and numbers on both sides of the back panel or other pre-approved method of marking.
- L. All traffic signal controller cabinets shall comply with the following conditions:
 1. All cabinet harnesses and wiring shall be neatly and firmly laced or bound together (with tie-rip or other pre-approved equivalent).
 2. Every terminal shall be numbered and identified in accordance with the cabinet wiring diagrams and prints.
 3. Cabinet wiring diagrams shall be supplied with the cabinet that show and identify the connectors for all equipment, and for all switches, terminal blocks, relays, flashers and signal control bases. Supply 2 complete sets of wiring diagrams on 36-inch by 24-inch size paper. A compact disc (CD) with the wiring diagram and cabinet schematic drawn in AutoCAD format shall also be supplied.
 4. The cabinet wiring diagram shall have an intersection sketch with signal heads and push-buttons identified as related to phasing.
 5. The following equipment shall be furnished and wired in all cabinets:
 - a. Three single-pole, surface-mount circuit breakers shall be installed in the controller cabinet to protect the different circuits indicated below.
 - 1) The circuit breakers shall accommodate a No. 1/0 AWG, 7-strand, copper, 600-volt service conductor.
 - 2) A supplemental terminal block may be installed if needed to accommodate the smaller terminal lug sizes.
 - a) One 20-amp circuit breaker to operate all the electronic equipment including the controller, conflict monitor, detection equipment, and preemption equipment and the upper utility plug.
 - b) One 15-amp circuit breaker for the fan, light, and lower utility plug.
 - c) One 40-amp circuit breaker to provide power to illuminate all the field indications at the intersection external from the cabinet.
 - b. There shall be a specific unfused, raw copper terminal, able to accept 1/0 AWG, 7-strand, copper 600-volt power conductor, for the neutral conductor of the power supply line. This terminal point shall be in the Buss 16204-3 terminal block, or approved equivalent, on the side panel of the cabinet.
 - c. There shall be a specific unfused, raw copper terminal, able to accept 1/0 AWG, 7-strand, copper 600-volt power conductor, for the chassis ground wire. This terminal point shall be in the Buss 16204-3 terminal block, or approved equivalent, on the side panel of the cabinet.
 - d. The terminal blocks for connecting the pedestrian and vehicle field wires which illuminate the independent signal heads shall be Thomas and Betts No. 35301, or approved equivalent. The mounting height to the bottom of these terminal blocks shall be between 14 and 18 inches from the bottom of the cabinet base.
 - e. Terminal blocks Cinch 12-142 with Thomas and Betts chair lugs, or approved equivalent, shall be used for connection of pedestrian push button field conductors.

- f. Terminal blocks shall be provided for all pins on wiring harnesses and for all connectors of the cabinet equipment.
 - 1) Separate terminal blocks for termination of the wiring harnesses for the controller, conflict monitor, loop and video detection systems, and emergency vehicle preemption system shall be provided.
 - 2) All connector pins shall be wired to the harnesses and terminated on the appropriate block.
- g. A minimum of two 16-terminal, compression type, copper ground strips shall be mounted to each side of the interior cabinet wall for connection of all neutral conductors.
 - 1) These terminal strips shall not be grounded and will be connected to the terminal block that accepts the #2 stranded wire for the neutral power supply wire.
 - 2) The terminal strips shall be mounted from 2 inches to 4 inches up from the bottom of the cabinet.
- h. A 24-position, compression-type, copper grounding strip shall be mounted on and grounded to each side of the cabinet wall for connection of all grounding conductors.
 - 1) These terminal blocks shall be connected to ground and shall be connected to the terminal block that accepts the No. 2 AWG stranded wire for the grounding conductor of the power supply.
 - 2) The grounding strips shall be mounted 4 inches above the bottom of the cabinet.
- i. Two dual-circuit, solid state, NEMA jack-mounted flashers having a flash rate of 50 to 60 flashes per minute (see NEMA TS 1, Section 8, "Solid State Flashers") shall be installed.
 - 1) The red position of the load switch bays shall be operated from the flasher contacts as follows:
 - a) Flasher 1, contact A - phases 1, 4, and OLA
 - b) Flasher 1, contact B - phases 5, 8, and OLB
 - c) Flasher 2, contact A – phases 2, 3 and OLC
 - d) Flasher 2, contact B – phases 6, 7 and OLD
 - 2) The red transfer relays will be wired in such a manner that the field wire outputs shall be flashing when the relays are de-energized. These transfer relays shall be energized to operate the traffic signal with colors.
- j. A single, duplex, U-ground type of convenience outlet shall be furnished for tools and lighting.
 - 1) It shall have an integral ground fault protection device and be installed adjacent to the breakers in the lower portion of the cabinet on the right side panel.
 - 2) The power source for this outlet shall be the 15-amp circuit breaker.

- 3) Two single, duplex, U-ground type of convenience outlets shall be furnished for video equipment and other electronic test equipment.
 - a) Neither shall have an integral ground fault protection device.
 - b) The outlets will be located no more than 12 inches from the roof of the cabinet, on the right side panel of the cabinet interior.
 - c) The power source for these outlets shall be the 20-amp circuit breaker.
 - 4) A fourth, single, duplex, U-ground type of convenience outlet shall be furnished for other electronic test equipment.
 - a) It shall not have an integral ground fault protection device.
 - b) This will be located no more than 12 inches from the roof of the cabinet, on the left side panel of the cabinet interior.
 - c) The power source for this outlet shall be the 20-amp circuit breaker.
- k. Police Panel Switch:
- 1) There shall be a double-pole, double-throw switch behind the police auxiliary door.
 - 2) This shall be identified "Auto/Flash."
 - 3) The Flash position of the switch shall cause the following:
 - a) De-energize signal light power and place the intersection to red flashing operation through the Conflict Monitor (see d) below). The controller power, however, shall remain energized.
 - b) Activate the Stop Time function within the controller. This will be accomplished through the Conflict Monitor (see d) below).
 - c) Provide logic ground to inform the 2070N controller that the Police Flash Switch has been turned on to put the traffic signal on flash, on Pin AA, Controller Plug A.
 - d) De-energize +24v II to the Conflict Monitor to cause it to fail, which in turn causes the Conflict Monitor to provide a logic ground to Controller Plug A, Pin n, and Stop Time to controller. This circuit shall be diode-isolated.
 - 4) When the police switch is placed back into Auto position, the intersection shall be transferred from red flashing operation to normal operation.
- l. The following switches shall be installed at the center of the interior of the cabinet door and shall function as described.
- 1) The Controller Power switch shall be labeled "On-Off" and wired to de-energize only the controller power when switched to the Off position.
 - 2) Tech Flash switch shall be labeled "Auto-Flash."
 - a) It shall be wired to remove the electrical power feeding the load switches and transfer relays when the switch is placed in the Flash position.

- b) Placing the switch in Flash shall cause the intersection signals to flash red for all movements except the pedestrian movements which shall show no indication.
 - c) The controller, conflict monitor, and all other cabinet equipment shall remain energized.
 - d) A logic ground shall be applied to Controller Plug A, Pin AA to inform the controller that the Tech Flash switch has been put on flash.
 - e) The Controller shall not stop timing while the Tech Flash switch is in the Flash position.
 - f) The intersection shall return to normal operation when the Tech Flash switch is placed back into the Auto position.
- 3) Stop Timing switch (identified "On-Off") shall be wired to Stop Time ring 1 and ring 2 on the controller when switched to the On position.
- 4) The Interval Advance switch shall be a momentary, pushbutton switch.
- a) The switch shall make electrical connection to the back panel through a 1/4-inch phone jack labeled "Interval Advance."
 - b) The Interval Advance switch shall be enabled by the Manual Control Enable (MCE) switch and wired to manually step the controller through intervals.
 - c) The Interval Advance switch shall have a guard to keep from accidentally advancing the controller.
- 5) The Manual Control Enable switch shall be labeled "MCE" and shall be wired to enable MCE in controller, while allowing the Interval Advance switch to operate.
- 6) Pedestrian and Vehicle Test switches shall be labeled "On/Off/Test" and shall be provided in each cabinet.
- a) The switches shall be installed on a vehicle and pedestrian detector test panel located on the inside of the cabinet door with the other test switches for the cabinet.
 - b) Toggle switches shall be provided for 8 vehicle and 8 pedestrian phases and wired independently to the terminal blocks.
 - c) All possible vehicle and pedestrian detector circuits shall have a separate toggle switch.
 - d) The switches shall conform to the following conditions:
 - (1) The toggle switches shall permit detection calls to be forwarded to the controller from the vehicle and pedestrian detection source for normal operation when placed in the up (On) position.
 - (2) Each toggle switch shall disconnect the vehicle and pedestrian detection source when placed in the center (Off) position. No detections shall be allowed to enter the controller when placed in this position.

- (3) The toggle switches shall place a call into the controller for the associated pedestrian or vehicular phase when placed in the down (Test) position. This position shall not be a momentary position. The switch shall be capable of being locked in Test position.
- 7) All switches shall be combined on a single panel and mounted on the inside cabinet door behind the police auxiliary panel.
- m. Surge suppressors for electrical power shall be Model HS-P-SP-120A-60A-RJ, and for telecommunications line protection shall be Model MDF 6 95V or MF 25 95V.
- 6. All mechanical relays shall have clear dust covers.
- 7. The cabinet and controller phasing shall be referenced as follows:



- a. Phase 6 shall be NB through
- b. Phase 8 shall be WB through

623 T.02.02 TRAFFIC SIGNAL CONTROLLER CABINET EQUIPMENT

- A. All traffic signal controller cabinets shall be furnished with the equipment specified below.
- B. Solid State Load Switches, Red Transfer Relays, and Sockets:
 - 1. All necessary cabinet wiring, connecting cables, terminal blocks, and sockets shall be provided for complete and proper functionality of an 8-vehicle, 4-pedestrian, and 4-overlap phase operation. A total of 16 NEMA load switches shall be provided with each cabinet.

2. Three wide-angle, high-intensity light emitting diodes (LED) of the corresponding colors RED, YELLOW, and GREEN shall be provided to indicate the status of each load switch input.
 - a. The LEDs shall be clearly visible in bright sunlight.
 - b. Refer to the latest NEMA standard publication for operational and dimensional requirements.
 3. There shall be 2 discrete NEMA flashers accompanying each cabinet.
 - a. Refer to the latest NEMA standard publication for operational and dimensional requirements.
 - b. Two wide-angle, high-intensity LEDs, clearly visible in sunlight, shall be provided for each load switch and flasher to indicate the status of each device.
 4. A minimum of 6 transfer relays shall be delivered with each cabinet.
 - a. These shall conform to the latest NEMA TS 1 specifications.
 - b. Load bay panels shall not exceed 0.125 inch of flex under 5 pounds of pressure.
- C. Pedestrian Push Button Circuit Isolation:
1. Six solid state isolation circuits shall be provided in the cabinet to separate the pedestrian detector input circuits to the controller from the pedestrian push button circuits in the field. Isolation circuits 1, 2, 3, and 4 shall correlate to signal phases 2, 4, 6, and 8, respectively, and the wiring shall be appropriately terminated within the cabinet.
 2. Circuits 5 and 6 shall be spares and shall be terminated to allow easy access from the front side of the detector panel. The Field push button circuits shall be energized by a 12 VAC source.
 3. The isolation circuits shall be mounted on an edge connector-type PC board with all required components, including the transformer and integrated circuit chips, and shall display an LED indication showing status of field buttons.
- D. Video Detection: All cabinets shall be wired for Video Detection in addition to the requirement for loop detection harnesses and equipment.
1. All cabinets shall have a discrete Video Detection Interface Panel (VDIP) installed and wired into the back-panel as appropriate.
 - a. Phases 1 through 8 and overlaps A, B, C, and D green and red outputs and 24 VDC from the controller shall be wired to the VDIP from the back panel.
 - b. The 16-vehicle and pedestrian phase detection inputs shall also be terminated on the VDIP.
 2. The VDIP shall be installed on the upper left portion of the side panel within the cabinet where the terminal blocks are easily accessible. It shall be installed to permit wiring harnesses that accompany all Video Detection Systems to be connected to these independent termination points.
- E. Loop Detection: If specified in the Contract Documents, all traffic signal cabinets shall be wired with four single-channel loop amplifier wiring harnesses and five 4-channel loop amplifier wiring harnesses.
1. Single-Channel Detectors:

- a. There shall be 1 single-channel loop amplifier with wiring harnesses for each of the phases 2, 4, 6, and 8, for advance detection with added extension operation for the through phases.
 - b. These harnesses and plugs shall conform to the latest NEMA TS 1 specifications.
 - c. The harnesses shall be wired for the loops to be used as extension loops, with each conductor independently terminated onto an individual terminal.
 - d. The Relay Common (B pin) shall terminate before continuing to logic ground.
2. For 4-Channel Detectors:
 - a. There shall be 5 amplifiers with wiring harnesses installed and wired in the cabinet for the standard 4-channel detection unit specified in NEMA TS 1 standards, Section 11.2.28.2.
 - b. These detectors will be used for the presence detection at the intersection.
 - c. The harnesses shall be wired so the inputs of all channels are terminated directly to logic ground.
 - d. The number of detection outputs per phase shall be as indicated below with all harness wires being terminated on separate terminals.
 - 1) 4-channel Amplifier A - phases (1, 6, 6, 6)
 - 2) 4-channel Amplifier B - phases (3, 8, 8, 8)
 - 3) 4-channel Amplifier C - phases (5, 2, 2, 2)
 - 4) 4-channel Amplifier D - phases (7, 4, 4, 4)
 - 5) 4-channel Amplifier E - phases (1, 3, 5, 7)
- F. Optical Emergency Preemption:
 1. All cabinets shall be equipped with encoded 3M Opticom compatible Emergency Preemption.
 2. The phase selector(s) provided shall have the capability of providing traffic signal preemption for each intersection approach individually and separately from all other phases.
 3. A minimum of 4 channels shall be provided.
 4. Unless otherwise specified in the Contract Documents, each cabinet supplied shall be wired with an Optical Emergency Preemption Panel, and shall be marked accordingly.
 - a. The panel shall have termination points for 4 preemption outputs directly wired to the discriminator.
 - b. The M138 Emergency Preemption cable coming from the Optical Detectors shall be terminated to a terminal strip located on this panel.
 5. The wiring from this panel to the back panel shall be as follows:
 - a. Channel A to Controller Plug A, Pin q.
 - b. Channel B to Controller Plug A, Pin y.
 - c. Channel C to Controller Plug B, Pin W.

d. Channel D to Controller Plug B, Pin X.

G. Supplemental 2070N D Plug Interface Panel:

1. If specified in the Contract Documents, the cabinet shall be equipped with a D panel complete with wiring harness for the D plug to be furnished with the controller.
2. The plug used for the D plug on the 2070N controller shall be an MS3116-24-61S.
3. The terminations for the harness shall have independent termination points as shown on the panel below.
4. All wiring on this panel, except for the D plug connector wiring harness itself, shall be performed by the Maintaining Agency's staff after delivery and acceptance of the controller cabinet.

H. Conflict Monitor Interface Panel:

1. Unless otherwise specified in the Contract Documents, all traffic control cabinets shall be supplied with a conflict monitor with a minimum of 12 channels.
2. If specified in the Contract Documents, an 18-channel monitor shall be supplied.
3. Twelve-channel conflict monitors shall be furnished with the program card fully programmed for standard NEMA 8-phase operation.
4. Twelve-channel monitor harnesses shall be wired in accordance with the diagram shown below.
5. Eighteen-channel conflict monitors shall be furnished unprogrammed and the harnesses shall be wired by Maintaining Agency technicians.
6. The wiring harness for the conflict monitor shall have independent termination points.
7. All conductors shall be terminated independently and separately onto a single terminal.
8. Appropriate conductors shall be landed on the back panel as necessary.
9. Unused wires shall be terminated on a separate terminal board that is easily accessible from the front of the cabinet without removing other panels.
10. There shall be no conductors hanging loose or not terminated.

I. All conflict monitors shall be NEMA standard, meeting all requirements of Section 6 of the latest edition of NEMA TS 1.

1. The conflict monitors shall also come equipped with PLUS options that are selected using dip switches or by use of the liquid crystal display (LCD) mounted on the front panel of the unit.
2. In addition, all monitors shall be equipped with the features defined below:
 - a. Conflict monitors shall be equipped with a front panel display that is menu driven.
 - 1) The display shall be LCD and shall be temperature compensated to prevent screen blackout in extreme temperature conditions.
 - 2) The LCD shall be backlit for night operation.

- b. Minimum vehicle clearance time monitoring shall be programmable and shall be available on each channel separately and independently.
- c. The LCD shall show separate indicators for activity on each of the red, amber, green, and walk inputs of each monitor channel.
- d. The LCD shall have indicators showing active channel(s), date, time, and description of the current status, while showing a log of 6 or more of the most recent failures. All such data shall be stored in a non-volatile memory.
- e. Failure status indicators shall be shown on the front panel to show the failure status for CVM, 24-1, 24-2, conflict, red failure, clearance failure, minimum green failure, dual indication, and program card ajar.
- f. The monitor shall provide a front panel display of the approximate time and date of the occurrence of any power failure in excess of 500 milliseconds duration and the date and time of power restoration. The monitor program shall have computed and logged this data in non-volatile memory by the end of the power restart flash interval.
- g. All conflict monitors shall have RS-232 capability.
- h. The vendor shall supply software to interface between an IBM compatible computer and the monitor unit for downloading failure event information and other programmable events including but not limited to timing.
- i. Front panel connectors A and B mounted directly to printed circuits will not be accepted.

623 T.02.03 TRAFFIC SIGNAL CONTROLLERS

- A. Traffic signal controller assemblies shall conform to the following specifications.
- B. General:
 - 1. Controller Assemblies.
 - a. A controller assembly shall consist of a complete mechanism for controlling the operation of a traffic control signal, including the controller unit and all necessary auxiliary equipment, mounted in a traffic signal control cabinet.
 - b. All equipment required to provide the operation shown on the Drawings and specifications shall be provided.
 - 2. Flashing Operations.
 - a. All controllers shall be equipped for flashing operation of signal lights.
 - b. Flashing operations, when required by railroad preemption, flashing emergency traffic control, or other causes, shall be set for flashing red on all approaches unless otherwise specified.
 - 3. Wiring Diagrams.
 - a. A schematic diagram of the controllers and auxiliary equipment furnished under the contract shall be submitted at the time the controllers are delivered for testing or, on demand of the Engineer, prior to purchase.
 - b. This diagram shall show all circuits, all electronic elements including transistors, capacitors, inductors, resistors, integrated circuit chips, connectors and other parts in detail.

- c. All parts, materials, and equipment shall be shown by name and number in such manner as to be readily identified.
 - d. This requirement may be waived at the discretion of the Maintaining Agency.
- 4. Operating Voltage.
 - a. All equipment including interconnection facilities, and excepting pedestrian push buttons and pressure detectors, shall be designed to operate on 120 volts, 60 Hz AC.
 - b. Operation shall be satisfactory at voltages from 105 to 130.
 - c. The voltage for pedestrian push buttons shall not exceed 24 volts AC.
- 5. Tests. Prior to completion of the work, the Contractor shall cause the following tests to be made on all electrical circuits, in the presence of the Engineer:
 - a. Test for continuity of each circuit.
 - b. Visual inspection for earth and system electrical grounds in each circuit. Electrical equipment and components shall not be energized until properly grounded to the system and to earth.
 - c. A flash test for traffic signal installations to verify the terminals and connections before turn-on.
 - d. A megohmmeter test on each single conductor circuit between the circuit conductor and all other circuit and ground conductors in the conduits.
 - 1) The insulation resistance shall not be less than 500 megohms when tested at 1,000 volts for 1 minute.
 - 2) Individual conductors in traffic signal cable, other multi-conductor cables, and coaxial cables may be exempted from the megohm testing by the Maintaining Agency if a visual inspection of these cables shows no suspicious cuts, tears, or other damages to the cable or wire insulation.
 - e. A functional test in which it is demonstrated that each and every part of the system functions as specified or intended herein.
 - f. Any fault in any material or in any part of the installation revealed by these tests shall be replaced or repaired by the Contractor in a manner as directed by the Engineer, and the same test shall be repeated until no fault appears.
 - 1) After testing of each traffic signal system, the system shall be activated and required to function without failure for a period of 14 calendar days.
 - 2) Any fault or failure to the system during this period shall be corrected by the Contractor at no additional cost to the Contracting Agency, and the system will then be required to function for a period of 14 calendar days without failure.
 - 3) This procedure will continue until the system successfully operates continuously without failure for 14 calendar days.
- 6. System Turn-On.
 - a. Contractor shall not energize any traffic signal equipment without the written approval of the Engineer.

- b. The actual date and time of turn-on shall be coordinated with the Maintaining Agency.
 - c. Systems shall be permitted to be made operational only after on-site testing and certification by the Maintaining Agency.
 - d. The video detection manufacturer shall provide a technical representative at the intersection during the turn-on and testing period if required and directed by the Engineer.
 - e. The Contractor shall provide uniformed traffic control officers as required and directed by the Engineer to direct traffic during the turn-on period.
 - f. The Contractor shall immediately remove all conflicting traffic markings and signs prior to the successful turn-on of the traffic signal and dispose of all removed materials as specified in the Contract Documents.
- C. Controller Construction Specification. When a 2070N controller is supplied, the following requirements are mandated:
- 1. The 2070N controllers supplied shall conform to the latest published revision of the California Department of Transportation (CALTRANS) Transportation Electrical Equipment Specifications (TEES) requirements published at time of bid. The following configuration will apply to any controller supplied.
 - a. A 2070-7 Async Serial Comm Module shall be supplied and installed in each controller. The communications interface connection cable incorporated with the 2070-8 shall be supplied with connector DB-9S to mate with the 2070-7 module, unless otherwise directed by Drawings and specifications.
 - b. A communications modem shall be supplied in accordance with FAST system requirements. The modem shall be delivered complete with the power cord and a 5-foot DB25 to DB25 RS232 cable for connection of the EX2 connector on the 2070-8 to the DTE connector on the modem, unless otherwise specified.
 - c. Each 2070N Controller shall come equipped with a 2070-1B single-board CPU, which holds 1 MB capacitor-backed static RAM, and is equipped with an RJ45 Ethernet Communications on face plate. This port will support standard TCP/IP protocols. The module shall also contain a DB25 EIA485 serial communications port.
 - d. The controller that is provided shall be configured with a short power outage tolerance of at least 400 milliseconds without causing a CPU reset, and a minimum of 4 MB of DRAM memory, 4 MB of FLASH memory, and 512 KB of SRAM.
 - 2. The A, B, C, and D plugs shall be installed on the front of the controller with the identification letters for the Cannon plugs right-side up. The master key shall be located at the top of the plug, not the bottom.
 - 3. The 2070N Controller supplied shall, at a minimum, meet the following criteria:
 - a. Proper implementation of all TEES and the above specifications.
 - b. Successful monitoring of the operation in a test cabinet environment.
 - c. Confirmation that the LCD display and the display cover are environmentally sealed to keep dust and other particles from entering between them.

- d. Verification of operation with short power outages and momentary surges.
 - e. Verification of operation with the following provisions of software operation and compatibility.
4. All 2070N controller units shall be compatible and function properly with the latest revision of the Next Phase Intersection Management Software developed by Siemens ITS. All 2070N controller units shall be compatible and function properly with the i2tms communication package developed by Siemens ITS for the FAST Traffic Signal System, and shall be complete with all requisite hardware, cables, connectors, and related firmware for connection to and communication with the i2tms central software.
- D. Alternate (non-2070N) Controller Construction Specification:
1. General Description. This specification describes an advanced traffic signal controller, meeting the latest NEMA specification, as well as providing advanced features for future enhancements. This Controller shall be supplied if specified in the Contract Documents.
 2. Traffic signal controller shall meet or exceed all requirements of NEMA TS 2-2003.
 - a. The supplier shall provide a letter with bid from an independent testing laboratory certifying controller compliance to NEMA TS 2-2003.
 - b. A programming instruction manual shall be supplied on a CD with each controller purchased.
 3. The controller shall meet the Standard NEMA configuration as NEMA TS 2-2 Type 2 for direct parallel connection to load switches and detectors, fully backward compatible with NEMA TS 1 Type 1 equipment.
 4. In addition to NEMA requirements, the Central Processor Unit (CPU) shall provide the following:
 - a. Microware OS-9 operating system with runtime license.
 - b. Controller shall be capable of accessing OS-9 operating system via shell interface through RS-232 front panel communications port and be compatible with all NextPhase versions.
 - c. A Motorola 68360 microprocessor, 25 MHz version.
 - d. Four megabytes minimum dynamic random access memory (DRAM).
 - e. Eight megabytes minimum FLASH memory organized as a disk drive.
 - f. One megabyte minimum static random access memory (SRAM).
 - g. Time of Day (TOD) clock with hours, minutes, seconds, month, year, and automatic daylight savings time adjustment. TOD may be implemented in the CPU via electronic circuitry, operating system software, or a combination of both.
 - h. During power failures, the SRAM and TOD shall be powered by standby voltage from the power supply.
 5. Controller shall not require additional hardware to run NextPhase software.
 6. In addition to NEMA requirements, the power supply shall provide the following:

- a. Line Frequency Reference (LFR) signal shall be by crystal oscillator, which will synchronize to the 60 Hz AC incoming power at 120 degrees and 300 degrees. A continuous square wave signal shall be provided at +5 VDC amplitude, 8.333 ms half-cycle pulse duration, and 50 ± 1 percent duty cycle.
 - b. The LFR shall compensate for missing pulses and line noise during normal operation. The LFR shall continue through 500 millisecond power interruptions.
 - c. Standby voltage will be maintained by super capacitor. No batteries of any type will be used.
- 7. In addition to NEMA requirements, keyboard and display shall provide the following:
 - a. The keypad may be removable by pulling off and installed by pushing on, without the use of tools.
 - b. If a removable keypad is provided, an extension cord will be provided to allow use of the keyboard while it is not attached to the controller. It will be stowed in an obvious and easily reachable location.
 - c. The keypad/display will be a Liquid Crystal Display (LCD) with 8 lines, 40 characters each.
 - d. LCD contrast will be adjustable.
 - e. Backlighting will be provided for the LCD.
- 8. In addition to NEMA requirements, the controller shall provide the following communications functions:
 - a. Built-in native 10 Base-T Ethernet with RJ-45 connector on controller front panel.
 - b. Built-in configurable Internet Protocol (IP) address with factory default and unique MAC address.
 - c. Built in Infra-Red (IR) wireless port.
 - d. Built in EIA-232 port for uploading and downloading applications software, as well as to update the operating system.
- 9. In addition to NEMA requirements, the controller housing shall conform to the following:
 - a. Polycarbonate construction, except back panel, rear mounting tabs, and power.
 - b. Supply mounting plate shall be aluminum for electrical grounding.
 - c. Built-in polycarbonate carrying handle.
 - d. The physical size shall not exceed 16 inches wide by 10 inches deep by 8 inches tall.
 - e. The NEMA A, B, and C plugs mounted on the front panel shall have the plug key in the upright (12 o'clock) position.
- E. The controller harnesses for connectors A, B and C shall be connected according to the following diagrams.

CONTROLLER CONNECTOR A			
Pin	Function	Pin	Function
A	Reserved	AA	Test Input B
B	+24 V DC External	BB	Walk Rest Modifier
C	Voltage Monitor	CC	Coded Status Bit A (Ring 1)
D	PH 1 Red	DD	PH 1 Phase ON
E	PH 1 Don't Walk	EE	PH 1 Ped Omit
F	PH 2 Red	FF	Ped Recycle (Ring 1)
G	PH 2 Don't Walk	GG	Max II Selection (Ring 1)
H	PH 2 Ped Clear		
J	PH 2 Walk		
K	PH 2 Veh Call Det		
L	PH 2 Ped Call Det		
M	PH 2 Hold		
N	Stop Timing (Ring 1)		
P	Inhibit Max Term (Ring 1)		
R	External Start		
S	Internal Advance		
T	Indicator Lamp Control		
U	AC- Common		
V	Chassis Ground		
W	Logic Ground		
X	Flashing Logic Out		
Y	Coded Status Bit C (Ring 1)		
Z	PH 1 Yellow		
a	PH 1 Ped Clear		
b	PH 2 Yellow		
c	PH 2 Green		
d	PH 2 Check		
e	PH 2 Phase ON		
f	PH 1 Veh Call Det		
g	PH 1 Ped Call Det		
h	PH 1 Hold		
i	Force-off (Ring 1)		
j	Ext Min Recall All PH's		
k	Manual Control Enable		
m	Call to Non Actuated I		
n	Test Input A		
p	AC+ (control)		
q	5 PPS		
r	Coded Status Bit B (Ring 1)		
s	PH 1 Green		
t	PH 1 Walk		
u	PH 1 Check		
v	PH 2 Ped Omit		
w	Omit All Red Clear (Ring 1)		
x	Red Rest Mode (Ring 1)		
y	Spare 1		
z	Call to Non Actuated II		

CONTROLLER CONNECTOR B			
Pin	Function	Pin	Function
A	PH 1 Phase Next	AA	Overlap A Green
B	*	BB	Overlap B Yellow
C	PH 2 Next	CC	Overlap B Red
D	PH 3 Green	DD	Overlap C Red
E	PH 3 Yellow	EE	Overlap D Yellow
F	PH 3 Red	FF	Overlap C Green
G	PH 4 Red	GG	Overlap B Green
H	PH 4 Ped Clear	HH	Overlap C Yellow
J	PH 4 Don't Walk		
K	PH 4 Check		
L	PH 4 Veh Call Det		
M	PH 4 Ped Call Det		
N	PH 3 Veh Call Det		
P	PH 3 Ped Call Det		
R	PH 3 Phase Omit		
S	PH 2 Phase Omit		
T	PH 5 Ped Omit		
U	PH 1 Phase Omit		
V	Ped Recycle (Ring 2)		
W	*		
X	*		
Y	PH 3 Walk		
Z	PH 3 Ped Clear		
a	PH 3 Don't Walk		
b	PH 4 Green		
c	PH 4 Yellow		
d	PH 4 Walk		
e	PH 4 Phase ON		
f	PH 4 Phase Next		
g	PH 4 Phase Omit		
h	PH 4 Hold		
i	PH 3 Hold		
j	PH 3 Ped Omit		
k	PH 6 Ped Omit		
m	PH 7 Ped Omit		
n	PH 8 Ped Omit		
p	Overlap A Yellow		
q	Overlap A Red		
r	PH 3 Check		
s	PH 3 Phase ON		
t	PH 3 Phase Next		
u	Overlap D Red		
v	*		
w	Overlap D Green		
x	PH 4 Ped Omit		
y	Spare 5		
z	Max II (Ring 2)		

*User Assigned

CONTROLLER CONNECTOR C			
Pin	Function	Pin	Function
A	Coded Status Bit A (Ring 2)	AA	PH 6 Ped Clear
B	Coded Status Bit B (Ring 2)	BB	PH 6 Check
C	PH 8 Don't Walk	CC	PH 6 Phase ON
D	PH 8 Red	DD	PH 6 Phase Next
E	PH 7 Yellow	EE	PH 7 Hold
F	PH 7 Red	FF	PH 8 Check
G	PH 6 Red	GG	PH 8 Phase ON
H	PH 5 Red	HH	PH 8 Phase Next
J	PH 5 Yellow	JJ	PH 7 Walk
K	PH 5 Ped Clear	KK	PH 7 Ped Clear
L	PH 5 Don't Walk	LL	PH 6 Walk
M	PH 5 Phase Next	MM	PH 7 Check
N	PH 5 Phase ON	NN	PH 7 Phase ON
P	PH 5 Veh Call Det	PP	PH 7 Phase Next
R	PH 5 Ped Call Det		
S	PH 6 Veh Call Det		
T	PH 6 Ped Call Det		
U	PH 7 Ped Call Det		
V	PH 7 Veh Call Det		
W	PH 8 Ped Call Det		
X	PH 8 Hold		
Y	Force-off (Ring 2)		
Z	Stop Timing (Ring 2)		
a	Inhibit Max Term (Ring 2)		
b	Spare 1		
c	Coded Status Bit C (Ring 2)		
d	PH 8 Walk		
e	PH 8 Yellow		
f	PH 7 Green		
g	PH 6 Green		
h	PH 6 Yellow		
i	PH 5 Green		
j	PH Walk		
k	PH 5 Check		
m	PH 5 Hold		
n	PH 5 Phase Omit		
p	PH 6 Hold		
q	PH 6 Phase Omit		
r	PH 7 Phase Omit		
s	PH 8 Phase Omit		
t	PH 8 Veh Call Det		
u	Red Rest Mode (Ring 2)		
v	Omit All Red (Ring 2)		
w	PH 8 Ped Clear		
x	PH 8 Green		
y	PH 7 Don't Walk		
z	PH 6 Don't Walk		

CONTROLLER CONNECTOR D			
Pins are user defined, and shall be wired			
Pin	Function	Pin	Function
A		AA	
B		BB	
C		CC	
D		DD	
E		EE	
F		FF	
G		GG	
H		HH	
I		JJ	
J		KK	
K		LL	
L		MM	
M		NN	
N		PP	
P			
R			
S			
T			
U			
V			
W			
X			
Y			
Z			
a			
b			
c			
d			
e			
f			
g			
h			
i			
j			
k			
l			
m			
n			
p			
q			
r			
s			
t			
u			
v			
w			
x			
y			
z			

623 T.02.04 MAGNETIC INDUCTION LOOP DETECTORS**A. General.**

1. The term "loop detector" applies to a complete and operating installation consisting of a loop or loops installed in the roadway in accordance with the Drawings and specifications, a sensor unit with solid state switching output, and a power source.
2. Loop detectors shall meet the requirements of and operate in accordance with the latest edition of NEMA TS 1.
3. All loop locations shall be approved by the Engineer prior to installation.
4. Loop leads shall be properly marked in the pull box and the cabinet as to the location and which vehicular phase of the traffic signal is associated with that loop.
5. A minimum of 2 feet of loop wire and 2 feet of loop lead-in shall be provided and stored in the pull box for slack.
6. All loop wires home run to pull box shall clearly identify the direction of the cables windings for ease of installation.
7. Minimum 3 turns per foot shall be provided.
8. The completed loop detector shall be capable of detecting any vehicle currently licensed by the state of Nevada.

B. Preformed Loops.

1. Loop detector wires shall be installed as preformed loop sensors when new roadways are being constructed or the existing asphalt or concrete pavement is being replaced.
 - a. The wires shall be installed in the roadway base material at least 2 inches below the concrete or below the first course of asphalt/concrete paving.
 - b. Preformed loop wires constructed specifically to be embedded directly into the subbase material or to be installed as preformed loops shall be used as shown on the Drawings.
 - c. The loop assemblies shall be properly located under the roadway in the proposed lane configuration and appropriately secured to prevent movement prior to and during the installation of the paving material.
2. Direct burial loop wires shall not be installed in road base material containing aggregate with sharp edges or aggregate larger than 1/2-inch diameter.
 - a. However, this requirement shall not prevent the installation of preformed loops.
 - b. The materials surrounding the wires shall be changed to meet this specification if necessary.
3. Preformed loop detectors shall be installed when pavement is milled 2-1/2 inches or more by cutting loop wire slots into the coarse grade of the asphalt pavement material and installing the direct-burial preformed loop wires.
 - a. The overlay material may then be applied over the embedded loop wires with the finish course to complete the installation.
 - b. These preformed loops supplied shall be as specified in the Contract Documents and approved by the Engineer.

4. Preformed loops may be required to be installed as replacements to regular loops as specified in the Contract Documents or as directed by the Engineer.
 - a. In this case, the cut in the roadway shall be made through the existing finish grade of the asphalt or concrete.
 - b. The preformed loops shall be placed in the roadway cut 2 inches below the surface of the roadway and sealed using approved loop sealant.
 5. The preformed loops shall be factory assembled.
 - a. Home runs and interconnections shall be prewired and shall be an integral part of the loop assembly.
 - b. Each loop shall be fabricated for the specific application.
 - c. All materials used in the fabrication of the preformed loops shall be flexible and shall have properties that will withstand the temperatures and pressures of paving applicators without melting, breaking, or cracking.
 6. The tee shall be constructed of heavy-duty, high-temperature synthetic rubber or high-impact glass impregnated plastic.
 - a. The minimum size of loop wire permitted shall be 18 AWG stranded copper with TFFN or XLPE insulation.
 - b. Splices are not allowed in the loop wire.
 - c. The tee shall not melt, break, or crack under the thermal and pressure conditions of the paving operations.
 - d. Preformed loop lead home run wires from the tee to the pull box shall be the same as the loop wire since splicing is not permitted.
 - e. Loop leads shall be twisted a minimum of 3 times per foot of length.
 - f. Tees shall be checked electrically for wire breaks and continuity following assembly and construction before shipment to the project site.
 7. All preformed loops and the type to be used shall be approved by the Engineer prior to installation.
- C. Cable-in-Duct System.
1. Traffic signal detection loops that are to replace existing loops or are otherwise to be placed by cutting through the finished pavement surface and that are not preformed loops shall be installed using a cable-in-duct system.
 2. The loop wires shall be installed in slots cut in the pavement and shall be oriented and sized in accordance with the Contract Documents or as directed by the Engineer.
 3. The cable-in-duct system is a loop wire encased in flexible plastic tubing.
 - a. The system shall consist of flexible plastic tubing, 1/4-inch outside diameter, surrounding a single conductor, No. 14 AWG, XHHW-2, cross-linked, polyethylene insulated loop wire.
 - b. The tubing containing the loop wire shall be installed in a 3/8-inch wide saw slot in accordance with the Uniform Standard Drawings.
 4. The flexible plastic tubing shall be Type III, Grade P33, Category 5, Class C, and shall meet the following physical dimensions:

- a. Duct Size: 0.250 inch.
 - b. Outside Diameter: 0.250 (± 0.010) inch.
 - c. Wall Thickness: 0.032 (+0)(-0.010) inch.
 - d. Nominal Inside Diameter: 0.185 inch.
 - e. Minimal Bending Radius: 1.00 inch.
5. The loop wire shall meet IMSA 51-5.
 - a. The wire shall be single conductor, No. 14 AWG copper wire with 19 strands.
 - b. The insulation shall be 15 mils of black PVC complying with UL 62 with an overall jacket of clear nylon in accordance with ASTM D4066.
 - c. The wire shall be rated for 600 volts and have a nominal OD of 0.25 inch.
 6. The cable-in-duct system shall meet the performance tests as specified in NEMA standards.
 7. Sawed slots shall be blown clean and dried prior to the installation of the loop wire.
 - a. Loop wire shall be carefully placed into the saw slot using special tools to avoid damaging the wire.
 - b. The saw cuts shall be blown clean after wire installation and before placement of sealant.
- D. Loop wire insulation shall be tested using a megohmmeter prior to the placement of loop wire sealant. Insulation resistance readings shall not be less than 100 megohms at 1,000 volts.
- E. Detector loop sealant to be used shall be approved by the Engineer prior to installation.
- F. Loop Lead-In Conductors.
1. The loop lead-in cable shall be 1 pair No. 12 AWG, tinned copper, 19 strands each in accordance with IMSA 50-2.
 2. The pair shall be twisted a minimum of 3 times per foot.
 3. Insulation on the individual wires shall be high-molecular weight polyethylene complying with ASTM D1248, clear and black.
 4. The wires shall be wrapped helically with aluminum/polyester tape applied with stranded copper drain wire.
 5. The overall insulation jacket shall be polyethylene.
 6. The cable shall be rated for 600 volts with a nominal OD of 0.376 inch.
- G. Each through lane presence and advance detection loop in the system shall have a separate lead-in cable to the controller cabinet.
1. A lead-in cable shall be provided for every 2 left turn presence loops.
 2. Each loop shall be 6 feet by 6 feet unless specified otherwise in the Contract Documents or directed by the Engineer.
- H. Detector Operational Characteristics. All loop detector amplifiers shall meet NEMA specifications and shall conform to the following requirements:
1. All detector amplifiers shall give a constant output with an open or failed loop.

2. All detectors shall be shelf mounted or rack mounted as specified in the Contract Documents.
 3. All detector amplifiers shall be equipped with a fully functional LCD that is used for both monitoring and programming.
 4. Amplifier programming shall be accomplished through the LCD.
 5. The LCD shall be backlit and shall display the complete status of the connected loop, which includes but is not limited to the loop inductance, the loop frequency, and the accumulated number of loop failure incidents.
 6. Fully functional delay/extend functions shall be incorporated into the programming.
 7. Loop amplifiers shall be equipped with a phase green override input for each detection channel.
 8. All loop amplifiers shall be capable of presence or pulse modes of operation.
 9. There shall be 1, 2, or 4 channels per each loop detector, as specified in the Contract Documents.
 10. Loop detector amplifiers shall have loop fail memory log and loop fail diagnostics.
 11. Loop detector amplifiers shall have a minimum of 4 loop frequencies and a minimum of 8 sensitivity settings including the "Off" position.
 12. Loop detector amplifiers shall contain solid-state components only. Relays are not allowed.
 13. Loop detector amplifiers shall be self-tuning and have complete environmental tracking.
 14. The detector amplifier shall be capable of continuous operation in a temperature range of -35 degrees F to +165 degrees F.
 15. The amplifiers shall place a permanent vehicle call to the traffic signal controller if a power interruption occurs. The unit shall retune automatically within 15 seconds after the restoration of power.
 16. The amplifiers shall not require a warm-up period prior to operation.
 17. The amplifier units shall incorporate built-in lightning protection meeting the latest NEMA Standard.
 18. All loop detector amplifiers shall have circuitry and controls for individual selection of delay or extension timing on each channel.
 19. The sensor unit power supply shall be integral to the amplifier.
- I. Cabinet Wiring for Induction Loops.
1. If single channel shelf-mount detectors are specified on the Drawings, each loop detector shown on the Drawings shall be individually wired to terminal blocks in the controller cabinet.
 2. Each loop detector amplifier shall have a standard cable harness at least 6 feet long wired to the terminal blocks.
 3. Connection to the amplifier unit shall be made using a threaded shell type connector pinned for the circuitry as shown below:

- a. For a 4-Channel Detector Amplifier: MS Connector Circuit
 - 1) A Power, Neutral, 120 VAC Power, Neutral, 120 VAC
 - 2) B Channel 4 Output, Relay Common Channel 4 Output, Source
 - 3) C Power, Line, 120 VAC Power, Line, 120 VAC
 - 4) D Channel 1 Loop Input Channel 1 Loop Input
 - 5) E Channel 1 Loop Input Channel 1 Loop Input
 - 6) F Channel 2 Loop Input Channel 2 Loop Input
 - 7) G Channel 2 Loop Input Channel 2 Loop Input
 - 8) H Chassis Ground Chassis Ground
 - 9) J Channel 3 Loop Input Channel 3 Loop Input
 - 10) K Channel 3 Loop Input Channel 3 Loop Input
 - 11) L Channel 4 Loop Input Channel 4 Loop Input
 - 12) M Channel 4 Loop Input Channel 4 Loop Input
 - 13) N Channel 1 Output, Relay Normally Open Channel 1 Output, Drain
 - 14) P Channel 1 Output, Relay Common Channel 1 Output, Source
 - 15) R Channel 2 Output, Relay Common Channel 2 Output, Source
 - 16) S Channel 2 Output, Relay Normally Open Channel 2 Output, Drain
 - 17) T Channel 3 Output, Relay Common Channel 3 Output, Source
 - 18) U Channel 3 Output, Relay Normally Open Channel 3 Output, Drain
 - 19) V Channel 4 Output, Relay Normally Open Channel 4 Output, Drain
- b. For a Single Channel Detector Amplifier: MS Connector Circuit
 - 1) A 120-volt (AC grounded conductor)
 - 2) B Relay Contact Common (Output Negative)
 - 3) C 120-volt (AC line)
 - 4) D Loop
 - 5) E Loop
 - 6) F Relay Contact (Output Positive) N.C.
 - 7) G Relay Contact, Open for Call
 - 8) H Chassis Ground
 - 9) I Spare
 - 10) J Spare

J. Slot Sealant Tests and Acceptance.

1. Insulation Test. Insulation tests for each loop to ground shall be in accordance with the latest edition of NEMA TS 1.
2. Sensitivity Test. The completed loop detector shall be capable of detecting any vehicle currently licensed by the state of Nevada.

K. Installation of Inductive Detector Loop Sealant.

1. Detector loop sealant shall be either:
 - a. A 2-component epoxy or a polyurethane material that cures in the presence of moisture and conforms to the following specifications.
 - b. A hot-melt, rubberized asphalt material conforming to the following specifications.
2. Sealant shall be suitable for use in both asphalt concrete and Portland cement concrete pavements.

TWO COMPONENT EPOXY COMPOSITION

Parts by Weight	
Component A:	
Epoxy Resin, Araldite 6010	100
Nonyl Phenol	20
Alkylbenzene, Alkylate 31	20
Titanium Dioxide, Titanox 2015	1.62
Colloidal Silica, Cabosil	3
Glycerine	0.5
Silicone Anti-foam, G.E. Viscasil	0.01
Component B:	
Poly Mercaptan, Dion 3800 L C	40
N-Aminoethylpiperazine	17
2,4,6 - Tri (dimethylaminomethyl) Phenol	2
Furnance Black	0.03
Nonyl Phenol	34.6
Alkylbenzene, Alkylate 31	34.6
Colloidal Silica, Cabosil	4
Glycerine	0.5
Silicone anti-foam, G.E. Viscasil	0.01
Characteristics of Adhesives:	
Component A:	
Viscosity, Poise, Brookfield	150-300
Shear Index	2.5 minimum
Component B:	
Viscosity, Poise, Brookfield	100-250
Shear Index	2.0 minimum
Characteristics of Compounded Adhesive:	
Gel Time, Minutes	13 to 16
On 1/8 inch cast sheet, cured 18 hours at 77 degrees F plus 5 hours at 158 degrees F	
Tensile Strength Minimum	700 psi
Elongation, Percent, Minimum	70

TWO COMPONENT EPOXY COMPOSITION**Parts by Weight**

Shore D Hardness, Minimum 50

Color shall match Federal Standard No. 595;
color range shall be 26081 to 26173

POLYURETHANE SEALANT**Property and Results****Measuring Standard and Conditions**

Hardness (indentation) — 65-85

ASTM D2240 Rex Type A, Model 1700

77 degrees F, 50 percent relative humidity

Tensile Strength — 500 psi (minimum)

ASTM D412 Die C, pulled at 20 ipm

Elongation — 400 percent, minimum

ASTM D412 Die C, pulled at 20 ipm

Flex at -40 degrees F — no cracks

25 mil free film bend over 1/2-inch mandrel

Weathering Resistance — Slight Chalking

ASTM D822 Weatherometer 350 hours

Cured 7 days at 77 degrees F

50 percent relative humidity

Salt Spray Resistance — 500 psi,
minimum tensile; 400 percent minimum
elongation

ASTM B117, 28 days at 100 degrees F

5 percent NaCl, Die C, pulled at 20 ipm

Dielectric Constant — Less than
25 percent change over a temperature
of -22 degrees F to 122 degrees F

ASTM D150

Chemical Resistance: Chemical and Results**Test Method**

De-Icing Chemical — No Effect

ASTM D471

Gasoline — Slight Swell

ASTM D471

Hydraulic Brake Fluid — No Effect

ASTM D471

Motor Oil — No Effect

ASTM D471

Calcium Chloride (5 percent) — No Effect

ASTM D471

Tests conducted on deaerated, 0.020 inch, dry film liquid immersion; 28 days at 77 degrees F

HOT-MELT, RUBBERIZED ASPHALT SEALANT**Property and Limits****Measuring Standard and Conditions**

Cone Penetration — 20 - 35 (1/10 mm.) max.

ASTM D5,

77 degrees F, 150 g, 5 sec

Flow -- 5 mm. maximum

ASTM D5329, Section 6, 140 degrees F

Resilience --60% minimum

ASTM D6690, 77 degrees F

Softening Point — 200 degrees F

ASTM D36

Ductility -- 30 - 55 centimeters

ASTM D113,

77 degrees F, 5 cm/sec

Flash Point --575 degrees F

ASTM D92, COC

Viscosity -- 2,500 - 3,500 centipoises
(Brookfield)

ASTM D3236

375 degrees F

623 T.02.05 EMERGENCY VEHICLE PRIORITY CONTROL SYSTEM (INTERNAL PREEMPTION)**A. General Emergency Vehicle Detection System Description.**

1. The Priority Control System shall consist of a data-encoded optical emitter, optical detectors, optical detector cable, and priority control unit.
2. The system shall employ data-encoded optical communications to identify the presence of designated priority vehicles, cause the traffic signal controller to initiate a specific preprogrammed preemption procedure, and record the vehicle by classification and identification number.
 - a. The matched set of components that make up the system shall cause the existing traffic controller to be manipulated upon recognition of the signal from the vehicle.
 - b. The vehicle communication is provided to the controller by the optical detectors at or near the intersection which receives a pulsating light from the vehicle over a line-of-sight path.
3. The system shall require no action of the vehicle operator other than the operation of the emitter switch located in the vehicle. The vehicle operator leaves the switch in the ON position until the vehicle passes the targeted traffic signal.
4. The system shall interface with existing traffic signal controllers without compromising normal operation or existing safety provisions.
 - a. The system shall operate on a first-come, first-served basis or on a selected priority.
 - b. The higher priority requests will override lower priority requests.
 - c. The system shall be designed to yield to other priority demands such as railroads.

B. Matched System Components.

1. To ensure desired performance, the system shall provide the synergy of the 4 principal components, matched and proven through integrated testing and extensive functional experience.
2. The matched component system shall offer compatibility with all types of traffic signal controllers and shall provide future compatibility of all priority control elements.
3. Data-Encoded Optical Emitter. Shall be a compact, lightweight, weatherproof, light-emitting device with internal, regulated power supply designed to produce high intensity optical energy in visible and infrared wavelengths as well as encoded pulses that carry vehicle class and ID number information, from a single source, precisely timed by a crystal controlled circuit.
4. Optical Detector.
 - a. Shall be a lightweight, weatherproof, adjustable, bidirectional optical detector assembly.
 - b. Internal circuitry shall transform optical energy from the optical emitter assembly into electrical signals for delivery (up to 1,000 feet) via optical detector cable to the priority control unit.
5. Optical Detector Cable. Shall be a durable, shielded, 3-conductor cable with a drain wire and the necessary electrical characteristics to carry power to the optical

detector from the priority control unit and to carry the optical detector signal to the priority control unit.

6. Priority Control Unit. This equipment shall provide interface between the optical detectors and the traffic signal controller unit and shall comply with the following while not compromising the existing fail-safe provisions:
 - a. Provide sufficient power to all optical detectors required for the intersection.
 - b. Differentiate optical detector signals from 1 or more emitters on a first-come, first-served basis.
 - c. Provide output signals to the traffic signal controller to cause a preemption sequence to display the desired phase green for the approaching emergency vehicle.
 - d. All input and output wires of the priority control system shall be terminated on a separate panel before being wired to the controller back panel.
 - e. Assist the traffic signal controller in providing a smooth transition to non-priority operation after the passage of the emergency vehicle through the intersection.
 - f. Store up to 100 of the most recent priority control calls in non-volatile memory and retain the record if power terminates.
- C. System Operation. The emergency vehicle preempt system shall operate in accordance with the following:
 1. Priority control system shall be activated by an optically transmitted signal capable of recognizing and discriminating an Optical Emitter flash rate of Class I 9.63855 Hz ± 0.0014 Hz or Class II 14.0359 Hz ± 0.0039 Hz from a single light source or upon the actuation of a test switch or remote call signal to the phase selector. The system shall cause the traffic controller to select the green phase associated with the approaching emergency vehicle and place a priority call to initiate that phase.
 2. The system shall not require modification or replacement of the existing controller unit beyond adding the necessary system hardware.
 3. The system shall not cause the traffic signal controller to skip vehicular change or clearance intervals.
 4. The system shall be capable of accepting emergency preempt calls from all approaches to the intersection independently without modification or replacement of the existing phase selector unit.
 5. The system shall maintain adequate minimum traffic signal displays when priority control is active and all traffic signal display indications and sequences shall conform to the MUTCD.
 6. The system shall provide for up to 3 optical detectors to be connected to each channel.
 7. The system shall allow the traffic signal controller to resume normal timing operation after the preempt clears.
 8. The system shall not attempt controller manipulation nor retain priority vehicle calls during periods of Intersection Flash operation.
- D. System Component Specification. System components shall conform to the following:
 1. Data-encoded Optical Emitter.

- a. The flash signal shall consist of a frequency base signal and a coded overlay signal that can be used to transmit information.
 - b. The flash sequence generated by the data-encoded emitter shall carry 3 types of information:
 - 1) The base frequency as established in ***Subsection 623 T.02.05.C "System Operation,"*** subparagraph 1.
 - 2) The vehicle classification and identification code. The data-encoded emitter shall be capable of setting a minimum of 10 different classifications with 1,000 different identification numbers per class for each priority.
 - 3) Intersection detection range setting.
 - c. The data-encoded emitter will conduct self-diagnostics designed to check for missing pulses.
 - d. The data-encoded emitter will be equipped with a disable input that, when activated, will cease unit operation, thereby eliminating the possibility of inadvertent signal transmission after the priority vehicle has arrived at its destination.
2. Optical Detector.
- a. The optical detector shall be a lightweight, weatherproof device capable of sensing and transforming pulsed optical energy into electrical signals usable by the phase selection equipment.
 - b. The unit shall be high-impact polycarbonate construction with non-corrosive hardware.
 - c. The unit shall be designed for simple mounting at or near an intersection on mast arm, pedestal, pipe, or traffic signal.
 - d. The unit shall accept optical signals from all approaches to the intersection independently without modification or replacement of the existing phase selector unit.
 - e. The unit shall include a design feature to allow aiming of the 2 optical sensing inputs for skewed approaches or slight curves, and may be field verified.
 - f. The unit shall be responsive to the optical emitter at a distance of 1,800 feet.
 - g. The unit shall be capable of providing the necessary electrical signal to the priority control unit (phase selector) through up to 1,000 feet of optical detector cable.
3. Optical Detector Cable.
- a. The cable shall deliver the necessary signal from the optical detector to the phase selector over a maximum distance of 1,000 feet.
 - b. The cable shall be three No. 20 AWG (minimum gauge) stranded copper conductors and 1 bare ground wire.
 - c. The individual conductors shall be tinned copper and shall be color coded as follows:
 - 1) Orange for delivery of optical detector power (+).
 - 2) Bare for optical detector neutral (-).

- 3) Yellow for optical detector signal.
 - 4) Blue for a second optical detector signal.
 4. Priority Control Equipment (Phase Selector). The Emergency Vehicle Priority Control or Phase Selector shall be a self-contained stand-alone unit that shall recognize input signals from separate preempt channels for all traffic signal approaches and shall contain the following major parts:
 - a. Card Rack:
 - 1) The power supply shall be contained in a card rack.
 - 2) The power supply shall be powered from AC mains in the traffic signal cabinet, and shall supply power to the Optical Detectors.
 - 3) Plug-in card edge connectors and appropriate plugs and harnesses shall be used to connect the card rack unit to the cabinet wiring assembly.
 - b. Priority Control Discriminator Plug-in Module:
 - 1) This module unit shall either be a single plug-in 4-channel device or 2 plug-in 2-channel devices, as specified in the Contract Documents or directed by the Engineer, designed to be used with optical Emitters and Detectors.
 - 2) The unit shall be capable of recognizing and discriminating Optical Emitter flash rates as described in **Subsection [623 T.02.05.C "System Operation,"](#)** subparagraph 1.
 - 3) The unit shall be capable of recognizing and distinguishing data-encoded optical signals and shall meet the following requirements:
 - a) Programming and retrieving the data stored shall be accomplished using an IBM PC-compatible computer. Unit shall have the capability of storing 100 of the most recent calls. Each record entry shall include information as follows:
 - (1) Vehicle Classification.
 - (2) Vehicle Identification Number.
 - (3) Vehicle Priority level.
 - (4) Vehicle Direction.
 - (5) Call Duration.
 - (6) Final green indications at the end of the preempt call.
 - (7) Duration of final green indications.
 - (8) Time date and duration of the call.
 - b) Unit shall be capable of 3 levels of discrimination of data-encoded optical signals as described elsewhere in this specification.
 - c) Interface with the cabinet shall be wired as described elsewhere in this specification.
- E. Reliability. All equipment supplied as part of the optical priority remote traffic control system intended for use in the traffic signal controller cabinet shall meet the electrical and environmental specifications contained in the latest edition of the NEMA standards.

623 T.02.06 TRAFFIC SIGNAL VIDEO IMAGE DETECTION SYSTEMS

- A. Video detection systems shall be as specified in the Contract Documents or equal as approved by the Engineer.

623 T.02.07 SYNCHRONIZING CLOCK

- A. Unless otherwise specified in the Contract Documents, all controllers shall be supplied with a highly accurate synchronizing clock that maintains time by referencing signals that are broadcast from Global Positioning System (GPS) satellites.
- B. The timing device shall be provided on an integrated circuit card format that slides easily into the rack of a 2070 traffic signal controller.
 - 1. The timing device shall have the same footprint as the ATC/2070-7x and shall be capable of accuracy to within 10 milliseconds of the GPS data stream.
 - 2. The timing device shall be an output only device and shall not receive commands from the controller.
 - a. The time shall be updated every minute on the minute so that the controller maintains an accurate time of day and is referenced every minute to the GPS control.
 - b. Time zone and daylight savings shall be selected by means of an 8-position dipswitch on the circuit board.
- C. A signal status LED indicator shall be provided on the front panel of the timing device that shows the status of the clock signal. The LED indicator shall display the accuracy of the clock.
- D. Windows based software shall be provided with the timer that can be used for training, system configuration, and device testing.
- E. A small GPS antenna shall be provided that mounts on top of the control cabinet and connects to the circuit card for enhanced signal reception.
 - 1. The connecting coaxial cable shall be 6 feet in length.
 - 2. The antenna shall be mounted on the controller cabinet where there is a clear view of the sky to facilitate adequate linkage with satellite signals.

TRAFFIC SIGNALS AND FITTINGS**623 T.02.08 VEHICLE SIGNAL FACES**

- A. All vehicle signal faces shall consist of individual signal sections rigidly fastened together.
 - 1. Each section shall have a separate and complete housing.
 - 2. The actual number and type of sections shall be shown on the Drawings and in accordance with the *Manual on Uniform Traffic Control Devices* (MUTCD) and the Uniform Standard Drawings (USD).
 - 3. Vehicle signal face shall be installed as indicated on the Drawings.
 - 4. All vehicle signal faces shall be mounted onto their supports by mounting assemblies in accordance with the Uniform Standard Drawings.
- B. All new vehicle signal faces installed at any one intersection shall be the product of the same manufacturer.

- C. Traffic signal indications that have been installed and are not in operation shall be covered from public view in accordance with **Subsection 623 G.03.03, "Scheduling of Work,"** to clearly show that the signals are inoperative.
- D. Optical Units:
1. Optical units for vehicular traffic signals shall be LED modules and shall be interchangeable with all traffic signal head manufacturers.
 2. The LEDs shall be securely fastened to a printed circuit board and shall meet FCC Title 47, Subpart B, Section 15 Regulations for electrical noise.
 3. The LED module shall be watertight when properly mounted in the signal head enclosure and conform to NEMA and Institute of Transportation Engineers (ITE) moisture resistance standards. The modules shall specifically conform to the NEMA 250 moisture resistance standards for Type 4 enclosures.
 4. ALL LED modules shall be operationally compatible with NEMA TS 1 and NEMA TS 2 conflict monitoring parameters.
 5. All indications shall conform to the most recent edition of the ITE publication "Vehicle Traffic Control Signal Heads - Light Emitting Diode Circular Signal Supplement" (VTCSH-LED), adopted by reference into the MUTCD. The modules shall be certified by independent testing lab that they meet the VTCSH-LED specification.
 6. All vehicular LED modules shall reach 90 percent of full illumination within 110 milliseconds of the application of the nominal voltage and shall cease emitting visible illumination within 110 milliseconds of the removal of the nominal operating voltage.
 7. The LED module circuitry shall prevent flicker of the LED output at frequencies less than 100 Hz over the operating voltage range. There shall be no visible illumination from the LED module when the applied voltage is less than 35 VAC.
 8. The LED modules for vehicle signal control shall be 12 inches in diameter. They shall be complete individual units, consisting of plastic tinted lenses (red, yellow, or green) made of ultraviolet stabilized polycarbonate, an LED circuit board inclusive of all individual LEDs and required circuit components, a minimum 39-inch 18 AWG color-coded wire leads with strain relief and female quick connect/fasten terminals for 18 AWG wire, and a 1-piece commercial grade neoprene gasket.
 9. The LED modules shall be connected directly to line voltage, 117 VAC nominal, and shall operate over the voltage range of 80 VAC to 135 VAC, with a power factor exceeding 0.90.
 - a. Total harmonic distortion shall be 20 percent or less.
 - b. The intensity of the LED signal shall not vary by more than 10 percent over the allowable voltage range.
 10. The failure of any one LED in ball modules shall not cause the loss of more than 2-1/2 percent of lens surface illumination, nor more than 1 percent of the entire module luminosity.
 11. Lenses for LED modules shall incorporate facets that serve to enhance the optical efficiency of the LED traffic signal module.
 - a. Facets shall be arranged on the inside of the lens.
 - b. External lens facets are not allowed.

- c. The LED lens shall reduce glare and sun reflection.
 - 12. The housing of the LED vehicular signal module shall be marked "TOP" to designate the proper orientation of the module in the traffic signal housing and shall be marked with a color-coded symbol to identify the color of the LED module. In addition, all arrow indications shall designate the orientation by a label affixed to the assembly.
 - 13. All LED vehicular indications shall produce the appearance of an incandescent traffic signal indication.
 - a. The illuminated surface of each LED ball indication shall appear to the motorist as uniform and shall have a wide viewing angle that makes it suitable for installation on wide roadways.
 - b. Individual LED arrays shall not be visible separately for these indications but shall light the surface of the tinted lens uniformly to make the indication appear to be illuminated by incandescent lamps.
 - 14. Manufacturer Warranty:
 - a. The manufacturer's warranty of all LED modules shall be minimum 5-year replacement of any defective or failed LED units from the time of activation.
 - b. The manufacturer shall further warranty all LED modules for a minimum life of 5 years for compliance with minimum illumination output from date of acceptance.
 - c. The manufacturer shall be responsible for all pickup or shipping costs for the replacement units.
- E. Housing.
- 1. Each signal section housing shall be either die-cast or permanent mold-cast aluminum conforming to ANSI Standard C-10.1.
 - 2. Maximum height of a signal section shall be 10 inches for each 8-inch section and 14-1/16 inches for each 12-inch section.
 - 3. Each section shall be complete with a 1-piece, hinged door mounting for the lens and other parts of the optical system, watertight gaskets, and a simple door-locking device.
 - 4. The optical system shall be mounted for ready access and removal.
 - 5. The sections shall be interchangeable and so constructed that sections can be removed and added.
 - 6. There shall be an opening in the top and bottom of each section to receive a 1-1/2-inch pipe.
 - 7. All bolts, screws, hinge pins, door-locking devices, and other hardware shall be stainless steel.
 - 8. All gaskets shall be of neoprene.
 - 9. Each signal section shall be constructed so that structural failure of the housing will not occur with a wind load pressure of 25 pounds per square foot on the projected area of the complete signal face housing, including backplate and visors.

10. Any fracture within the housing assembly or a deflection of more than half the lens diameter of the signal section will be considered structural failure.
- F. Electrical Components.
1. Traffic signal section wiring shall conform to ANSI Standard D-10.1.
 2. Each LED module shall be wired to a terminal block mounted inside at the back of the signal housing.
 3. The terminal block shall have sufficient screw-type terminals to terminate all field conductors independently with separate screws.
 4. The terminals to which field conductors are attached shall be permanently identified or conductors shall be color coded to facilitate field wiring.
- G. Visors. Each section shall be provided with a removable, full-circle, metal visor conforming to ANSI Standard D-10.1 and the Uniform Standard Drawings, unless otherwise shown on the Drawings.
- H. Directional Louvers.
1. Where shown on the Drawings, directional louvers shall be furnished and installed in signal visors.
 2. Directional louvers shall be so constructed as to have a snug fit in the signal visors.
 3. The outside cylinder shall be constructed of 0.030-inch nominal thickness or thicker sheet steel or the cylinder and vanes shall be constructed of 3003 H14 aluminum alloy of equivalent thickness.
 4. Dimensions of louvers and arrangements of vanes shall be as shown on the Drawings.
- I. Backplates.
1. Backplates shall be furnished and installed on all vehicular signal heads.
 2. Dimensions, materials, and installation details shall be as shown in the Uniform Standard Drawings No. 840 through No. 842.
 3. No background light shall show between the backplate and the signal face or between sections.
 4. Where a backplate consists of 2 or more sections, the section shall be fastened with rivets or with aluminum bolts peened after assembly to prevent loosening.
 5. All traffic signal backplates shall have a 2-inch retroreflective fluorescent yellow ASTM D4956-13 Type XI or better adhesive sheeting border on the entire outer perimeter of the front side of the backplate. The backplate shall be louvered and shall be painted or powder coated flat black using the same technique as on the signal housing.
- J. Signal Mounting Assemblies.
1. Assemblies for the mounting of signal faces shall consist of 1-1/2-inch standard steel pipe and necessary fittings, slip-fitters, and terminal compartments painted or powder-coated using the same technique and the same color as on the signal housing.
 - a. All post top and side mount brackets shall have bronze or ferrous terminal compartments.

- b. Each terminal compartment shall be fitted with a terminal block containing a minimum of 12 poles, each with 2 screw-type terminals.
 - c. Each terminal shall be designed to accommodate at least five No. 14 AWG conductors.
 - d. A cover shall be provided on the compartment to give ready access to the terminal block.
2. Bracket-mount terminal compartments shall be designed to bolt securely to a pole.
- a. The dimensions of mounting assembly members between the axis through the center of the terminal compartment, or slip-fitter, shall not exceed 11 inches, except where required to provide proper signal face alignment or permit programming of programmed visibility signal faces or when otherwise directed by the Engineer.
 - b. Each mounting assembly shall be oriented to provide maximum horizontal clearance to the adjacent roadway.
 - c. All mounting assembly members shall be either plumb or level, symmetrically arranged, and securely assembled.
 - d. All conductors shall be concealed.
 - e. Mounting assemblies shall be watertight and free of sharp edges or protrusions that might damage conductor insulation.
3. Post-top mounted signals shall be installed using a slip-fitter.
- a. The slip-fitter shall fit over a 4-1/2-inch outside diameter pipe or tapered standard end.
 - b. Each slip-fitter shall be provided with 3 cadmium-plated or stainless steel set screws evenly arranged around the fitting.
 - c. Each slip-fitter used to post-top mount signals with brackets shall be provided with an integral terminal compartment.
4. Side mount assemblies shall be attached to the signal pole in accordance with Drawings No. 858 through No. 864 of the Uniform Standard Drawings.
5. All mounting assemblies shall be provided with positive locking, serrated fittings that, when mated with similar fittings on the signal faces, shall prevent faces from rotating. Fittings shall permit fastening at increments of not more than 7 degrees.

623 T.02.09 PROGRAMMED VISIBILITY VEHICLE SIGNAL FACES

- A. Each programmed visibility signal face and the installation thereof shall conform to ***Subsections [623 T.02.08.I](#), "Backplates," and [623 T.02.08.J](#), "Signal Mounting Assemblies."***
- B. Each programmed visibility signal section shall provide a nominal 12-inch solid or arrow indication.
 - 1. Color and arrow configuration shall conform to ANSI Standard D-10.1.
 - 2. Each section shall be provided with a sun visor.

- C. All signal sections shall be provided with an adjustable connection that permits incremental tilting from 0 to 10 degrees above or below the horizontal while maintaining a common vertical axis through couplers and mountings.
 - 1. Terminal connection shall permit external adjustment about the mounting axis in 5 degree increments.
 - 2. The signal shall be mountable with ordinary tools and capable of being serviced without tools.
 - 3. Adjustment shall be preset at 4 degrees below the horizontal, unless otherwise specified.
- D. The visibility of each programmed visibility signal face shall be capable of adjustment or programming within the face. When programmed, each signal face's indication shall be visible only in those areas or lanes to be controlled, except that during dusk and darkness a faint glow to each side will be permissible.
- E. Prior to programming, each signal section with a yellow indication shall provide a minimum luminous intensity of 3,000 candela on the optical axis, and a maximum intensity of 30 candela at 15 degrees horizontal from the axis.
 - 1. Each such signal section shall be capable of having its visibility programmed to achieve the following luminous intensities:
 - a. A minimum of 3,000 candela on the optical axis.
 - b. A maximum of 100 candela at from 1/2 degree to 2 degrees horizontal from the axis.
 - c. A maximum of 10 candela at from 2 degrees to 15 degrees horizontal from the axis.
 - 2. Under the same conditions, the intensities of the red indication and the green indication shall be at least 19 and 38 percent respectively of the yellow indication.
- F. Each signal face or each signal section shall include integral means for regulating its luminous intensity between limits in proportion to the individual background luminance.
 - 1. Lamp intensity shall not be less than 97 percent of uncontrolled intensity at 1,000 foot-candles, and shall reduce to 15 $\pm$ 2 percent of maximum intensity at less than 1 foot-candle.
 - 2. The dimming device shall operate over an applied voltage range of 95 volts to 130 volts, 60 Hz and a temperature range of -40 degrees F to 165 degrees F.
- G. The Contractor shall have a manufacturer's representative program the heads.

623 T.02.10 PEDESTRIAN SIGNAL FACES

- A. Each pedestrian signal face shall conform to the following:
 - 1. Messages shall be Lunar White WALKING PERSON and Portland Orange COUNTDOWN conforming to the requirements of the *Manual on Uniform Traffic Control Devices*.
 - 2. Each pedestrian signal face shall be installed at the location and mounted in the manner shown on the Drawings.
 - 3. All new pedestrian signal faces installed at any one intersection shall be of the same make and manufacturer.

4. Pedestrian signal indications that have been installed and are not in operation shall be covered from public view in accordance with **Subsection [623 G.03.03](#), "Scheduling of Work,"** to clearly show that the signals are inoperative.
 5. Pedestrian signals may be temporarily turned so that the faces are not visible to pedestrians if approved by the Engineer.
- B. Optical Units.
1. Optical units for pedestrian signals shall be LED modules and shall be interchangeable with all pedestrian signal head manufacturers.
 2. The LEDs shall be securely fastened to a printed circuit board and shall meet FCC Title 47, Subpart B, Section 15 Regulations for electrical noise.
 3. The LED module shall be watertight when properly mounted in the signal head enclosure and conform to NEMA and ITE moisture resistance standards. The modules shall specifically conform to the NEMA 250 moisture resistance standards for Type 4 enclosures.
 4. ALL LED modules shall be operationally compatible with NEMA TS 1 and NEMA TS 2 conflict monitoring parameters.
 5. The LED module circuitry shall prevent flicker of the LED output at frequencies less than 100 Hz over the operating voltage range. There shall be no visible illumination from the LED module when the applied voltage is less than 35 VAC.
 6. The LED modules for pedestrian signals shall be 17 inches wide and 16 inches high.
 - a. LED modules shall be complete units, consisting of clear, textured and stabilized polycarbonate lenses, an LED circuit board inclusive of all individual LEDs and required circuit components, a 39-inch No. 18 AWG color-coded wire leads with strain relief and female quick connect/fasten terminals for No.18 AWG wire, and a one-piece commercial grade neoprene gasket.
 - b. The LEDs shall be securely fastened to a printed circuit board and shall meet FCC Title 47, Subpart B, Section 15 Regulations for electrical noise.
 7. LED modules shall have textured lenses to reduce glare.
 8. The COUNTDOWN LED modules shall utilize exclusively AS or TS ALnGaP technology. The PERSON LED modules shall utilize InGaN technology.
 - a. LED modules shall not exhibit degradation of more than 30 percent of their initial light intensity following accelerated life testing (operating at 185 degrees F and 85 percent humidity for 1,000 hours).
 - b. LED modules shall be connected directly to line voltage, 117 VAC nominal, and shall operate over the voltage range of 80 VAC to 125 VAC, with a power factor of 0.90 or better.
 - c. Total harmonic distortion shall be 20 percent or less.
 - d. The intensity of the LED signal shall not vary by more than 10 percent over the allowable voltage range.
 9. Each individual LED module shall have a separate power source for the WALKING PERSON and COUNTDOWN indications internal to the module.
 10. The LED modules shall be energy efficient.

11. Unless otherwise specified, the LED modules shall include a countdown indication as specified in the most recent MUTCD requirements.
12. Manufacturer Warranty:
 - a. The manufacturer's warranty of all LED modules shall be minimum 5-year replacement of any defective or failed LED units from the time of activation.
 - b. The manufacturer shall further warrantee all LED modules for a minimum life of 5 years for compliance with minimum illumination output from date of acceptance.
 - c. The manufacturer is responsible for all pickup or shipping costs for the replacement units.

C. Housing.

1. The housing shall be made of 3003 H14 die cast aluminum alloy with smooth finish on both sides.
 - a. Thickness shall be 1/8-inch minimum at the points of support.
 - b. The housing shall be corrosion resistant and shall provide for easy access to and replacement of all components.
 - c. All machine screws, studs, and washers shall be either nickel plated brass, stainless steel, or other corrosion resistant material.
 - d. Gaskets shall be provided as required to make the housing rain-tight and dust tight.
 - e. Gaskets shall conform to the provisions in ASTM D1056, Grade SBE42.
2. The housing shall be provided with top and bottom openings for 1-1/2-inch pipe.
 - a. Unused openings shall be closed with watertight closures painted to match the housing, as shown on the Uniform Standard Drawings.
 - b. The housing construction design shall not incorporate a clamshell mounting.
 - c. The housing shall be fully adjustable.
3. Terminal Block: A light duty terminal block shall be mounted in the housing for field wiring.
4. Finish: The outside of the housing shall be painted the same color using the same painting process as for the vehicular signals.
5. Pedestrian Signal Mounting Assemblies:
 - a. Assemblies for the mounting of pedestrian signals shall consist of 1-1/2-inch standard steel pipe and necessary fittings, slip-fitters, and terminal compartments painted or powder-coated using the same technique and the same color as on the signal housing.
 - b. All post top and side mount brackets shall have bronze or ferrous terminal compartments.
 - 1) Each terminal compartment shall be fitted with a terminal block containing a minimum of 6 poles, each with 2 screw-type terminals.
 - 2) Each terminal shall be designed to accommodate at least five No. 14 AWG conductors.

- 3) A cover shall be provided on the compartment to give ready access to the terminal block.
- c. Bracket-mount terminal compartments shall be designed to bolt securely to a pole.
 - 1) The dimensions of mounting assembly members between the axis through the center of the terminal compartment, or slip-fitter, shall not exceed 11 inches, except where required to provide proper pedestrian signal face alignment.
 - 2) Each mounting assembly shall be oriented to provide maximum horizontal clearance to the adjacent roadway.
 - 3) All mounting assembly members shall be either plumb or level, symmetrically arranged, and securely assembled.
 - 4) Construction shall permit all conductors to be concealed.
 - 5) Mounting assemblies shall be water-tight and free of sharp edges or protrusions which might damage conductor insulation.
- d. Post-top mounted pedestrian signals shall be installed using a slip-fitter.
 - 1) The slip-fitter shall fit over a 4-1/2-inch outside diameter pipe or tapered standard end.
 - 2) Each slip-fitter shall be provided with 3 cadmium-plated or stainless steel set screws evenly arranged around the fitting.
 - 3) Each slip-fitter used to post-top mount signals with brackets shall be provided with an integral terminal compartment.
- e. All mounting assemblies shall be provided with positive locking, serrated fittings that, when mated with similar fittings on the signal faces, shall prevent faces from rotating. Fittings shall permit fastening at increments of not more than 7 degrees.

623 T.02.11 PEDESTRIAN PUSH BUTTONS

- A. Pedestrian push buttons of tamper-proof construction shall be furnished and installed for all pedestrian phases. The assembly shall be weatherproof and so constructed that it will be impossible to receive any electrical shock under any weather condition.
- B. The pedestrian push button switch shall be a phenolic, enclosed, precision snap-acting type switching unit. It shall be single-pole, double-throw, with screw-type terminals, rated 15 amperes at 125 VAC, and shall have the following characteristics:
 1. The switching unit shall have a stainless steel plunger actuator.
 2. The switch shall be provided with U-frame to permit recessed mounting.
 3. The switch shall have an operating force of 0.56 to 0.81 lbf and have a minimum release force of 0.25 lbf.
 4. Switch pre-travel shall be 1/64 inch maximum.
 5. Switch over-travel shall be 7/32 inch minimum.
 6. Switch differential travel shall be 0.0004 to 0.002 inch.
- C. Push buttons shall be 2-inch minimum diameter.

- D. Pedestrian push button housings attached to poles shall be shaped to fit the curvature of the pole and secured to provide a rigid installation. Saddles shall be provided to make a neat fit when required.
- E. Pedestrian push buttons to be mounted on top of a 2-1/2-inch diameter post shall incorporate a slip-fitter coupling with recessed set screws for securing the mechanism rigidly to the post.
- F. Push button and sign shall be installed on crosswalk side of the pole.
- G. Arrows on push button sign shall point in same direction of corresponding crosswalk.
- H. Mounting height of the pedestrian push button shall be in accordance with the latest published edition of the ADA Guidelines.
- I. Pedestrian push button signs shall be designated on the Drawings.

623 T.02.12 FLASHERS

- A. All flasher signal heads shall be a minimum 12-inch diameter lens.
- B. Visors. Each flashing beacon shall be provided with a tunnel type visor.
- C. Flashing Beacon Control Assembly.
 - 1. Each flashing beacon control assembly shall consist of switches, circuit breakers, terminal blocks, flasher, wiring, and electrical components necessary to provide proper operation of the beacons, all housed in a single enclosure.
 - 2. The enclosure shall be as specified in the Uniform Standard Drawings or Special Provisions.
- D. Circuit Breakers and Switches.
 - 1. A single-pole 15-ampere circuit breaker shall be installed to control each ungrounded conductor entering the enclosure.
 - 2. A switch to permit manual operation and testing of the flasher circuit shall be provided and labeled "Auto-Test."
 - 3. The switches shall be toggle type, single-pole, single-throw, and rated at 15 amperes, 125 VAC.
 - 4. Switches shall be connected in parallel with the timing control circuit so that the timer is bypassed when the switch is in the Test position.
- E. Flasher. A 15-ampere solid state flasher shall provide for a 2-circuit alternate operation of beacons.
- F. Terminal Blocks. Terminal blocks shall be rated at 25 amperes, 600 volts, shall be molded from phenolic material, and shall be the barrier type with plated brass screw terminals and integral type marking strips.

623 T.02.13 TRAFFIC SIGNAL POLES

- A. All traffic signal poles shall consist of a continuous tapered rounded or multi-sided steel pole shaft of the length specified, pole cap, anchor bolt cover, and hand hole cover(s), with the bolts, nuts, and washers necessary to complete the installation of the pole shaft.

- B. The traffic signal and luminaire mast arms shall consist of continuous, tapered round steel tubes of the lengths specified, mast arm end caps and bolts, nuts, and washers necessary to complete the installation of the mast arms.
- C. Pole assemblies, traffic signal mast arms, luminaire mast arms and brackets, anchor-bolt and handhole covers, and pole and mast arm caps shall be hot-dip galvanized in conformance with ASTM A123.
 - 1. Associated hardware shall be hot dip galvanized in accordance with ASTM A153.
 - 2. Flaws in the appearance of galvanized components shall be cause for rejection by the Engineer.
 - 3. The Engineer shall reject galvanized materials with finishes that have a striped or uneven appearance, a build-up of zinc hydroxide, rust stains, ash inclusions, dross protrusions, and/or flux inclusions.
 - 4. Galvanized materials that exhibit these flaws shall also be rejected.
- D. Anchor-bolt covers shall be a two-piece aluminum or ferrous metal design with a finish to match the pole shaft.
 - 1. Anchor bolt covers shall cover the base plate completely and shall be firmly secured in place at the bottom of the pole.
 - 2. Anchor bolt covers for traffic signal poles shall rest on the top of the foundation when installed properly but shall not exceed 6 inches in height.
 - 3. All bolts, screws, nuts, and washers necessary to assemble the cover shall be included.
- E. Poles shall sustain a horizontal test load in accordance with manufacturer's specifications without failure of any component part.
- F. Luminaire arms for traffic signal poles shall sustain a vertical load of 100 pounds applied within 3 inches of the luminaire end of the support with the support attached to a rigid structure.
 - 1. The vertical deflection shall not exceed 5-1/2 percent of the bracket or mast arm length.
 - 2. The luminaire brackets or mast arms shall sustain a transverse horizontal load of 150 pounds applied within 3 inches of the luminaire end of the support with the support attached to a rigid structure.
 - 3. The horizontal deflection shall not exceed 10 percent of the bracket or mast arm length.
 - 4. The pole attached devices shall not develop any looseness within the specified loading range.
- G. Traffic signal mast arms shall sustain the vertical loads as represented in the Uniform Standard Drawings.
- H. All welds shall be continuous.
 - 1. One circumferential weld shall be allowed for each 10 feet of length and 1 longitudinal weld will be permitted in assembling the shaft.
 - 2. Where the sections are butt-welded together, the welded seams of adjacent sections shall be placed together to form a continuous weld.

3. Butt joints shall be reinforced in the pole/arm by 3-inch wide sleeves of the same composition and gauge as the steel in the pole/arm.
 4. The sleeves shall be centered at the joint and shall be in full contact with the metals that are being joined.
 5. The weld metal shall extend to the sleeve, making the sleeve an integral part of the joint.
 6. Welding shall be done by American Welding Society (AWS) certified welders.
- I. All surplus weld material or protrusions shall be ground smooth.
1. Ground joints shall maintain the strength of the original metal.
 2. Exposed welds, except fillet and longitudinal welds, shall be ground flush with the base metal.
- J. Exposed edges of base plates shall be broken. The pole shaft shall telescope through the base plate and shall be secured by 2 continuous welds, 1 on the inside at the bottom of the plate and the other on the outside on top of the plate.
- K. The pole shafts shall be of round cross section, with a minimum outer diameter at the base as shown in the Uniform Standard Drawings for the type of pole specified, and shall uniformly decrease in diameter at the rate of 0.14 inches per foot of length.
1. The pole shafts may be multi-sided with a minimum roundness ratio of 98 percent so that the poles retain the appearance of a round unit.
 2. Multi-sided poles shall have a minimum of 16 sides.
 3. Poles that appear multi-sided, with noticeable edges between the sides that are clearly visible, may be rejected by the Engineer.
 4. Pole shafts shall be straight, with a permissive variation not to exceed 1/4 inch for each 10 feet of pole shaft.
 - a. A 30-foot pole would have 3/4 inch allowable deviation at the midpoint of the pole shaft.
 - b. A 20-foot shaft would have 1/2 inch allowable deviation.
 - c. A 10-foot shaft could deviate a maximum of 1/4 inch at the midpoint.
- L. Type 1-A and 1-B traffic signal poles shall be constructed of 0.120-inch or thicker steel with the dimensions shown in the Uniform Standard Drawings.
- M. A grounding lug shall be supplied interior to all signal and lighting pole shafts, including 1-A and 1-B pedestal poles, opposite the handhole for securing the grounding connections. This grounding lug shall be threaded to accept a standard 1/2-inch bolt and shall be welded to the inside of the pole where it is easily accessed for maintenance and repairs.
- N. Traffic signal pole luminaire mast arms shall be manufactured of tapered steel and shall be 15 feet.
1. The tapered arms shall taper to provide a minimum of 7-1/2 inches of arm of a constant and uniform outside diameter of 2.4 inches perpendicular to the shaft for attaching the luminaire.

2. Alternatively, the arm may include a luminaire end consisting of 2-inch, Schedule 40 pipe, conforming to ASTM A53 or ASTM A500, Grade B, welded in place so that a minimum of 7-1/2 inches is exposed for the attachment of the luminaire.
 3. The pole attachment end shall include a 3-bolt, rain-tight steel fitting as called for on Standard Drawing No. 318.
 4. The fitting shall be welded in place.
 5. The bolts shall be high strength conforming to ASTM A325.
- O. Signal poles and arms shall be fabricated from weldable grade sheet steel having a minimum yield strength, after fabrication, of 48,000 psi.
- P. All 30- and 40-foot traffic signal poles shall be furnished with 2 luminaire mast arm mounting plates with the 3-bolt simplex shown in the Uniform Standard Drawings.
- Q. All surplus weld material or protrusions shall be ground smooth.
1. Ground joints shall maintain the strength of the original metal.
 2. Exposed welds, except longitudinal and fillet welds, shall be ground flush with the base metal.
 3. Anchor bolts, nuts, and washers for traffic signal poles shall conform to the Uniform Standard Drawings for the type of pole specified and shall be hot-dip galvanized.
 4. The bolts shall be galvanized for the entire length of the bolt.
- R. Handholes in the base of XX, XX-A, and XX-B traffic signal poles shall have a minimum I.D. of 6 inches by 9 inches.
1. Handholes shall face away from oncoming traffic and shall be located 12 inches bottom base plate to bottom handhole.
 2. The handhole shall be 6 inches by 9 inches I.D. reinforced frame with flat or indented type cover.
 3. The handhole cover shall utilize two 1/4-inch standard thread screws secured to steel plates welded inside the handhole opening to hold the cover in place.
 4. The screws shall be a weather and vandal resistant 1/4-inch hexagonal socket head screw.
 5. Handholes may be rectangular or oval.
- S. Handholes opposite the traffic signal mast arms of XX, XX-A, and XX-B traffic signal poles shall have a minimum I.D. of 6 inches by 9 inches.
1. Handholes shall be 180 degrees opposite the signal mast arms and shall conform to the Uniform Standard Drawings.
 2. The handhole shall be centered with the mast arm assembly.
 3. The handhole cover shall utilize two 1/4-inch standard thread screws secured to steel plates welded inside the handhole opening to hold the cover in place.
 4. The screws shall be a weather and vandal resistant 1/4-inch hexagonal socket head screw.
 5. Handholes may be rectangular or oval.

- T. Handholes for 1-A and 1-B traffic signal poles shall have a minimum I.D. of 4 inches by 6 inches, and the bottom shall be 8 inches bottom base plate to bottom handhole.
 - 1. The cover plate shall be secured with two 1/4-inch bolts secured to steel plates welded inside the handhole opening with standard thread and tamper-proof hexagonal heads.
 - 2. Handholes may be rectangular or oval.
- U. Poles, arms, and associated hardware to be painted shall be galvanized in accordance with ASTM A123 and ASTM A153 prior to applying the finish coating.
 - 1. The finish of the galvanized materials shall then be prepared according to the paint manufacturer's recommendation before the finish paint or powder coating is applied.
 - 2. The finish coating shall consist of a minimum of 2 coats of aliphatic urethane or Triglycidyl Isocyanurate (TGIC) Polyester Powder.
 - 3. The finish shall be colored as specified in the Contract Documents or by the Engineer at the time of order.
- V. The manufacturer's identification tag shall be mounted above the handhole.

623 T.02.14 INTERCONNECT JUNCTION CABINET

- A. Traffic signal interconnect junction cabinets are not permitted except as specifically approved by the Engineer in consultation with FAST.
- B. The interconnect junction cabinets shall be Tesco Enclosure Class 22-000-NR, 43 inches by 20 inches by 11 inches, or approved equal.
- C. The cabinet shall be equipped with 1 Reliable Electric No. R66B4-25 terminal block, or approved equal, having capacity for 25 pairs of No. 22 AWG wire.
- D. The terminal block shall be mounted on a painted wood panel secured to the back of the cabinet.
- E. The Contractor shall provide and install a door lock with a key and all foundation, anchor bolts, and hardware in accordance with instructions of the cabinet manufacturer.

623 T.02.15 RED LIGHT DISPLAY INDICATORS

- A. Red light display indicators shall be installed at the locations shown in the Drawings or as directed by the Engineer.

623 T.02.16 INTERNALLY ILLUMINATED STREET NAME SIGNS

- A. Internally illuminated street name signs shall be provided at all traffic signal locations, unless otherwise specified in the Contract Documents.
- B. The signs shall be 8 feet long and 22-5/16 inches high with street names on both sides of the sign. The signs shall be weather-tight and consist of 6063 T-5 alloy aluminum housing.
- C. The sign panels shall be fabricated of clear plastic sheeting having a minimum thickness of 0.1875 inches with aluminum framing.
 - 1. The clear plastic panels shall be covered with translucent white, wide-angle, prismatic reflective sign face sheeting, and either reverse-screened with manufacturers' recommended green ink and clear coating or overlaid with green, electronic cuttable, transparent overlay film.

2. The sign sheeting shall be applied in a vertical orientation in accordance with the manufacturer's recommendations.
 3. The sign face shall have a 2-1/4-inch white border.
 4. Sign lettering shall be 8-inch series D upper/lower case design unless otherwise specified by the Engineer.
 5. Lower case letters shall be 5 inches in height.
 6. The sign face shall have the compass direction of the location marked in the upper left corner of each sign panel with a 5-inch upper case letter (N, S, E or W).
 7. The street name suffix (Street, Way, Blvd., and so forth) shall be displayed in the upper right corner of the sign panel with upper case letters.
 8. The street address number of the location shall be shown at the lower right corner in 5-inch upper case letters and numerals.
 9. Engineer approval is required for the sign faces prior to fabrication.
- D. The lighting ballast shall be Advance 120V, 60 Hz RSM175STP, Class P, Type HL, Type 1 outdoor ballast.
1. Lamps shall be 430 mA cool white.
 2. Two lamps, spaced 6 inches apart, are required for each lighted sign.
 3. A lighting ballast is required for each lamp.
- E. The internal wires shall be carefully installed along the side of the street name sign canister and shall be secured in place with a continuous bead of clear silicon rubber.
- F. The sign shall be capable of withstanding winds of 100 mph without damage.

623 T.02.17 ELECTRICAL SERVICE

- A. Electrical service pedestals to be installed for traffic signals systems shall comply with ***Subsection 623 G.02.07, "Electrical Service Pedestals."***
- B. Connection to the electrical utility shall be as shown on the Drawings, as indicated in the Special Provisions, or as directed by the Engineer.
- C. The Contractor shall be responsible for coordinating with the electrical utility at the proper time to ensure the electrical connection will be energized on schedule.

623 T.02.18 UNINTERRUPTIBLE POWER SUPPLY SYSTEMS (UPS)

- A. When specified, an uninterruptible power supply system shall be supplied in accordance with the Contract Documents.

03CONSTRUCTION**623 T.03.01 PAINTING**

- A. The preparation and finishing of new equipment and refinishing existing materials shall be as follows:
1. Galvanized and stainless steel devices shall not be painted unless otherwise specified in the Contract Documents or approved in writing by the Engineer.

2. Non-ferrous surfaces shall be painted only if specified in the Contract Documents or approved and directed by the Engineer. Surfaces shall be cleaned and coated with vinyl wash primer. Ferrous metal surfaces shall be cleaned and immediately coated with the primer specified in ***Subsection 714.03.01.B, "Pre-Treatment, Vinyl Wash Primer (State Specification 8010-61J-27)."***
3. All traffic signal poles, posts, and mast arms shall be hot-dip galvanized by the manufacturer in accordance with ASTM A123. Traffic signal poles shall not be painted unless specifically called for in the Drawings and Special Provisions.
4. Directional louvers and backplates shall be painted flat black.
5. Traffic signal cabinets and controller boxes shall conform to ***Subsection 623 T.02.01, "Traffic Signal Controller Cabinets."***
6. Factory enameled equipment and materials shall be examined for damaged paint after installation, and such damaged surfaces shall be refinished by the Contractor to the satisfaction of the Engineer.
7. Existing equipment and material to be repainted, whether remaining in place or to be relocated, shall be cleaned of all rust, scale, grease, dirt, and poorly bonded paint to the satisfaction of the Engineer.
8. All bare metal shall be prime painted immediately after cleaning, or as specified for new material. Two finish coats shall then be applied over newly primed areas.
9. Blast cleaning of galvanized metal surfaces that are in good condition will not be permitted.
10. Paint coats may be applied either by hand brushing or by approved spraying machines with the work performed in a neat and workmanlike manner.
 - a. No spraying shall be done at the job site in windy or bad weather conditions unless approved by the Engineer.
 - b. The Engineer may require the use of brushes or spray equipment for the application of paint depending on the application and the weather conditions.
11. The thickness of each paint coat shall be limited to that which will result in uniform drying throughout the film. Skips, holidays, thin areas, or other deficiencies in any 1 coat of paint shall be corrected to the satisfaction of the Engineer before the next coat of paint is applied.
12. The final coat shall present a smooth surface, uniform in color, and free of runs, sags, excessive brush marks, tiger-stripping, or other deformities as determined by the Engineer.
13. Galvanizing repair shall consist of metalizing or hot-stick galvanizing.
 - a. Surfaces regalvanized shall be prepared in accordance with ASTM A780.
 - b. Application of the zinc metalizing protection shall be in accordance with ANSI/AWS C2.18-93.
 - c. Zinc soldering or hot-stick galvanizing shall be performed by skilled personnel familiar with the procedure and surrounding areas shall not be damaged by the heat applied.
 - d. In either case, the renovated areas shall have a zinc coating thickness of at least as thick as that specified in ASTM A123.

- e. Cold galvanizing spray or other methods of applying cold galvanizing shall not be allowed.

623 T.03.02 ELECTRICAL TESTING

- A. Prior to completion of the work, the Contractor shall cause the following tests to be made on any or all new electrical circuits, as required by the Engineer and in the presence of the Maintaining Agency representative:
 - 1. Test for continuity of each circuit.
 - 2. A visual inspection of all grounding connections. Electrical equipment and components shall not be energized unless properly grounded as specified in the Contract Documents and directed by the Engineer.
 - 3. A megohmmeter test on each single conductor circuit between the circuit conductor and all other circuits and ground as specified in the Contract Documents and directed by the Engineer.
 - a. The insulation resistance shall not be less than 500 megohms when tested at 500 volts.
 - b. Individual conductors in traffic signal cable, RF cable, Opticom cable, CCTV power cable, communications cable, other multi-conductor cables, and coaxial cables shall be exempted from the megohm testing by the Engineer if a visual inspection of these cables shows no suspicious cuts, tears, or other damage to the outside insulation.
 - c. Under no circumstances shall street light fixtures, video detection cameras, or other low voltage components be subjected to the high voltage of this test.
 - 4. A flash test for traffic signal installations to verify the terminals and connections before turn-on.
 - 5. A functional test in which it is demonstrated that all parts of the system function as specified or intended.
 - 6. Any fault in any material or in any part of the installation revealed by these tests shall be replaced or repaired by the Contractor immediately. All repairs and material replacements shall be completed to the satisfaction of the Engineer.

623 T.03.03 GROUNDING

- A. All electrically conductive materials of the electrical system shall be connected to earth and system grounds and shall conform to the following:
 - 1. Metal pull box covers shall be grounded with No. 4 AWG 7-strand copper wire connected to the system ground and the pull box cover.
 - a. The connection to the pull box cover shall be made using an exothermal welding system that is appropriate for the material of the cover.
 - b. An irreversible compression type connector shall be used to connect to the system grounding conductor.
 - 2. The Contractor shall be responsible for grounding the electrical system including pull boxes, poles, cabinets, conduits, service pedestals, and other enclosures to the satisfaction of the Engineer. No separate payment shall be made for this work unless specifically shown in the list of pay items.

3. Poles and traffic signal cabinets shall be grounded to the system and earth grounds using bare No. 4 AWG copper wire connected to the anchor bolts of the concrete foundation and to the grounding plate installed under the foundation. Grounding the system shall comply with Drawing No. 725 of the Uniform Standard Drawings.
4. Service pedestals shall be grounded using UFER ground of 20 feet of No. 4 AWG, bare, stranded copper conductor coiled under the foundation of the pedestal.
5. The bare grounding wire of traffic signal poles shall be equipped with a copper grounding lug to be attached to the equipment ground screw.
 - a. The lug shall be sized to snugly fit over the grounding bolt of the equipment.
 - b. The grounding wire lug shall be an irreversible, compression type component and shall be installed on the bare grounding conductor 24 inches from the end of the wire to allow connection of other grounding conductors to the end of the bare wire.
 - c. The grounding lug shall be installed so that the bare grounding wire end, when pulled through the handhole, shall have a minimum length of 12 inches outside of the pole.
 - d. The No. 8 AWG green system grounding conductor from the conduit and all other grounding conductors servicing equipment on the pole shall be connected to the end of the bare grounding conductor with a removable, mechanical device such as a split bolt.

623 T.03.04 CABINET INSTALLATIONS

- A. Electrical service pedestals and traffic signal controller cabinets shall not be installed in areas that are regularly irrigated with broadcast sprinklers or areas that may become flooded with sprinklers.

STREET LIGHTING SECTION

01DESCRIPTION

623 L.01.01 GENERAL

- A. Street lighting construction shall consist of furnishing, installing, modifying, or removing street light poles and fixtures or other electrical installations in the roadway right-of-way as shown on the Drawings and specified in the Contract Documents.
- B. The locations of street light poles, electrical services, and other associated equipment shown on the Drawings are approximate. The Engineer will confirm exact locations of these items in the field.
- C. All materials furnished and installed shall be manufactured, handled, and used in a manner to ensure completed work with undamaged equipment and materials in accordance with the Drawings, specifications, and Special Provisions. Engineer approval of all materials shall be required prior to installation.
- D. All systems shall be complete and in satisfactory operating condition at the time of acceptance including successful completion of all testing required by these specifications.
- E. All work performed on any street lighting component or system shall be under the direct on-site supervision of an Electrician certified as a Journeyman or greater. An electrician

- with Journeyman level status certification or IMSA Roadway Lighting certification shall supervise the installation of electrical raceways that are part of a street lighting system.
- F. The Contractor shall be responsible for locating and protecting all underground and aerial utilities and infrastructure improvements.
1. The exclusion of utilities and other structures on the Drawings or in the Special Provisions does not limit the Contractor's responsibility for these construction elements.
- G. If specified in the Contract Documents, GPS coordinates shall be supplied.

02MATERIALS

623 L.02.01 STREET LIGHT POLES AND ARMS

- A. All lighting poles shall consist of a continuous tapered round steel pole shaft of the length specified, pole cap, anchor bolt cover, and hand hole cover(s), with the bolts, nuts, and washers necessary to complete the installation of the pole shaft.
- B. The luminaire arm shall have a minimum length of 8 feet.
1. The arm shall be formed from 2-inch, Schedule 40 pipe, with standard 2.4-inch outside diameter (OD) conforming to ASTM A53 or ASTM A500, Grade B.
 2. The overall length and vertical rise of the arm shall be in a ratio of 1:4, vertical to horizontal.
 3. The overall shape of the curvature of the arm shall be similar to the arms shown on Standard Drawing 316.
 4. A minimum straight portion of 7-1/2 inches shall be provided to attach the luminaire.
 5. The pole shaft end of the arm shall have a single bolt, rain-tight, steel fitting with a cupped rim, simplex hooking mechanism.
 6. The fitting on the arm shall be shaped to lock over the street light pole simplex fitting by gravity and shall be secured by a single 1/2-inch bolt with standard thread.
- C. Luminaire mast arms 10 feet and longer shall be manufactured of tapered steel tubing.
1. The arms shall taper to provide a minimum of 7-1/2 inches of arm of a constant and uniform outside diameter of 2.4 inches perpendicular to the shaft for attaching the luminaire.
 2. Or, alternatively, the arm may include a luminaire mounting end consisting of 2-inch, Schedule 40 pipe, conforming to ASTM A53, welded in place so that a minimum of 7-1/2 inches are exposed for the attachment of the luminaire.
 3. The pole attachment end shall include a 3-bolt, rain-tight, steel simplex fitting as called for on Standard Drawing No. 318.
 4. The fitting shall be welded in place.
 5. The bolts shall be high strength conforming to ASTM A325.
- D. Pole assemblies, luminaire mast arms and brackets, anchor-bolt and handhole covers, and pole and mast arm caps shall be hot-dip galvanized in conformance with ASTM A123.
1. Associated hardware shall be hot-dip galvanized in accordance with ASTM A153.
 2. Flaws in the appearance of galvanized components shall be cause for rejection.

3. The Engineer will reject galvanized materials with finishes that have a striped or uneven appearance, a buildup of zinc hydroxide, rust stains, ash inclusions, dross protrusions, and/or flux inclusions.
 4. Galvanized materials that exhibit a spidery, blotchy, or spotted appearance, that have a general surface roughness, or that exhibit lumpiness or runs in the finish shall also be rejected.
- E. Anchor-bolt covers shall be a 2-piece aluminum or ferrous metal design with a finish to match the pole shaft, shall cover the base plate completely, and shall be firmly secured in place at the bottom of the pole.
1. Anchor-bolt covers for street light poles shall rest on the top of the foundation when installed properly but shall not exceed 6 inches in height.
 2. All bolts, screws, nuts, and washers necessary to assemble the cover shall be included.
- F. Luminaire arms for street light poles shall sustain a vertical load of 100 pounds applied within 3 inches of the luminaire end of the support with the support attached to a rigid structure.
1. The vertical deflection shall not exceed 5-1/2 percent of the bracket or mast arm length.
 2. The luminaire brackets or mast arms shall sustain a transverse horizontal load of 150 pounds applied within 3 inches of the luminaire end of the support with the support attached to a rigid structure.
 3. The horizontal deflection shall not exceed 10 percent of the bracket or mast arm length.
 4. The pole attached devices shall not develop any looseness within the specified loading range.
- G. The pole shafts shall be of round cross section, with a minimum outer diameter at the base as shown in the Uniform Standard Drawings for the type of pole specified, and shall uniformly decrease in diameter at the rate of 0.14 inch per foot of length.
- H. Pole shafts shall be straight, with a permissive variation not to exceed 1/4 inch for each 10 feet of pole shaft.
1. A 30-foot pole would have 3/4 inch allowable deviation at the midpoint of the pole shaft.
 2. A 20-foot shaft would have 1/2 inch allowable deviation.
 3. A 10-foot shaft could deviate a maximum of 1/4 inch at the midpoint.
- I. Poles shall sustain a horizontal test load of 500 pounds applied 18 inches from the top of the shaft in any direction without failure of any component part, and with a deflection of not more than 7-1/2 percent of the pole shaft length as measured from point of load application to the base plate.
- J. All welds shall be continuous.
1. One circumferential weld shall be allowed for each 10 feet of length and 1 longitudinal weld will be permitted in assembling the shaft.
 2. Where the sections are butt-welded together, the welded seams of adjacent sections shall be placed together to form a continuous weld.

3. Butt joints shall be reinforced in the pole/arm by 3-inch wide sleeves of the same composition and gauge as the steel in the pole/arm.
 4. The sleeves shall be centered at the joint and shall be in full contact with the metals that are being joined. The weld metal shall extend to the sleeve, making the sleeve an integral part of the joint.
 5. Welding shall be done by AWS certified welders.
- K. All surplus weld material or protrusions shall be ground smooth.
1. Ground joints shall maintain the strength of the original metal.
 2. Exposed welds, except fillet welds, shall be ground flush with the base metal.
- L. Street light pole safety bases shall conform to Uniform Standard Drawings or as specified in the Contract Documents and approved by the Engineer.
- M. Sheet steel used in the manufacturing process of street light poles shall have a minimum yield of 48,000 psi, or which after forming or cold rolling shall develop a minimum of 48,000 psi.
1. Poles shall have a minimum thickness of 0.119 inch for 11 gauge poles and 0.179 inch for No. 7 gauge poles.
 2. The shaft shall be formed from not more than 1 piece of sheet steel for each 10 feet of pole length.
- N. The pole base plate shall be 1 inch thick for No. 11 gauge standards and 1-1/8 inch thick for No. 7 gauge pole shafts.
1. Both base plates shall be 11-1/2 inches square and shall conform to ASTM A27, Grade 65-35 cast steel; ASTM A36 steel plate; or ASTM A283, Grade D steel plate.
 2. The base plates shall be slotted to accommodate four 1-1/8-inch anchor bolts equally spaced at the corners for a 10-1/2-inch to 11-1/2-inch bolt circle diameter.
 3. The slots shall be 2-1/8 inches long OD.
 4. Exposed edges of base plates shall be finished smooth with the corners neatly rounded to a radius of approximately 1/8 inch.
 5. The pole shaft shall telescope through the base plate and shall be secured by 2 continuous welds, 1 on the inside at the bottom of the plate and the other on the outside on top of the plate.
- O. Unless otherwise specified in the Contract Documents, the handhole shall have a reinforced frame with an opening at least 4 inches wide X 6 inches tall inside dimension. The handhole cover assembly shall be slip resistant with a single 1/4 inch X 2 inch vandal resistant hexsocket head screw. When this single bolt is tightened, a steel "backer bar" will secure the cover into place.
- P. The pole shall have an easily accessible grounding point located at the bottom of the reinforced frame of the handhole. A single hole shall be drilled and threaded into the frame to accept a 1/2 inch by 3/4 inch long cap screw. The hole shall be located towards the inside of the pole so the bolt extends inside the pole when tightened. The threads shall be cleaned with a 1/2 inch tap to easily accept the cap screw when tightened in the hole. The manufacturer's identification tag shall be placed next to the handhole.

623 L.02.02 ANCHOR BOLTS

- A. Anchor bolts for standard lighting poles shall conform to the following:
1. Anchor bolts shall conform to ASTM F1554, Grade 55, or ASTM A307 and shall have a minimum yield strength of 36,000 psi.
 2. Anchor bolts shall be provided with 2 nuts and two 2-inch washers.
 3. The anchor bolts and all nuts and washers shall be galvanized by the hot-dip process conforming to ASTM A123 and ASTM A153.
 4. Anchor bolts shall be galvanized for the entire length of the bolt.
 5. After galvanizing, the bolt threads shall accept the standard galvanized nuts for the full length of the thread without requiring tools, causing removal of protective coating, or requiring rethreading of the bolt or nut.
 6. Anchor bolts for No. 7 gauge street light poles shall be 1-1/8 inches by 40 inches by 4 inches.
 7. Anchor bolts for No. 11 gauge street light poles shall be 1 inch by 36 inches by 4 inches.
 8. The upper 8 inches of the anchor bolts shall be threaded.

623 L.02.03 STREET LIGHTING LUMINAIRES

- A. The standard luminaire shall be of the high pressure sodium type, horizontal burning, cobra head style, and in wattages specified in the Contract Documents.
1. The luminaire shall consist of a precision die cast aluminum housing, globe ring, lens, ballast, socket assembly, igniter, reflector, and hinged door.
 2. The hinged door shall be lowered by releasing a latch mechanism and allowing the door to swing free on its hinge.
 3. The latch assembly shall be easily operated while wearing lineman's gloves.
 4. The hinged door latch shall have an audible locking mechanism and shall provide easy access to the refractor, reflector, ballast, igniter, and lamp.
 5. The luminaire shall be provided with a terminal connection block installed in the upper housing.
- B. The luminaire fixture shall be bonded to earth ground with a grounding conductor.
- C. The luminaire housing and optical assemblies for 250-watt and 750-watt fixtures shall be the same size as is normally standard usage by the manufacturer for 400-watt fixtures.
1. The slip fitter shall be capable of adapting to 1-1/4-inch through 2-inch pipe bracket without rearrangement of parts and be adjustable +5 degrees from horizontal.
 2. The optical assembly shall consist of an aluminum reflector, prismatic acrylic refractor for 100-watt luminaires, and borosilicate prismatic glass refractor for 150-watt through 750-watt luminaires or, when specified, shall be of polycarbonate resin vandal resistant material.
 - a. The refractors shall have accurately molded light controlling prisms and shall be resistant to impact and thermal shock.

- b. The refractor shall provide maximum transmission and minimize unwanted spill light.
 - c. The socket size shall be mogul.
 - d. The socket shall be heavy duty, 20-ampere shrouded porcelain and shall be vertically and horizontally adjustable to obtain variations in light distribution patterns.
 - e. The socket shall have a non-cantilevered, spring loaded contact.
 - f. Standard street light fixtures shall be supplied with medium semi-cutoff photometrics and IES type III distribution, unless otherwise specified in the Contract Documents or directed by the Engineer.
- D. The starting aid (igniter) for all luminaires shall be the plug-in type, removable without the use of tools.
- E. The ballast shall be located in the top portion of the light fixture and shall be prewired to the lamp socket and terminal board.
 - 1. Ballasts mounted on the hinged door are not allowed.
 - 2. The ballast shall be of a "multi-tap" configuration, capable of starting and operating the lamp of the type and wattage indicated in Drawings and specified herein from a nominal 120-volt, 240-volt, 60 Hz power source, as shown in the Drawings within the limits specified by the lamp manufacturer.
 - 3. The ballast, including starting aid, shall protect itself against normal lamp failure modes.
 - 4. The ballast shall be capable of operating the lamp in an open or short circuit-condition for 6 months without significant loss of ballast life.
- F. The ballast shall be a magnetic regulator type.
 - 1. The coils and insulation shall be impregnated and baked using a high temperature varnish.
 - 2. This treatment shall make the ballast impervious to normal moisture and environmental conditions and shall provide mechanical strength to thoroughly bond the coils to withstand vibration and shock.
- G. The ballast shall reliably start and operate the lamp in ambient temperatures down to -30 degrees F for the rated life of the lamp.
 - 1. Ballast primary current during starting shall not exceed normal operating current.
 - 2. The lamp current crest factor shall not exceed 1.8 for ± 10 percent line voltage variation at any lamp voltage.
 - 3. The power factor of the lamp-ballast system shall not drop below 0.95 for ± 10 percent line voltage variations at any lamp voltage.
 - 4. The ballast design shall be such that the normal manufacturing tolerance for capacitors of ± 6 percent will not cause more than a ± 5 percent variation in regulation throughout rated lamp life for nominal line voltage.
- H. Cut off luminaires shall be furnished for intersection lighting unless otherwise specified in the Contract Documents or directed by the Engineer.

1. This luminaire shall meet all of the applicable specifications contained herein and provide true 90-degree light cutoff and shielding with an Alzak aluminum reflector, a heat and impact resistant flat (or sag) glass lens, a 2-position adjustable socket holder, and a mogul size porcelain screw shell socket with lamp grips.
 2. Maximum candela at 80 degrees shall be 9 and maximum candela at 90 degrees shall be 0.
 3. The light distribution shall be IES Type III.
 4. Intersection lighting installed in conjunction with traffic signals or at future traffic signal locations shall be 120-volt, HPS with IES SC3 optics.
- I. Luminaires shall be leveled and adjusted in accordance with instructions of the manufacturer or as directed by the Engineer.
1. A leveling mechanism shall be provided for leveling the luminaire in both major directions.
 2. A bubble leveling device shall be provided on the exterior of the luminaire to aid in this process.
- J. Capacitors shall be suitably protected from corrosion and isolated from higher temperatures created by the ballast.
- K. A slip-fitter shall be provided with a leveling clamp providing ± 5 degrees vertical leveling.
- L. All parts and fittings shall have a corrosion resistant finish.
1. The housing shall be free of any casting or forming burrs before the finish is applied.
 2. Luminaires shall be painted with 2 finish coats of high gloss gray enamel or polyurethane powder coating.
- M. The complete unit shall have uniform lines throughout and shall aesthetically combine in a cobra head design. The luminaire shall maintain the horizontal line of the housing when properly mounted on the bracket arm.
- N. A permanent data sheet shall be provided on the inside of the housing containing pertinent information, such as a connection diagram, operating voltages, size of lamp required, part number of required igniter, and ballast requirements.
- O. Heat and moisture resistant silicon rubber or fiber gaskets shall be provided around the reflector to produce a completely sealed optical assembly. A heat resistant silicon gasket shall also be provided between the reflector and the socket.
- P. Unless otherwise specified in the Contract Documents or directed by the Engineer, all street lighting luminaires shall be furnished complete with high-pressure sodium high intensity discharge lamps with the following characteristics:

Type/Watts	Description	ANSI Code	Lamp	Initial Lumens	Rated Life
HPS 750	LU750	S51WA-400	Clear	110,000	16,000 hours
HPS 400	LU400	S51WA-400	Clear	50,000	24,000 hours
HPS 250	LU250	S50VA-250	Clear	28,000	24,000 hours
HPS 200	LU200	S66MN-200	Clear	22,000	24,000 hours
HPS 150	LU150/55	S55SC-150	Clear	16,000	24,000 hours
HPS 100	LU100	S54SB-100	Clear	9,500	24,000 hours

- Q. The Contractor shall guarantee that all lamps that fail within 1 year under normal operating conditions shall be replaced at no additional cost to the Contracting Agency.
- R. All luminaires and component parts shall be new with labels in accordance with ANSI standards. Reconditioned, reconstructed, or remanufactured luminaires and component parts are not acceptable.
- S. Engineer approval of all street light fixtures shall be required prior to installation.

623 L.02.04 FUSEHOLDERS AND FUSES

- A. This subsection applies to multiple street lighting circuits only.
- B. Fuseholders and fuses shall be installed in the bases of all street lighting poles and shall be accessible through the handholes.
 - 1. The fuseholders shall be single pole for 120 volts or double-pole for 240 volts.
 - 2. The fuseholders shall be waterproof without the use of tape, with integral or separate conductor insulating boots.
- C. The single pole fuse holders used for 120-volt circuits shall be composed of 2 parts that consist of sections for the line side and the load side. The fuseholder body and terminals shall be vapor and waterproof when the line and load sections are mated together according to the manufacturer's recommendations.
- D. The double-pole fuseholder shall contain 2 fuseholder chambers that consist of a line side section and a load side section that are secured together with a screw when properly closed. Both load side connections shall be simultaneously disconnected when the fuseholder is opened.
- E. Electrical arcs that may occur when connecting the matching pieces while the circuit is operational shall be confined within the body when a properly sized fuse is seated firmly in the terminals.
- F. Fuse holders shall be rated for 600 volts and shall accept Midget 250-volt L4J12F fuse or approved equal. Glass, paper, or indicating type fuses are not acceptable.

623 L.02.05 STREET LIGHTING SYSTEMS

- A. Unless otherwise specified on the Drawings, all the street lighting systems shall be 240-volt, single phase, 2-wire circuits connected in parallel (multiple).
- B. Unless otherwise specified in the Contract Documents or approved by the Engineer, the 2-wire system shall consist of two No. 4 AWG stranded copper conductors with black and red THW-2 or XHHW-2 insulation to carry the load, and 1 green 8 AWG THW-2 or XHHW-2 equipment bonding conductor. Engineer approval of conductors to be installed shall be required prior to installation.
- C. The service wire for the 240-volt/100-amp pole mounted service panel shall be three No. 1/0 AWG, stranded copper, THW-2 or XHHW-2 conductors from the service panel to the electrical utility transformer.
- D. Electrical services installed for lighting on collector or arterial streets shall be standard electrical service pedestals and shall comply with ***Subsection 623 G.02.07, "Electrical Service Pedestals."***
- E. Unless otherwise specified in the Contract Documents, the cable from the base of the lighting pole to the luminaire shall be 3 conductors (one of them ground), No. 10 AWG

solid copper with insulation, rated at 600 volts. The individual conductors shall be insulated with TW grade, and the outer jacket shall be PVC jacket type UF grade.

MISCELLANEOUS ELECTRICAL EQUIPMENT

623 L.02.06 STREET LIGHT CONTROLS

- A. Contactor shall be a heavy-duty, commercial, mechanical armature type.
 - 1. The mechanical type shall consist of an operating coil, a laminated core, a laminated armature, contacts, and terminals.
 - 2. Contacts shall be silver alloy.
- B. For series lighting systems the photoelectric control shall be capable of switching series lighting systems through a high voltage controller.
- C. Types of photoelectric controls shall be as follows:
 - 1. Type I. Type I photoelectric control shall consist of a photoelectric unit and a contactor in a single weatherproof housing.
 - 2. Type II.
 - a. Type II photoelectric control shall consist of a photoelectric unit installed at the top of the first lighting standard from the service point, and shall control the lighting contactor in the pad mounted service cabinet.
 - b. A bypass switch shall be included to permit manual operation of the lighting system contactor.
 - c. Unless otherwise specified in the Contract Documents, the photoelectric units shall be for 120-volt operation on 2-wire or 3-wire single phase multiple lighting systems.
 - 3. Equipment Details.
 - a. The photoelectric unit shall consist of a light sensitive element connected to a control relay.
 - b. The light sensitive element shall have a spectral response such that it is especially sensitive to north sky illumination and shall have an ON level adjustable between minimum limits of 0.6 footcandles and 1.1 footcandles.
 - c. The unit shall be so designed that a failure of any electrical or electronic component will energize the lighting circuit.
 - d. The photoelectric unit shall be mounted at the top of the standard designated on the Drawings and shall be oriented as directed by the Engineer.
 - 4. Contactor.
 - a. The contactor shall be constructed in accordance with NEMA standards for lighting contactors and shall have contacts rated to switch the specified lighting load.
 - b. Contactor shall be the mechanical armature type.
 - c. The mechanical type shall consist of an operating coil, a laminated core, a laminated armature, contacts, and terminals.
 - d. Contacts shall be silver alloy.

5. Housing.
 - a. The contactor may be either integral with the photoelectric unit or may be located externally from it.
 - b. When located externally, the contactor shall be housed in a suitable NEMA Type 3 rain-tight enclosure with hasp for a padlock.
 - c. The rain-tight enclosure shall be mounted on the same standard as the photoelectric unit at a height of approximately 28 feet above the base.
 - d. All contactors' housings shall be approved by the Engineer prior to installation.
6. Wiring. Conductors between the photoelectric unit and an external contactor shall be a minimum No. 12 AWG, and shall be installed inside the lighting standard.

623 L.02.07 PAINT

- A. Unless otherwise specified herein all metal parts, fittings, signal heads, posts, pedestals, standards, cabinets, controller boxes, and so forth shall be prepared and painted according to these specifications.
- B. Types of paints to be used shall be as specified in **Section 714, "Paint and Pavement Markings."**

03CONSTRUCTION

623 L.03.01 PAINTING AND FINISH REPAIR

- A. The preparation and refinishing of existing equipment to be reused on projects shall be as specified below.
- B. Galvanized, ferrous, and nonferrous surfaces to be painted shall be cleaned and immediately coated with vinyl wash primer, conforming to **Subsection 714.03.01.B, "Pre-Treatment, Vinyl Wash Primer (State Specification 8010-61J-27)."**
- C. Primer coats applied by the manufacturer shall be checked by the Engineer and shall be repainted by the Contractor if necessary. Primer coats that are considered to be in good condition by the Engineer shall not require reapplication by the Contractor.
- D. All removed and reused equipment and equipment that has been repaired in-place shall require appropriate refinishing by the Contractor.
- E. Factory enameled equipment and materials shall be examined for damaged paint after installation, and such damaged surfaces shall be repainted to the satisfaction of the Engineer.
- F. Existing equipment and material to be repainted, whether remaining in place or to be relocated, shall be cleaned of all rust, scale, grease, dirt, and poorly bonded paint by any method satisfactory to the Engineer.
 1. Immediately after cleaning, all material shall be primed as appropriate and 2 finish coats of paint shall be applied after the primer coat has dried.
 2. Blast cleaning of galvanized metal surfaces in good condition, as determined by the Engineer, will not be permitted.
- G. Paint coats may be applied either by hand brushing or by approved spraying machines in the hands of skilled operators.

1. No spraying shall be done at the job site in windy or bad weather conditions and unless approved by the Engineer.
 2. The work shall be done in a neat and workmanlike manner.
 3. The Engineer may require the use of brushes or spray equipment for the application of paint depending on the materials and the weather conditions.
- H. The thickness of each paint coat shall be limited to that which will result in uniform drying throughout the film. Skips, holidays, thin areas, or other deficiencies in any 1 coat of paint shall be corrected to the satisfaction of the Engineer before the succeeding coat is applied.
- I. The final coat shall present a smooth surface, uniform in color, and free of runs, sags, or excessive brush marks.
- J. Galvanizing repair of street light poles and appurtenances shall consist of metalizing or hot-stick galvanizing.
1. Surfaces regalvanized shall be prepared in accordance with ASTM A780.
 2. Application of the zinc metalizing protection shall be in accordance with ANSI/AWS C2.18-93.
 3. Zinc soldering or hot-stick galvanizing shall be performed by skilled personnel familiar with the procedure, and surrounding areas shall not be damaged by the heat applied.
 4. In either case, the renovated areas shall have a zinc coating thickness of at least as thick as that specified in ASTM A123.
 5. Cold galvanizing spray or other methods of applying cold galvanizing shall not be allowed.

623 L.03.02 BONDING AND GROUNDING

- A. Metallic cable sheaths, steel conduit, metal poles, pedestals, pull boxes, and other metal enclosures shall be metallically joined together and made mechanically and electrically secure to form a continuous electrical conducting path, and shall be effectively grounded as required by the *National Electrical Code*.
- B. All conduits shall contain a No. 8 AWG, stranded copper grounding conductor with THW-2 or XHHW-2 green insulation to be used as a systems ground.
- C. Bonding of street light poles and foundations shall be accomplished with a bare No. 4 AWG stranded copper wire attached to each anchor bolt and to the grounding bolt installed on the lower lip of the lighting pole handhole or inside the base of the pole as shown on the Uniform Standard Drawings.
1. The grounding end of the bare wire shall be connected to a grounding plate installed under a felt protective insulator under the foundation.
 2. An extra length of 20 feet of No. 4 AWG grounding wire shall be coiled under the foundation for added contact with the earth.
 3. The No. 8 AWG green systems grounding conductor from the conduit and the No. 10 AWG luminaire ground shall be connected to the No. 4 AWG bare foundation grounding wire.

- D. Additionally, all electrically conductive materials of the electrical system shall be connected to earth and system grounds and shall conform to the following:
1. Pull box covers shall be grounded with No. 4 AWG 7-strand copper bare wire connected to the system ground and the pull box cover.
 - a. The connection to the pull box cover shall be made using an exothermal welding system that is appropriate for the material of the cover.
 - b. An irreversible compression type connector shall be used to connect to the system grounding conductor.
 2. The Contractor shall be responsible for grounding the electrical system in accordance with the Contract Documents including pull boxes, poles, cabinets, conduits, service pedestals, and other enclosures to the satisfaction of the Engineer.
 3. Grounding of conduit and neutral at the service point shall comply with the applicable sections of Article 250 of the *National Electrical Code*.
 4. Pole foundation grounding wire shall be equipped with a copper grounding lug to be attached to the equipment ground screw.
 - a. The lug shall be sized to fit over the 1/2-inch grounding bolt of the pole.
 - b. The grounding wire lug shall be an irreversible, compression type component and shall be installed on the bare grounding conductor approximately 24 inches from the end of the wire to allow connection of other grounding conductors.
 - c. The grounding lug shall be installed so that the bare grounding wire end, when pulled through the handhole, shall have a minimum length of 12 inches outside of the pole.
 - d. The No. 8 AWG green system grounding conductor from the conduit and all other grounding conductors servicing equipment on the pole shall be connected to the end of the bare grounding conductor with a removable, mechanical device such as a split bolt.

623 L.03.03 ELECTRICAL TESTING

- A. Prior to completion of the work, the Contractor shall cause the following tests to be made on all lighting and electrical circuits, as directed by the Engineer and in the presence of the Maintaining Agency representative:
1. Test for continuity of each circuit.
 2. A visual inspection of all grounding connections. Electrical equipment and components shall not be energized unless properly grounded to the satisfaction of Engineer.
 3. A megohmmeter test on each single conductor circuit between the circuit conductor and all other circuits and ground in the conduits.
 - a. The insulation resistance shall not be less than 500 megohms when tested at 1,000 volts for 1 minute.
 - b. Individual conductors in UF cable and other multi-conductor cables shall be exempted from the megohmmeter testing by the Engineer if a visual inspection of the cables show no suspicious cuts, tears, or other damage to the outside insulation.

- c. Under no circumstances shall street light fixtures or other low voltage components be subjected to the high voltage of this test.
- 4. Any fault in any material or in a part of the installation revealed by these tests shall be replaced or repaired by the Contractor in a manner approved by the Engineer, and the same test shall be repeated until corrected.

04METHOD OF MEASUREMENT

623.04.01 MEASUREMENT

- A. The unit of measurement for "Traffic Signal Systems," "Street Lighting Systems," "Traffic Signal and Street Lighting Systems," and appurtenances for a complete operating system will be lump sum or unit price as specified in the Contract Documents.
- B. All measurements will be made in accordance with **Subsection 109.01, "Measurement of Quantities."**

05BASIS OF PAYMENT

623.05.01 PAYMENT

- A. The lump sum price or unit prices paid for traffic signal systems, street lighting systems, sign illumination systems, service pedestals, modifying existing systems, or any combination thereof shall be full compensation for doing all the work complete and in place as indicated in the Contract Documents and as directed by the Engineer, including excavation and backfill; concrete foundations; restoring sidewalk, pavement, and appurtenances damaged or destroyed during construction; salvaging existing materials; and making all required tests.
- B. Full compensation for all additional materials and labor, not shown on the Drawings or specified, which are necessary to complete the installations of the various systems, shall be considered as included in the prices paid for the systems, or units thereof, and no additional compensation will be allowed therefor.
- C. All payments will be made in accordance with **Subsection 109.02, "Scope of Payment."**

PAY ITEM

PAY UNIT

Traffic Signal Systems (may include sign lighting)	Lump Sum or Unit Price
Street Lighting Systems (may include sign lighting)	Lump Sum or Unit Price