

SECTION 02892

TRAFFIC SIGNAL

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Materials and procedures for installing traffic signals.
- B. Materials and procedures for installing traffic counting loop detectors.

1.2 RELATED SECTIONS

- A. Section 02741: Hot Mix Asphalt (HMA)
- B. Section 02748: Prime Coat/Tack Coat
- C. Section 03055: Portland Cement Concrete
- D. Section 03211: Reinforcing Steel and Welded Wire
- E. Section 03310: Structural Concrete
- F. Section 03575: Flowable Fill

1.3 REFERENCES

- A. AASHTO M 111: Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
- B. ASTM A 123: Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
- C. ASTM A 325: Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength
- D. ASTM A 307: Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength
- E. ASTM A 570: Steel, Sheet and Strip, Carbon, Hot-Rolled, Structural Quality
- F. ASTM B 85: Aluminum-Alloy Die Castings

- G. ASTM B 117: Operating Salt Spray (Fog) Apparatus
- H. ASTM B 766: Electrodeposited Coatings of Cadmium
- I. ASTM D 638: Tensile Properties of Plastic
- J. ASTM D 2240: Rubber Property-Durometer Hardness
- K. ASTM D 3005: Low-Temperature Resistant Vinyl Chloride Plastic Pressure-Sensitive Electrical Insulating Tape
- L. American Iron and Steel Institute (AISI)
- M. American National Standards Institute (ANSI)
- N. Electric Utility Service Equipment Requirements Committee (EUSERC)
- O. Electronics Industries Association (EIA)
- P. International Municipal Signal Association (IMSA) Standards
- Q. Institute of Electrical and Electronics Engineers (IEEE)
- R. Institute of Traffic Engineers (ITE), Technical Reports
- S. Military Specifications
- T. National Electric Code (NEC)
- U. National Electrical Manufacturers Association (NEMA)
- V. Pedestrian Traffic Control Signal Indicator (PTCSI) Standard
- W. Rural Electrical Association (REA) Bulletin
- X. Underwriters Laboratory (UL)
- Y. Vehicle Traffic Control Signal Head (VTCSH) Standards
- Z. 3M - 8982/Gel

1.4 SUBMITTALS

- A. Certified test report of wire compliance as specified. IMSA 20-1, 50-2, 51-1, 51-3, 51-5, 51-7, 60-6.
- B. Submit samples of materials for approval when requested.
- C. Submit two copies of the following within 15 days after receiving a Notice to Proceed:
 - 1. List of equipment and materials (name of manufacturer, size, and identification number).
 - 2. Detailed shop drawing, wiring diagrams, and certifications.
 - 3. Manufacturers' warranties, guarantees, instruction sheets, and parts lists.

1.5 ACCEPTANCE

- A. Signal Warranties and Guarantees
 - 1. The notice of acceptance for traffic signal work is not given until six months after the date of the inspection.
 - 2. During this period, all manufacturer's warranties and guarantees on Contractor- furnished electrical and mechanical equipment are enforced.
 - 3. At the end of the period and after all electrical and mechanical defects within the scope of warranties and guarantees are corrected, the Engineer makes written acceptance of the work completed and relieves the Contractor of further responsibility for that portion of the project.
 - 4. Partial acceptance does not void or alter any terms of the Contract
- B. The six-month warranty period for signal work does not affect the processing of a semi-final estimate when the Contract is 95 percent or more complete, or after completion of work on the project.
- C. Detector Loop Circuit: Conduct the following acceptance tests before and after backfill for approval by the Engineer.
 - 1. Loop Resistance Formula: $R_t = R_l + R_d$
 - R_t = Resistance of loop as measured at pull box.
 - R_l = Resistance of loop lead in wire (from the loop to junction box per meter) equals 0.0213 ohms, measured from loop to pull box splice.
 - R_d = Resistance of Loop = $P \cdot T \cdot R_c$ (See Loop Resistance Table below)
 - P = Perimeter of loop in meters.
 - T = Number of turns in the loop.
 - R_c = Resistance of #14 AWG copper wire per yard equals 0.0107 ohms.

Table 1

Loop Resistance			
Loop Type			R_d Loop Resistance (ohms)
Width (ft)	Length (ft)	Turns	
5	6	4	.29
5	10	4	.39
6	6	4	.31
6	10	4	.41
6	12	4	.47
6	14	3	.39
6	16	3	.43

2. A minimum reading between the conductor and ground of 100 MΩ when tested with a 500 V megger meter.
3. An inductance between 65 μH and 1000 μH.
4. Signal Power Circuits:
 - a. Continuity of grounding conductors to maintain a 1000 W load at each pole to maintain less than 2 V drop.
 - b. Insulations resistance of supply conductors to ground no less than 40 MΩ (500 V megger meter).

D. Video Detection Circuit: Provide cabling and install State-furnished video detection equipment to construct a complete video detection circuit at each intersection specified in the project and demonstrate each circuit operates per manufacturer's specifications.

PART 2 PRODUCTS

2.1 MATERIALS

- A. Use electrical components as listed and defined by the National Electric Code (NEC).

2.2 SIGNAL POLE AND TRAFFIC SIGNAL LIGHT SUPPORT ARM

- A. Post mounted Tapered Signals Pole: Standard Drawing SL 5.
 1. Steel, as specified. ASTM A 570, Grade 33.
 Allowable stresses: $F_b = 21,750 \text{ psi } (0.66F_y)$
 $F_v = 10,900 \text{ psi } (0.33 F_y)$
 2. Galvanized as specified. AASHTO M 111.

3. Wind load: 80 mph wind with 105 mph gusts.
- B. Foundation:
1. Concrete: Class AA(AE) Concrete. Refer to Section 03055.
 2. Reinforcing steel: Coated steel. Refer to Section 03211.

2.3 BOLTS AND NUTS

- A. Anchor bolts and nuts: Follow Standard Drawing SL 5.
1. Steel as specified. ASTM A 307.
 2. Zinc-plated or galvanized, as specified.
 - a. Zinc-plated as specified. ASTM B 766.
 - b. Galvanized steel: ASTM A 123.
 3. Nuts: free running, by hand, for total thread length.
- B. Slip Bolts as specified.
1. Zinc plated: ASTM B 766.
 2. Steel: ASTM A 325.

2.4 WIRE

- A. Copper, as specified. International Municipal Signal Association (IMSA)
- B. Size as specified. American Wire Gauge (AWG)
- C. Service Cable:
1. Single-conductor, as specified. Type THWN, THW, THHW.
- D. Interconnect cable:
1. Twisted pair filled shielded cable, as specified.
 2. IMSA 60-6.
- E. Signal Cable:
1. Multi-colored cables, as specified.
 2. IMSA 20-1
- F. Ground Wire:
1. Solid, bare, soft-drawn, copper wire, as specified.
 2. NEC 250-1.
- G. Splice Sealing: Rural Electrical Association (REA) Bulletin 17551-100.
1. Rigid body re-enterable gel-filled enclosure. Meet 3M-8982/gel, or equivalent.
 2. Mastic rubber pads and overwrap with vinyl electric tape.

3. ASTM D 3005, Type I or II. UL 510.
- H. Color Coding Tape:
1. Vinyl electric tape, as specified.
 2. UL 510.
- I. Video Detection Circuit:
1. Camera circuit cable - Belden 8281 or equivalent, coaxial cable, RG 59/U Type 20 AWG.
 2. Camera power circuit - 4-conductor, 14AWG SJOW cable, IMSA specification 20-1.

2.5 TRAFFIC SIGNAL HEAD

- A. Use SL series Standard Drawings.
- B. 12 inch vehicular signal heads:
1. With tunnel hoods and mounting brackets, square doors,
 2. Capable of adjusting a full 360 degrees around a vertical axis in one direction.
- C. Assembly:
1. LED Ball and Arrow Vehicle Signal Modules:
 - a. Modules fit into existing housing built to the VTCSH standard without modification to the modules or housing.
 - b. Arrow modules have at least three rows of LEDs. Balls must be full field design. Both ball and arrow modules must be capable of installation in signal head with reflector in place.
 - c. Ensure the measured chromaticity coordinates of modules is between 500 nm and 650 nm, conforming to the chromaticity requirements of the VTCSH standard.
 2. Sections Heads:
 - a. Separate, interchangeable, and expandable without tie rods.
 - b. Stainless steel bolts, screws hinge pins, and door-locking devices in any exposed sections.
 - c. Die-cast aluminum parts, including the doors, as specified: ASTM B 85. Clean, smooth parts free from flaws, cracks, blow holes, or other imperfections.
 - d. Moisture and dust resistant.
 - e. All surfaces inside and out of signal housing, door, and outside of visor are painted with electrostatically-applied, fused-polyester paint in Highway Yellow. Inside of visor is painted flat black.
 - f. Integrally round serrated boss openings in the top and bottom of each section that receives 1.5-inch supporting pipe frame.

- g. Rain-tight top opening and an ornamental cap for closing the bottom opening.
 - h. Visor securely mounted at a minimum of four points.
- D. Optical Unit:
- 1. Watertight and dust resistant, mounted so various parts swing open for easy access. Provide and install green, amber, and red LED modules. Install each LED signal module in the door frame of a standard traffic signal head housing. Remove the lamp socket, reflector, reflector holder, and lens used with an incandescent lamp. Do not use with the LED signal module. Remove socket, reflector, reflector holder, and lens and wire the LED module to the traffic signal heads.
- E. Louvered back plate
- 1. Constructed from minimum 18-gage aluminum.
 - 2. Both sides primed and painted flat black.
 - 3. Designed to be attached to the signal head used.

2.6 PEDESTRIAN SIGNAL HEAD

- A. Follow SL series Standard Drawings.
- B. Includes a housing, swing down door assembly, parabolic reflector, message lens, sunshield, two signal lamps and two sockets.
- 1. Housing:
 - a. Dustproof and weatherproof.
 - b. Die cast, single piece aluminum allot.
 - c. 1-1/2 inch top and bottom openings with integrally-cast shurlock boss when used with pipe mount brackets.
 - d. Use stainless steel screws springs, and assembly hardware.
 - 2. Swing down door assembly:
 - a. Capable of being opened without tools.
 - b. Made of a single piece aluminum alloy, die cast with two hinge lugs at the bottom and two latch slots at the top of the door.
 - 3. Install each LED pedestrian head in the door frame of a standard pedestrian head housing. The lamp socket, reflector, reflector holder, and lens used with an incandescent lamp must be removed and not used with the LED pedestrian modules. Remove lamp socket, reflector, reflector holder, and lens and wire the LED module to the pedestrian heads.
 - 4. Sunshield:
 - a. Eggcrate-type with 15 vertical and 26 horizontal members.
 - b. Two anti-vandal, integral locking strips.
 - c. Minimum thickness of 20-gage.
 - d. Finish: 100 percent impregnated black, polycarbonate plastic, with a flat finish on both sides.

5. Electrostatically apply synthetic enamel as specified.
 - a. Gloss black case and door frame.
 - b. Flat black sunshield.
 - c. Oven-cure finish for a minimum of 20 minutes at 350 degrees F.
6. Pedestrian Display Signal Module
 - a. Use LED Pedestrian Signal Modules that are a retrofit replacement for the message bearing surface of a 16 inch x 18 inch pedestrian traffic signal housing built to the Pedestrian Traffic Control Signal Indicator (PTCSI) Standard. The message-bearing surface of the module shall be supplied with "HAND" and "MAN" symbol that complies with PTCSI standard for this symbol. This message-bearing surface is designed so that it can be removed from the sealed unit for replacement without further damage to the module.
 - b. Ensure the exterior of the lens of the LED Pedestrian Signal Module is smooth and frosted to prevent sun phantom.
 - c. Ensure all Portland Orange LEDs utilize "AlInGap" technology or equivalent, and rated for 100,000 hours or more at 77 degree F and 20 mA.
 - d. Ensure the LED Pedestrian Signal Module is designed so that when operated over the specified ambient temperature and voltage range, the signal will attract the attention of, and be readable to a viewer (both day and night) at all distances from 10 ft to full width of the area to be crossed. Use a minimum of 150 LEDs in the Portland orange hand symbol and 100 LEDs in the white man symbol.
 - e. Ensure the measured chromaticity coordinates of the LED Pedestrian Signal Module conforms to the chromaticity requirements of the PTCSI Standard.
 - f. Ensure the LED pedestrian signal module is operationally compatible with the currently used controller assemblies and conflict monitors.
- C. Ensure symbol messages blank out under ambient light conditions when the pedestrian signal is not energized.

2.7 ELECTRICAL CONDUIT

- A. Conduit and fittings:
 1. Schedule 40 PVC rated at 190 degrees F as specified. NEMA TC-2, TC-3. UL Listed.
 2. Rigid steel as specified. UL 6.
 3. Galvanized as specified. ANSI C80.1.
- B. Casing: Smooth steel with a minimum 1/4 inch wall thickness as specified.

2.8 DETECTOR CIRCUIT

- A. Wire:
1. Detector Lead-In Wire (feeder): as specified. IMSA 50-2.
 2. PVC Sensor Loop Wire - No. 14, single-conductor, stranded wire as specified. IMSA 51-3.
 3. Saw Cut Sensor Loop Wire.
 4. No. 14, single-conductor, stranded wire encased in a polyethylene tube as specified. IMSA 51-7.
- B. Traffic loop embedding sealant:
1. Isophthalic, acid-based, unsaturated, polyester resin.
 2. With sufficient adhesion, strength, and flexibility to:
 - a. Withstand normal movement in asphaltic and concrete pavements
 - b. Protect the loop wire from moisture penetration, fracture and shear.
 3. Cured sealant resistant to motor oils, gasoline, anti-freeze solution, brake fluid, and de-icing chemicals.
 4. Meet the physical property requirements in Table 2.

Table 2

Traffic Loop Embedding Sealant		
Physical Properties	Test	
Shore D Hardness	ASTM D 2240	74
Specific Gravity		1.13 - 1.20
Styrene Monomer, percent		28 - 32
Viscosity: Pa·s	Brookfield Model LVF #3 Spindle @ 60 rpm	0.7-0.9
Gel Time	MEK Peroxide 46-709	11 - 15 minutes
Tensile Elongation, % @ Break	ASTM D 638	50
Pot life, minimum		5 minutes
Tensile Strength	ASTM D 638	2,000 psi

2.9 LUMINAIRE

- A. Housing:
1. Die-cast aluminum
 2. Reflectors, sockets, mounting cradles, and clamps fitted to the upper housing.

- B. Integral ballast: Pre-wired with quick disconnect plugs mounted on a removable, hinged power door.
- C. Power Door: Ballast assembly interchangeable with all luminaires, regardless of wattage.
- D. Optical assembly: Formed aluminum reflectors with a chemically bonded, non-breakable, glass finish on both the inside and outside surfaces.
- E. Mogul base sockets:
 - 1. Adjustable with split-shell, tempered-brass lamp grips.
 - 2. Free-floating, spring loaded center contacts.
 - 3. Heat- and impact-resistant glass prismatic refractors.
- F. Mounting adjustment:
 - 1. Ten degrees above horizontal for the reflector and refractor.
 - 2. Five degrees adjustment from vertical on the bracket arm.
- G. Weight: no more than 75 lbs.
- H. Projected area: no more than 3 square feet.
- I. Ballast: high pressure sodium type that will:
 - 1. Maintain a minimum power factor of 90 percent.
 - 2. Maintain lamp wattage of not more than five percent for nominal line and lamp voltage.
 - 3. Maintain regulation of not more than 35 percent for a 10 percent line voltage variation.
 - 4. Start and operate the lamp at ambient temperatures down to -40 degrees F.
 - 5. Sustain lamp operation for a minimum of four seconds at a voltage dip of 35 percent.
- J. Lamp: high pressure sodium lamp that uses clear bulbs and has:
 - 1. Apparent color temperature of 2100 K.
 - 2. CIE chromaticity of $X = 0.512$, $Y = 0.420$.
 - 3. Rated-life of not less than 24,000 hours per 10 hour start.

2.10 GROUND ROD

- A. Copper-coated steel as specified.
- B. ANSI/UL 467.

2.11 MESSENGER

- A. 3/8 inch diameter galvanized, stranded steel cable.
- B. Minimum breaking strength of 10,800 lbs. as specified.
- C. ASTM A 123.

2.12 MOUNTING BANDS AND BUCKLES

- A. As specified.
- B. American Iron and Steel Institute, (AISI) Type 201.

2.13 POWER SOURCE

- A. Pole Mount: SL series Standard Drawings.
 - 1. Service disconnect:
 - a. Single pole 40 amp 120 volt AC metered for signal.
 - b. Double pole 20 amp 240 volt un-metered for lighting.
 - 2. Provide a manual Electrical Utility Service Equipment Requirements Committee (EUSERC) approved circuit closing link by-pass release meter socket.
 - 3. Unmetered street lighting circuit.
- B. Underground Service Pedestal: As specified. ASTM B 117, and ASTM A 123 (Cabinet). UL E 50076
 - 1. Enclosure: 0.120 inch galvanized steel or anodized aluminum.
 - a. 0.080 inch galvanized steel or anodized aluminum covers.
 - b. Finished surface with an environmental green, baked enamel over zinc-chromate primer as specified, or anodized aluminum. ASTM B 117.
 - c. Bottom access opening.
 - d. EUSERC approved circuit-closing by-pass release meter socket.
 - e. Baffled ventilation louvers.
- C. Circuit Breaker: Main Breaker
 - 1. Six space metered.
 - 2. Six space unmetered bus.
- D. Detachable, pad-mount base.

2.14 FLOWABLE FILL

- A. Refer to Section 03575.

2.15 HOT MIX ASPHALT

- A. Half inch maximum. Refer to Section 02741.

2.16 LED TRAFFIC SIGNAL HEAD MODULE

- A. Regulations and Codes. Use new modules that conform to the applicable requirements of the Underwriters Laboratory Incorporated (UL), the Institute of Electrical and Electronics Engineers (IEEE), the Electronics Industries Association (EIA), the National Electronic Code (NEC), the American Society of Testing and Materials (ATMS), the American National Standards Institute (ANSI), and the applicable standards, specifications, and regulations of the UDOT.
- B. Ensure certification to NEMA, ITE and VTCSH Standards. Ensure LED TSMs meet current applicable NEMA standards. Bidders are required to supply a certified letter from an independent testing laboratory stating the module(s) has been tested and meets NEMA environmental standards and test procedures.
- C. Physical and Mechanical Requirements
 - 1. Retrofit Requirements
 - a. Use retrofit module replacements for existing signal lamps that do not require special tools for installation. Use modules that fit into existing traffic signal housing without modification to the housing.
 - b. Use retrofit replacement modules that only require removal of the existing optical unit components, i.e., lens, lamp module, gaskets, and reflector. The module is weather tight and fits securely in the housing, and connects directly to existing electrical wiring. Screw-in modules are not acceptable.
 - c. Use retrofit module that includes all necessary components to complete the conversion, including a one-piece gasket.
 - 2. Optical Unit - Use modules capable of replacing the optical unit.
 - 3. Tinting - Use tinted lens or transparent film or materials with similar characteristics.
 - 4. Lens - Use module lens that is a field replaceable part without the need to replace the complete module.

- D. Environmental Requirements
1. Use modules rated for use in the ambient operating temperature range, measured at the exposed rear of the module, of -40 degrees F to +165 degrees F. Use modules that incorporate temperature compensated LED technology to operate in the above mentioned temperature ranges.
 2. Use modules protected against dust and moisture intrusion per the requirements of NEMA Standard 250-1991, sections 4.7.2.1 and 4.7.3.2, for Type 4 enclosures to protect all internal LED, electronic, and electrical components.
 3. Use polycarbonate module lens that is UV stabilized and is a minimum of 1/4 inch thick.
- E. Construction
1. Use modules that are a single, self-contained device, not requiring on-site assembly for installation into an existing traffic signal housing, with the power supply integrated into the module.
 2. Use modules that have an assembly and manufacturing process designed to assure all internal LED and electronic components are adequately supported to withstand mechanical shock and vibration from high winds and other sources.
 3. Use modules that are repairable by a bench technician.
- F. Materials
1. Use materials for the lens and signal modules construction that conform to ASTM specifications for the materials where applicable.
 2. Use enclosures containing either the power supply or electronic components of the signal module constructed of UL94VO flame retardant materials. The signal module lenses are excluded from this requirement.
- G. Module Identification - Identify each individual module for warranty purposes.
1. Identify each module on the backside with the manufacturer's name and serial numbers.
 2. Identify the following operating characteristics: nominal operating voltage, power consumption, and Volt-Ampere.
 3. Use modules that have a prominent and permanent vertical indexing indicator, i.e., UP ARROW or the word UP or TOP, for correct indexing and orientation inside a signal housing.
 4. Use modules conforming to this specification that have the following statement: "Manufactured in Conformance with the Interim Purchase Specification of the ITE for LED Vehicle Traffic Signal Modules" on an attached label.

H. Photometric Requirements

1. Luminous Intensity And Distribution

- a. Ensure the maintained minimum luminous intensity values for modules throughout the warranty period, under the operating conditions defined in Articles D and I-2a, and at the end of the warranty period, are not be less than the values shown in Table 3.

Table 3

Maintained Minimum Luminous Intensity for LED Signal Modules Candlepower Values (candelas [cd])				
Vertical Angle Down (degrees)	Horizontal Angle Left & Right (degrees)	Red (12-inch) (cd)	Yellow (12-inch) (cd)	Green (12-inch) (cd)
2.5	2.5	339	1571	678
	7.5	251	1159	501
	12.5	141	655	283
	17.5	77	355	154
7.5	2.5	226	1047	452
	7.5	202	935	404
	12.5	145	673	291
	17.5	89	411	178
	22.5	38	178	77
12.5	27.5	16	75	32
	2.5	50	234	101
	7.5	48	224	97
	12.5	44	206	89
	17.5	34	159	69
	22.5	22	103	44
17.5	27.5	16	75	32
	2.5	22	103	44
	7.5	22	103	44
	12.5	22	103	44
	17.5	22	103	44
	22.5	20	94	41
	27.5	16	75	32

- b. Ensure the maximum luminous intensity for 12-inch signals do not exceed 800 candelas for the Red, 1,600 candelas for the Green, 3,700 candelas for the Yellow when operating within the temperature specified in Articles D-1 during the warranty period.

2. Color and Brightness - Use modules that meet all ITE color and brightness specifications.

3. Photometric Maintenance - Ensure the manufacturer has a process to test compliance of minimum intensity values in a controlled and independent laboratory during anytime in the warranty period. Alternately, ensure the manufacturer has available a portable, calibrated light meter to allow for field measurement of luminous intensity of Modules.

I. Electrical Requirements

1. General - Ensure all wiring and terminal blocks meet the requirements of Section 13.02 of the VTCSH standard. Two secured, color coded, 36-inch long, 600V, 16 AWG minimum, insulated wires, conforming to the NEC, rated for service at 220 degrees F, and spaded lugs, are provided for electrical connection.
2. Voltage Range.
 - a. Ensure modules operate from a 60 ± 3 cycle ac line power over a voltage range from 80V rms to 135V rms. The current draw shall be sufficient to ensure compatibility and proper triggering and operation of load current switches and conflict monitors in the signal controller units the Department has in use.
 - b. Ensure nominal operating voltage for all measurements is 120 ± 3 volts rms.
 - c. Ensure fluctuations in voltage over the range of 80V rms to 135V rms do not affect luminous intensity by more than ± 10 percent.
 - d. Ensure the LED circuitry prevents flicker at less than 100 Hz over the voltage specified in Articles I-2a.
3. Transient Voltage Protection - Ensure module on-board circuitry includes voltage surge protection to withstand high-repetition noise transients and low-repetition, high-energy transients as stated in Section 2.1.6, NEMA Standard TS-2, 1992
4. LED Drive Circuitry - Ensure individual LED light sources are wired so that a catastrophic failure of one LED light source will result in the loss of not more than 20 percent of the signal module light output.
5. Electronic Noise - Ensure the LED signal and associated onboard circuitry meets Federal Communications Commission (FCC) Title 47, Subpart B, Section 15 regulations concerning the emission of electronic noise.
6. Power Factor (Pf) and AC Harmonics:
 - a. Ensure modules provide a power factor of 0.90 or greater when operated at nominal operating voltage, and 77 degrees F.
 - b. Ensure total harmonic distortion induced into an ac power line by a Module, operated at nominal operating voltage, with power consumption equal to or greater than 15 watts at 77 degrees F does not exceed 20 percent.
 - c. Ensure total harmonic distortion induced into an ac power line by a Module, operated at nominal operating voltage, with a power consumption equal to or less than 15 watts at 77 degrees F does not exceed 40 percent.

7. Failed State Impedance – Ensure modules are designed to sense a loss of light output due to catastrophic LED failures of between 25 to 40 percent. Loss of light output due to LED failure is not detected of losses of less than 25 percent but is detected for any loss of light greater than 40 percent. Ensure the unit, upon sensing a valid loss of light, presents an impedance of 500 K ohms to the ac line.
 8. Electronics Technology – Ensure modules use the latest 0.20-inch (5 mm) electronics technology.
- J. Manufacturers Certification of Compliance and Warranty Provisions:
1. Certificate of Compliance – Ensure manufacturers provide a Certificate of Compliance to this specification for each shipment of Modules. Identify each Module per Section G.
 2. Warranty Provisions - Ensure Bidder provides the following minimum warranty provisions:
 - a. Replace or repair module if it fails to function as intended due to workmanship or material defects within the first 84 months from the date of delivery. If repaired, the warranty covers all parts and labor necessary or incidental to the repair.
 - b. Ensure the period of guarantee coverage, in no case, is less than the manufacturers usual and customary guarantee period. Provide all guarantees that are customarily issued by the Bidder and/or manufacturer to the State of Utah.
 - c. The Bidder may elect to have UDOT make minor repairs or their appointee, with the consent of the manufacturer. Make all other repairs under warranty by the manufacturer. The manufacturer bears all costs including labor, parts, and shipping charges.
 - d. Replace or repair all LED Vehicle Traffic Signal Modules that exhibit luminous intensities less than the minimum values specified in Article H-1a within the first 60 months of the date of delivery.

2.17 VIDEO DETECTION CIRCUIT

- A. Provide conduit, cabling and lighting, and install State-Furnished video detection equipment as shown in the plans to construct a complete and operational video detection circuit at each intersection.
- B. Provide all additional mounting brackets, termination boxes, and other equipment, material and labor necessary to construct a complete and operational video detection circuit per manufacturer recommendations.

PART 3 EXECUTION

3.1 PREPARATION

- A. Conform to the National Electrical Code (NEC).
- B. Pick up State-furnished materials at the Department's Central Warehouse, 4501 South 2700 West, Salt Lake City, UT.
- C. Saw cut concrete or other improved surfaces to be removed in the sidewalk area, and replace with in-kind materials to match the existing grade.
- D. Attach brackets with a banding machine with stainless steel bands. Do not drill holes in poles except as shown on the plans. Follow SL series Standard Drawings.
- E. Do not disconnect or remove an existing signal system until the replacement system is functioning.
- F. Contact power company at least 30 days before the connection date, and verify the exact location, voltage, procedure, and materials required by the power company.

3.2 CONSTRUCT POLE FOUNDATION

- A. Follow SL series Standard Drawings.
- B. Concrete: AA(AE) required. Refer to Section 03055.
- C. Structural Concrete: Refer to Section 03310.
- D. Reinforcing Steel and Welded Wire: Refer to Section 03211.
- E. Do not weld reinforcing steel, anchor bolts, or conduit.
 - 1. Use tie wire to secure conduit.
 - 2. Use template to align and secure anchor bolts.
- F. Place the concrete directly into the excavation, and use minimum forming above ground.

3.3 TRENCH FOR CONDUIT

- A. Paved Surface (asphalt concrete):
 - 1. Do not use backhoe.
 - 2. Make the trench 6 inches wide or less.
 - 3. Use flowable fill to within 3 inches of the existing roadway surface.
 - 4. Evenly apply tack coat before final backfill.
 - 5. Match the composition, density, and elevation ($\pm 3/16$ inch) of the existing surface in the final 3 inches of backfill.

- B. Unpaved Surface:
 - 1. Use backfill that matches the composition, density, and elevation ($\pm 3/16$ inch) of the existing surface.
 - 2. Install conduits that cross finished curbs and gutters, sidewalks, concrete flatwork, textured or decorative surfaces by jacking, drilling, or pushing. Entirely replace any damaged section at no additional cost to Department.
 - 3. Dispose of surplus material daily.

- C. Trenching under Railroad (Subject to agreement with railroad):
 - 1. Install smooth steel casing a minimum depth of 4 ft under railroad track to house conduit.
 - 2. Six inch diameter casing with a minimum $7/32$ inch wall thickness, and a minimum yield strength of 34,950 psi.

- D. Minimum cover of conduit:
 - 1. Minimum cover for all roadway crossings: 2 ft.
 - 2. Minimum cover off roadway without concrete encasement or capping: 18 inches.
 - 3. Minimum cover off roadway with concrete encasement or capping with minimum thickness of 2 inches: 12 inches.

3.4 INSTALL CONDUIT

- A. Place all conduits in the same trench before surfacing.

- B. Above ground use galvanized rigid steel; under ground use PVC.

- C. Seal uncapped conduit ends inside junction box with at least 2 inches of duct caulking.

- D. In future-use conduit, install No. 14 single conductor copper, type THHN pull wire.
 - 1. On each end of conduit install cap with $7/32$ inch hole for pull wire.

2. Leave 20 inches of wire outside of the cap, fastened securely.
 3. Place future-use conduit in top portion of trench for easier access later.
- E. Secure conduit on structures with standard galvanized iron conduit clamps using at least 5/16 inch diameter concrete expansion anchors at maximum 5 ft spacing.
- F. Use conduit expansion fittings at structure expansion joint crossings.

3.5 INSTALL WIRING

- A. Conductors:
1. Clean and dry the inside of the conduit before installing conductors.
 2. Install grounding conductor in all power circuit conduits.
 3. Use powdered soapstone, talc or other approved lubricants when pulling conductors in conduit.
 4. Tape the ends of unused conductors and label them as spares.
 5. Use conductors that are color coded as specified. Meet IMSA 20-1.
- B. Ground wire:
1. In all non-metallic conduit, a ground wire must run continuously and be grounded at each junction box, except in those conduits used solely for interconnect and detector circuits.
 2. Bond the ground wire to the ground rod in each junction box except in circuits with less than 50 V.
- C. Neatly arrange wiring within cabinets, junction boxes, fixtures, etc.
- D. Terminate all terminal connections by a mechanical (spade) connector.
- E. Wire splicing:
1. Splice wires only in detection circuits where the wire type changes in the junction boxes.
 2. Mechanically secure or solder, individually insulate, and water seal all splices. Encapsulate in a rigid body re-enterable gel filled enclosure, or cover with mastic rubber pads and overwrap with vinyl electric tape.
- F. Mark cabinet cables with vinyl electrical color coding tape as specified according to Table 4. Meet UL 510.

Table 4

Cables Marked with Colored Tape				
	Northbound P2	Southbound P3	Eastbound P4	Westbound P1
Signal Circuit	Blue	Red	Yellow	Orange
Detector Circuit	Blue	Red	Yellow	Orange
	Circuit Coding One band, Through, 2 bands, Left Turn, 3 bands, "Q's", Four bands, Dilemma			
Pedestrian	Blue & Green	Red & Green	Yellow & Green	Orange & Green
Pedestrian Button Circuit (3)	Blue & White	Red & White	Yellow & White	Orange & White

G. Connect conductors according to Table 5.

Table 5

Color-Coded Conductors		
	North-South	East-West
Seven-Conductor Pedestrian Circuit	Red – Don't Walk Green -Walk White – Neutral	Black - Spare Orange – Don't Walk Blue - Walk White with Black Tracer - Neutral
Three-Conductor Pedestrian Head Circuit	Red - Pedestrian Call White - Common	Black - Pedestrian Call White - Common
Seven-Conductor Signal Circuit	White - Neutral Red - Red Through Orange - Yellow Through Green - Green Through Blue - Green Arrow White with Black Tracer - Yellow Left Black - Left red or spare	

3.6 INSTALL DETECTOR LOOPS

- A. Follow SL series Standard Drawings.
- B. One turn is once around the perimeter of the loop with the same conductor.
 - 1. Use number of turns as specified in Table 1 (Loop Resistance Table).

2. Do not allow twists in the loop.
- C. Loop lead-in from loop to junction box:
1. Minimum of 3 twists per yard in saw cut.
 2. Minimum of 10 twists per yard for conduit.
 3. Do not interweave with other loop lead-ins.
 4. Each lead-in requires a separate conduit.
- D. For Detector Lead-in (feeder) from the junction box to controller cabinet, carry shield across all splices.
- E. Saw cut loop:
1. Round the corners with a minimum of 2 inch drill.
 2. Remove all loose material and wash and dry all saw cuts.
 3. Place all loop wire in a 1/4 inch polyethylene tube.
 4. Seat the conductor with no damage at the bottom of the slot.
 5. Fill the saw cut with embedding sealant, surround the polyethylene tube to the level of the existing roadway surface \pm 1/4 inch. Remove any excess embedding sealant.
- F. PVC loop:
1. Trench 2 inch maximum width with 4 inch minimum to 6 inch maximum cover.
 2. Anchor sensor loops to prevent movement or floating.
 3. Apply a tack coat to the sides and the bottom of the remaining 3 inches of trench and backfill with hot mix asphalt. Refer to Sections 02741 and 02748.
 4. Loops in new pavement preformed and placed 1 3/4 inches below the surface of the base course and backfill with surrounding material.

3.7 INSTALL POWER SOURCE

- A. Verify the exact location, voltage, procedure, and materials required by the power company.
- B. Follow SL series Standard Drawings.

3.8 INSTALL LUMINAIRE

- A. As specified.
- B. Follow SL series Standard Drawings.

3.9 INSTALL SIGNAL HEAD

- A. Do not install signal heads at the intersection until ready for operation.
- B. If turn on is not immediate, completely cover the signal heads with non-transparent, non-paper material tied securely around head.
- C. Install directed and veiled optically-programmed signals following the manufacturer's instructions. Mask each section of the signal with prescribed materials.
- D. Use louvered back plates on all signal heads except Type V and VI. Use a minimum of four 1/8 inch stainless steel screws per section to mount the back plates, or according to manufacturer's instructions.

3.10 REMOVE AND SALVAGE EXISTING EQUIPMENT

- A. Light poles, signal poles, messenger cable, signal and pedestrian heads, controller cabinets, other items as specified on the plans remain the property of the Department.
- B. Transport items to the specified location.
- C. Remove foundations to a depth of at least 6 inches below the existing surface.
- D. Backfill all holes with local material and compact to the density of the surrounding area.

3.11 INSTALL VIDEO DETECTION

- A. Install all video detection components in accordance with the manufacturer specifications.
- B. Mount each video detection camera on the signal mast arm using the State-Furnished 46-inch extension pole and mounting bracket.
- C. Aim and set camera position and program detection areas as directed by the Engineer.

END OF SECTION