

SECTION 21 TRAFFIC SIGNAL

21.01 DESCRIPTION

Traffic signal, safety lighting, signal interconnect and related electrical work shall conform to the provisions in Section 86, "Signals, Lighting and Electrical Systems", of the State Standard Specifications, these Standard Specifications and other requirements as specified in the contract documents.

21.02 EQUIPMENT LIST AND DRAWINGS

The electrical Contractor must submit a "Notice of Materials to be Used" as specified in Section 86-1.03, "Equipment List and Drawings", of the State Standard Specifications.

The controller cabinet schematic wiring diagram and intersection sketch shall be combined into one drawing, so that, when the cabinet door is fully open, the drawing is oriented with the intersection.

The Contractor shall furnish to the City Engineer a copy of all purchase orders for equipment and materials used in reference to traffic signals within five days of when such orders are placed. The Contractor shall also provide copies of all correspondence with equipment and materials suppliers concerning availability, delivery dates, anticipated delays, and shipment notices within five days of each letter. References to cost may be omitted. Consideration for recommending time extensions for materials and equipment delivery delays will not be made unless these provisions are met.

The Contractor shall furnish two maintenance and operation manuals for cabinet, controller unit, auxiliary equipment, vehicle detector sensor units, control units, amplifiers, and any other auxiliary equipment furnished. The maintenance manual and operation manual may be combined into one manual. The maintenance manual or combined maintenance and operation manual shall be submitted at the time the controllers are delivered for testing.

The maintenance manual shall include, but need not be limited to, the following items:

- (a) Specifications
- (b) Design characteristics
- (c) General operation theory
- (d) Function of all controls
- (e) Trouble shooting procedure (diagnostic routine)
- (f) Block circuit diagram
- (g) Geographical layout of components
- (h) Schematic diagrams
- (i) List of replaceable component parts with stock numbers

21.03 MAINTAINING EXISTING AND TEMPORARY ELECTRICAL SYSTEMS

Unless otherwise permitted in writing by the City Engineer, existing traffic signal system shutdowns shall be limited to periods between the hours of 9 a.m. and 4 p.m.

21.04 EXCAVATING AND BACKFILLING

The third paragraph in Section 86-2.01, “Excavating and Backfilling”, of the State Standard Specifications is amended to read:

“The excavations shall be backfilled in conformance with the provisions in Section 19-3, ‘Structure Excavation and Backfill’. Backfill placed in conduit trenches to be outside the hinge point of slope and not under pavement shall be compacted to a relative compaction of not less than 90 percent. Backfill on slopes and in areas where pavement is to be constructed shall be compacted to a relative compaction of not less than 95 percent”.

21.05 FOUNDATIONS

The Contractor shall be responsible for locating and marking the positions of all signal standards and cabinets in the field. The locations shall be approved by the City Engineer prior to commencement of foundation work.

Anchor bolts shall be positioned so that a minimum of two and a maximum of four threads will be visible above the top nuts after signal standard has been erected and plumbed. All signal standards shall have a minimum of two inches and a maximum of three inches of grout installed between the bottom of the base plate and the finish grade.

The first sentence of the eighth paragraph in Section 86-2.03, “Foundations”, of the State Standard Specifications is amended to read:

“Anchor bars or studs and nuts, except for Type 30 and Type 31 lighting standards, shall conform to ASTM Designation: A 307. Headed anchor bolts for foundations shall conform to the specifications of ASTM Designation: A 307, Grade B with S1 supplementary requirements. At the option of the Contractor, nonheaded anchor bolts for foundations shall conform either to the specifications of ASTM Designation: A 307, Grade C or to the provisions in AASHTO designation: M 314, grade 36 or 55 with S1 supplementary requirements. When nonheaded anchor bolts conforming to the specifications of ASTM Designation: A 307, Grade C are furnished, the end of each fabricated anchor bolt shall be either coded by end stamping as required in ASTM Designation: A 307 or the end that projects from the concrete shall be permanently coded with a green color by the manufacturer”.

Where cast-in-drilled-hole concrete pile foundations are to be constructed in slag aggregate embankments, the diameter of the pile shall be increased to provide a minimum of three inches of concrete cover over the reinforcing steel.

Full compensation for the increased diameter of cast-in-drilled-hole concrete pile foundations in slag aggregate embankments, including additional Portland cement concrete, and any increased drilling and placement cost, shall be considered as included in the contract lump sum price paid for various contract items of electrical works involved and no additional compensation will be allowed therefor.

21.06 STANDARDS, STEEL PEDESTALS AND POSTS

Where the plans refer to the side tenon detail at the end of the signal mast arm, the applicable tip tenon detail may be substituted.

The sign mounting hardware, as shown on Detail “U” of State Standard Plan ES-6T, shall be installed at the locations shown on the plans.

On State Standard Plan ES-1A, under symbols for electroliers, the symbol labeled “22 Structure” is revised to read “22 Roadway”.

On State Standard Plan ES-6B, in the Luminaire Arm Data table, the “P” Mounting Height data listed under the No Barrier column shall apply to Type 22 lighting standards and the data listed under the 2’ feet – 8” inches Barrier column shall apply to Type 21 lighting standards.

On State Standard Plan ES-6E, the title of the expanded detail of the installation of a slip base is revised to read “SLIP BASE DETAIL”.

On State Standard Plan ES-6L, in the Signal Arm Data table, dimension “L” for 40’-0” and 45’-0” mast arms is revised to read 1 ¾ inches.

On State Standard Plan ES-6TA, in the Alternative Poles table, Standard Description, 17B-2-70-20’, is revised to read, 17-2-70-20’.

Sheet steel shall have a minimum yield of 48,000 psi.

At the option of the Contractor, poles with base diameter and respective wall thickness shown for each pole type in the table below may be substituted for those shown on the State Standard Plans.

Pole Type	Base Diameter x Wall Thickness (in.)
17A-1-70	9 x 0.1793
17-2-70	9 x 0.1793
18-1-70	9 x 0.1793
19-1-70	9 x 0.1793
18-1-80	9 x 0.1793
16-2-80	9 x 0.1793
19-3-70	11 x 0.1793
19A-3-70	11 x 0.1793
19A-2-80	11 x 0.1793
23-3-70	11 x 0.1793
23-4-70	12 x 0.1793
23-3-80	11 x 0.2391
26-3-80	12.75 x 0.2391
26A-3-80	12.75 x 0.2391
27-3-80	12.75 x 0.2391
27-4-80	12.75 x 0.2391

At the option of the Contractor, signal mast arms with base diameter and respective wall thickness shown in the table below may be substituted for those shown on the State Standard Plans.

Arm Type	Base Diameter x Wall Thickness (in.)
XX-1-70-20	6 x 0.1196
XX-2-70-20	6 x 0.1196
XX-3-70-20	6 x 0.1793
XX-2-80-20	7 x 0.1196
XX-3-80-20	7 x 0.1793
XX-1-70-25	7 x 0.1196
XX-2-70-25	7 x 0.1196
XX-3-70-25	7 x 0.1793
XX-4-70-25	7.5 x 0.1793
XX-1-80-25	7 x 0.1196
XX-2-80-25	7 x 0.1793
XX-3-80-25	8 x 0.1793
XX-1-70-30	7.5 x 0.1196
XX-1-80-30	7.5 x 0.1196
XX-3-80-30	9 x 0.1793
XX-4-80-30	9 x 0.1793
XX-3-70-35	8.5 x 0.1793
XX-3-80-35	9.5 x 0.1793
XX-4-80-35	10 x 0.1793
XX-3-70-40	10 x 0.1793
XX-4-70-40	10 x 0.1793
XX-0-80-40	10 x 0.1793
XX-3-70-45	10 x 0.1793
XX-4-70-45	10 x 0.1793
XX-3-80-45	10 x 0.2391
XX-4-80-45	10 x 0.2391
XX-5-70-55	50 ft = 12 x 0.1793 plus 5 ft @ 0.1196

Note: Pole type in the Arm Type column in the table has been designated XX, as pole type is not relevant to the dimensions shown.

Handholes for signal standards shall be located 90° clockwise from the traffic signal mast arm.

Type I standard shall be assembled and set with the handhole on the downstream side of the pole in relation to traffic, or as shown on the plans.

21.07 CONDUIT

Conduit to be installed underground shall be the rigid steel or rigid non-metallic type unless otherwise specified. Detector termination conduits may be the rigid non-metallic type.

The conduit between a foundation and the nearest pull box shall be the same type as in the foundation. Rigid non-metallic conduit may be used in all foundations.

When a standard coupling cannot be used for coupling metal type conduit, a UL listed threaded union coupling, as specified in the third paragraph in Section 86-2.05C, "Installation", of the State Standard Specifications, or a concrete-tight split coupling or concrete-tight set screw coupling shall be used.

For situations where the conduit cannot meet the minimum cover requirements, it may be laid at a depth of 12 inches below existing surface, providing that a minimum of six inches of commercial quality Class C concrete be placed over the conduit. Backfill shall be completed to the top of the trench with a minimum of four inches of surrounding material.

After conductors have been installed, the ends of conduits terminating in service and controller cabinets shall be sealed with an approved type of sealing compound.

At locations where conduit is required to be installed under pavement and existing underground facilities require special precautions, conduit shall be placed by the "Trenching in Pavement Method" as specified in Section 86-2.05C of the State Standard Specifications.

At other locations where conduit is required to be installed under pavement and if delay to any vehicle will not exceed five minutes, conduit may be installed by the "Trenching in Pavement Method" of said Section 86-2.05C of the State Standard Specifications.

21.08 PULL BOXES

Grout shall be placed in the bottom of all pull boxes.

Traffic pull boxes and covers shall have a vertical proof-load strength of 25,000 pounds. The 25,000 pound load shall be distributed through a 9" x 9" x 2" steel plate according to Federal Specification RR-F-621e. This load shall be placed anywhere on the box and cover for a period of one minute without causing any cracks or permanent deformations.

The No. 3 ½(T) and No. 5(T) pull boxes shall be reinforced with a galvanized Z-bar welded frame and cover similar to that for No. 6(T) pull boxes. Frames shall be anchored to the boxes by means of ¼ inch x 2 ¼-inch long concrete anchors. Four concrete anchors shall be provided for the No. 3 ½(T) pull box, one placed in each corner. Six concrete anchors shall be provided for each No. 5(T) and No. 6(T) pull box, one placed in each corner and one placed near the middle of each of the longer sides.

Hold down screws shall be 3/8-inch hex flange cap screws of Type 316 stainless steel. The nut shall be zinc plated carbon steel and shall be made vibration resistant with a wedge ramp at the root of the thread. The nut shall be spot welded to the underside of, or fabricated with, the galvanized Z-bar pull box frame.

Steel covers shall be countersunk approximately ¼ inch to accommodate the bolt head. The bolt head shall not extend more than 1/8 inch above the top of the cover

when tightened down. A ¼ inch tapped hole and brass bonding screw shall be provided.

The opening of traffic pull boxes shall have the following dimensions.

Pull Box Type	Width (± inch)	Length (± inch)
No. 3 ½(T)	10 ½”	17”
No. 5(T)	13”	24”
No. 6(T)	17”	30”

Concrete placed around and under traffic pull boxes shall contain a minimum of 564 pounds of cement per cubic yard.

After the installation of traffic pull boxes, the steel covers shall be installed and kept bolted down during periods when work is not actively in progress at the pull box. When placing the steel cover for the final time, the cover and the Z-bar frame shall be cleaned of all debris and securely tightened down.

21.09 CONDUCTORS AND WIRING

Splices shall be insulated by “Method B” as shown on State Standard Plan ES-13, or, at the Contractor’s option, splices of conductors shall be insulated with heat-shrink tubing of the appropriate size after thoroughly painting the spliced conductors with electrical insulating coating.

The Contractor shall provide the City Engineer with a Certificate of Compliance from the manufacturer in accordance with the provisions of Section 6-1.07, “Certificates of Compliance”, of the State Standard Specifications for all the conductors and cables furnished for the project.

Section 86-2.09, “Wiring”, of the State Standard Specifications is amended by retitling subsection 86-2.09D as “Splicing and Terminations”.

The last paragraph of said Section 86-2.09D is amended to read:

“All splices and terminal lugs for conductors sized No. 8 and smaller shall be soldered by the hot iron, pouring or dipping method. Open flame soldering will not be permitted”.

The color code for the No. 10 conductor shall be white.

21.10 SIGNAL INTERCONNECT CABLE

Signal interconnect cable shall consist of 12 No. 20, minimum, standard tinned copper conductors.

21.11 SERVICE

Continuous welding of exterior seams in service equipment enclosures is not required.

Type III service equipment enclosures shall be of the aluminum type.

Coordination for electrical power connection with the utility company shall be made by the Contractor with PG&E. The Contractor shall pay all required utility fees and costs related to providing electric service connection at the sites of work. The Contractor shall obtain utility company approval of service entrance and metering equipment shop drawings prior to fabrication of service equipment.

21.12 NUMBERING ELECTRICAL EQUIPMENT

The Contractor shall furnish and place numbers on electrical equipment as directed by the City Engineer.

Reflective numbers shall be applied to a clean surface.

Where shown on the plans, self-adhesive equipment numbers shall be placed for all electroliers associated with traffic signals. On electroliers, the numbers shall be placed as shown on State Standard Plan ES-6A.

Adhesive numbers for all locations except wood poles shall be white reflective adhesive sheeting, three inches in width, with three-inch Series D letters and numbers. The letters and numbers may be screened on to the reflective sheeting or may be die cut and adhesively attached. The labels for each location may be individual characters applied or a continuous strip applied. Reflective sheeting, numbers and letters shall comply with the respective specifications in the California Department of Transportation publication, "Specifications for Aluminum Reflective Sheeting Signs", dated June 1996.

21.13 CONTROLLER ASSEMBLY

The Model 170E Controller Assembly furnished shall be currently acceptable to the California Department of Transportation Laboratory, Sacramento, CA, and shall be currently listed on the California Department of Transportation Qualified Products List (QPL) and shall conform to the provisions in Section 86-3.11, "Model 170E Controller Assembly", of the State Standard Specifications.

The Model 170E Controller unit shall be installed in a Model 332 cabinet and shall conform to "Traffic Signal Control Equipment Specifications" (TSCES) dated January 1989 and any addendums thereto published by the California Department of Transportation. The Model 170E Controller assembly shall contain all necessary equipment, including software, to provide for the operation of the traffic signal.

The Model 170E Controller Assembly shall include a BI Tran 200CA local signal control program, a Model 400 modem and a Model 412C program module with 27256 EPPROM option, each with two copies of the operating manuals.

An initial signal timing plan shall be prepared by a qualified engineer and submitted to the City for approval prior to signal turn-on. The cost of preparing the signal-timing plan shall be borne by the Contractor.

The complete Controller Assembly, together with PROM and software shall be tested by a State certified testing laboratory for quality assurance and proper operations. A copy of the test results shall be provided to the City for review and approval prior to signal turn-on. A Certificate of Compliance shall also be furnished for the Model 170E Controller Assembly.

If the Controller Assembly fails to receive approval from the independent testing laboratory after three consecutive tests, the assembly shall be returned to the manufacturer and a new Controller Assembly shall be obtained from a different manufacturer at the Contractor's own expense. The new assembly shall be tested as before. The Contractor shall be responsible for all deliveries. Failure of the Controller Assembly to be approved by the independent testing laboratory shall not be considered a valid excuse for extension of the work schedule.

The Model 332 cabinet shall be installed on a foundation as shown on State Standard Plan ES-4B. The Contractor for the project shall be responsible for

making all field-wiring connections to the terminal blocks in the controller cabinet. The Model 332-controller cabinet shall be wired for phase operation as shown on plans. Load switches shall be provided as required for the intended operation or as shown on plans. Field wiring terminal strips shall be capable of accepting up to four conductors for each phase. The controller cabinet shall be constructed of aluminum and shall be anodized by manufacturer and not painted. The copper ground rod installed in controller cabinet shall be 3/4" inch diameter by 10' foot, minimum.

After installing the tested and approved Model 170E Controller Assembly and prior to the anticipated traffic signal turn-on, the Contractor shall perform the following functional tests in the presence of the City Engineer.

1. All vehicular and pedestrian indications shall individually be turned on momentarily and proper operation and phasing shall be checked.
2. The controller shall be turned on with the vehicle and pedestrian indications turned off, all pedestrian push buttons and inductive loop detectors shall be checked for proper operation and phasing.
3. All vehicular and pedestrian signal heads shall be properly adjusted and covered.

If any system component or circuit does not operate properly, it shall be repaired and retested prior to traffic signal turn-on. After the successful completion of all tests, the Contractor shall notify the City Engineer five days prior to date of anticipated turn-on of the traffic signal system. Traffic signal turn-on may occur only between the hours of 9 a.m. and 3 p.m. on Tuesday, Wednesday or Thursday on a week with no scheduled holidays, unless otherwise approved by the City Engineer.

The Contractor shall, at his own expense, arrange to have a signal technician employed by the controller unit manufacturer or his representative, who is qualified to work and implement the initial signal timing plan on the controller unit present at the project site at the time the signal is turned on. In addition, the Contractor shall arrange to have the City's signal maintenance personnel present for the signal turn-on. The initial cost for providing City's signal maintenance personnel shall be borne by the City. However, should the initial turn-on fail and another turn-on must be scheduled, the cost of having the City's signal maintenance personnel present for the additional turn-on shall be borne by the Contractor.

21.14 LIGHT EMITTING DIODE VEHICLE SIGNAL MODULES

All vehicle traffic signal faces with 12" (300mm) sections, 8" (200mm) sections or arrow sections shall use light emitting diode (LED) signal modules as the light source in conformance with the following requirements.

GENERAL

Type 1 LED signal modules shall be installed in the doorframes of standard traffic signal housings. Lamp sockets, reflectors, reflector holders and lenses used with incandescent lamps shall not be used when Type 1 LED signal modules are installed.

LED signal modules, including green, yellow, red, circular balls and arrow indications shall be from the same manufacturer, and each size shall be the same model.

Type 1 LED signal modules shall be sealed units with two color-coded conductors for power connection, a printed circuit board, a power supply, a lens and a gasket. LED signal modules shall be weatherproof after installation and connection. Circuit boards and power supplies shall be contained inside Type 1 LED signal modules. Circuit boards shall conform to the requirements in Chapter 1, Section 6 of the "Transportation Electrical Equipment Specifications," (TEES) published by the California Department of Transportation.

Conductors for Type 1 LED signal modules shall be one meter in length with quick disconnect terminals attached, and shall conform to the provisions in Section 86-4.01C, "Electrical Components," of the State Standard Specifications.

Lenses of Type 1 LED signal modules shall be integral to the units, shall be convex with a smooth outer surface and shall be made of ultraviolet (UV) stabilized plastic or glass. The lenses shall be capable of withstanding ultraviolet exposure from direct sunlight for a minimum period of 36 months without exhibiting evidence of deterioration.

Type 1 LED signal modules shall be sealed in doorframes with one-piece ethylene propylene rubber (EPDM) gaskets.

LEDs used in signal modules shall be of Aluminum Indium Gallium Phosphide (AlInGaP) technology for red and yellow indications and of Gallium Nitride (GaN) technology for green indications. LEDs shall be the ultra bright type rated for 100,000 hours of continuous operation from -40°C to +74°C.

Individual LEDs shall be wired so that a total failure of one LED will result in the loss of not more than 5 percent of the signal module light output. Failure of an individual LED in a string shall not result in the loss of the entire string or any other indication.

Maximum power consumption requirements for LED signal modules shall be as follows:

LED Signal Module	Power Consumption in Watts					
	Red		Yellow		Green	
	25°C	74°C	25°C	74°C	25°C	74°C
12" circular	11	17	22	25	12	12
8" circular	8	13	13	16	10	10
12" arrow	9	12	10	12	13	13

PHYSICAL AND MECHANICAL REQUIREMENTS

Arrow modules shall conform to the requirements in Section 9.01 of the Institute of Transportation Engineers (ITE) Publication: Equipment and Materials Standards, "Vehicle Traffic Control Signal Heads" for arrow indications. LEDs shall be spread evenly across the illuminated portion of the arrow area.

LED SIGNAL MODULE LENS

The LED signal module shall be capable of replacing the optical unit. The lens may be tinted or may use transparent film or materials with similar characteristics to enhance "ON/OFF" contrasts. The use of tinting or other materials to enhance "ON/OFF" contrast shall not affect chromaticity and shall be uniform across the face of the lens.

If a polymeric lens is used, a surface coating or chemical surface treatment shall be used to provide front surface abrasion resistance.

ENVIRONMENTAL REQUIREMENTS

LED signal modules shall be rated for use in the operating temperature range of -40°C to +74°C.

LED signal modules shall be protected against dust and moisture intrusion in conformance with the requirements in NEMA Standard 250-1991 for Type 4 enclosures to protect internal components.

CONSTRUCTION

LED signal modules shall be single, self-contained devices. The power supply for LED signal modules shall be integral to the module.

Assembly and manufacturing processes for LED signal modules shall be designed to assure all internal components will be adequately supported to withstand mechanical shock and vibration from high winds and other sources.

MATERIALS

Materials used for lenses and LED signal modules shall conform to the requirements in ASTM Specifications for the materials.

Enclosures containing the power supply or electronic components of LED signal modules shall be made of UL94VO flame-retardant materials. Lenses of LED signal modules are excluded from this requirement.

MODULE Identification

LED signal modules shall have the manufacturer's name, trademark, model number, serial number, lot number, month and year of manufacture, and required operating characteristics permanently marked on the back of the module. Required operating characteristics shall include rated voltage, power consumption and volt-ampere (VA).

Type 1 LED signal modules shall have prominent and permanent vertical markings for correct indexing and orientation within the signal housings. Markings shall consist of an up arrow or the word "UP" or "TOP."

PHOTOMETRIC REQUIREMENTS

Initial luminous intensity values for LED signal modules, operating at 25°C, shall meet or exceed the following minimum values:

Circular Indications (in cd)

Angle (v,h)	8"			12"		
	Red	Yellow	Green	Red	Yellow	Green
2.5, ±2.5	157	314	314	399	798	798
2.5, ±7.5	114	228	228	295	589	589
2.5, ±12.5	67	133	133	166	333	333
2.5, ±17.5	29	57	57	90	181	181
7.5, ±2.5	119	238	238	266	532	532
7.5, ±7.5	105	209	209	238	475	475
7.5, ±12.5	76	152	152	171	342	342
7.5, ±17.5	48	95	95	105	209	209
7.5, ±22.5	21	43	43	45	90	90
7.5, ±27.5	12	24	24	19	38	38
12.5, ±2.5	43	86	86	59	119	119
12.5, ±7.5	38	76	76	57	114	114
12.5, ±12.5	33	67	67	52	105	105
12.5, ±17.5	24	48	48	40	81	81
12.5, ±22.5	14	29	29	26	52	52
12.5, ±27.5	10	19	19	19	38	38
17.5, ±2.5	19	38	38	26	52	52
17.5, ±7.5	17	33	33	26	52	52
17.5, ±12.5	12	24	24	26	52	52
17.5, ±17.5	10	19	19	26	52	52
17.5, ±22.5	7	14	14	24	48	48
17.5, ±27.5	5	10	10	19	38	38

Arrow Indications (in cd/m²)

	Red	Yellow	Green
Arrow Indication	5500	11 000	11 000

LED signal modules shall meet or exceed the following minimum illumination values for a minimum period of 36 months, based on normal use in traffic signal operation over an operating temperature range of -40°C to +74°C. In addition, yellow LED signal modules shall meet or exceed the following minimum illumination values for a minimum period of 36 months, based on normal use in traffic signal operation at 25°C:

Circular Indications (in cd)

Angle (v,h)	8"			12"		
	Red	Yellow	Green	Red	Yellow	Green
2.5, ±2.5	133	267	267	339	678	678
2.5, ±7.5	97	194	194	251	501	501
2.5, ±12.5	57	113	113	141	283	283
2.5, ±17.5	25	48	48	77	154	154
7.5, ±2.5	101	202	202	226	452	452
7.5, ±7.5	89	178	178	202	404	404
7.5, ±12.5	65	129	129	145	291	291
7.5, ±17.5	41	81	81	89	178	178
7.5, ±22.5	18	37	37	38	77	77
7.5, ±27.5	10	20	20	16	32	32
12.5, ±2.5	37	73	73	50	101	101
12.5, ±7.5	32	65	65	48	97	97
12.5, ±12.5	28	57	57	44	89	89
12.5, ±17.5	20	41	41	34	69	69
12.5, ±22.5	12	25	25	22	44	44
12.5, ±27.5	9	16	16	16	32	32
17.5, ±2.5	16	32	32	22	44	44
17.5, ±7.5	14	28	28	22	44	44
17.5, ±12.5	10	20	20	22	44	44
17.5, ±17.5	9	16	16	22	44	44
17.5, ±22.5	6	12	12	20	41	41
17.5, ±27.5	4	9	9	16	32	32

Arrow Indications (in cd/m²)

	Red	Yellow	Green
Arrow Indication	5 500	11 000	11 000

Measured chromaticity coordinates of LED signal modules shall conform to the chromaticity requirements of the following table, for a minimum period of 36 months, over an operating temperature range of -40°C to +74°C.

Chromaticity Standards

Red	Y: not greater than 0.308, or less than 0.998 - x
Yellow	Y: not less than 0.411, nor less than 0.995 - x, nor less than 0.452
Green	Y: not less than 0.506 - 0.519x, nor less than 0.150 + 1.068x, nor more than 0.730 - x

LED signal modules tested or submitted for testing shall be representative of typical production units. Circular LED modules shall be tested in conformance with California Test 604. Optical testing shall be performed with LED signal modules mounted in standard traffic signal sections without visors or hoods attached to the signal sections.

LEDs for arrow indications shall be spread evenly across the illuminated portion of the arrow area. Arrow LED signal modules shall be tested in conformance with California Test 3001. Optical testing shall be performed with LED signal modules mounted in standard traffic signal sections without visors or hoods attached to the signal sections. LED arrow signal section indication shall provide minimum initial luminous intensity as listed herein. Measurements shall be performed at the rated operating voltage of 120 V (ac).

ELECTRICAL

Maximum power consumption requirements for LED signal modules shall not exceed those listed in "General." LED signal modules shall operate at a frequency of 60 Hz \pm 3 Hz over a voltage range from 95 V (ac) to 135 V (ac) without perceptible flicker. Fluctuations of line voltage shall have no visible effect on luminous intensity of the indications. Rated voltage for all measurements shall be 120 V (ac).

Wiring and terminal blocks shall conform to the requirements of Section 13.02 of the ITE Publication: Equipment and Material Standards, (Vehicle Traffic Control Signal Heads).

LED signal module on-board circuitry shall include voltage surge protection to withstand high repetition noise transients in conformance with the requirements in Section 2.1.6 of NEMA Standard TS2-1992.

LED signal modules shall be operationally compatible with currently used controller assemblies including solid-state load switches, flashers and conflict monitors. When a current of 20 milliamperes (ac) or less is applied to the unit, the voltage read across the two leads shall be 15 V (ac) or less.

LED signal modules and associated on-board circuitry shall conform to the requirements in Federal Communications Commission (FCC) Title 47, SubPart B, Section 15 regulations concerning the emission of electronic noise.

LED signal modules shall provide a power factor of 0.90 or greater.

Total harmonic distortion from current and voltage induced into an alternating current power line by LED signal modules shall not exceed 20 percent at an operating temperature of 25°C.

QUALITY CONTROL PROGRAM

LED signal modules shall be manufactured in conformance with a vendor quality control (QC) program. The QC program shall include two types of testing: (1) design qualification and (2) production quality. Production quality testing shall include statistically controlled routine tests to ensure minimum performance levels of LED signal modules built to meet these specifications.

Documentation of the QC process and test results shall be kept on file for a minimum period of seven years.

LED signal module designs not satisfying design qualification testing and the production quality testing performance requirements specified herein shall not be labeled, advertised or sold as conforming to these specifications.

Identification of components and subassemblies of LED signal modules, which may affect reliability and performance, shall be traceable to the original manufacturers.

DESIGN QUALIFICATION TESTING

Design qualification testing (DQT) shall be performed by the manufacturer or an independent testing lab hired by the manufacturer on new LED signal module designs, and on existing designs when a major design change has been implemented. Failure to conform to the requirements of any design qualification test shall be cause for rejection.

A major design change is defined as a design change, electrical or physical, which changes any of the performance characteristics of the LED signal module, results in a different circuit configuration for the power supply, or changes the layout of the individual LEDs in the signal module.

Two LED modules for each design shall be used for DQT. The two LED signal modules shall be selected at random. These signal modules shall be submitted to the California Department of Transportation Laboratory, Sacramento, CA, after the DQT is complete. Testing data shall be submitted with the modules to the California Department of Transportation Laboratory for verification of DQT data.

LED signal modules shall be energized for a minimum of 24 hours, at 100 percent on-time duty cycle, at a temperature of 74°C before performing any DQT.

After burn-in, LED signal modules shall be tested for rated initial luminous intensity in conformance with the provisions in "Photometric Requirements." Before measurement, LED signal modules shall be energized at rated voltage, with 100 percent on-time duty cycle, for a time period of 30 minutes. Photometrics, luminous intensity and color measurements for yellow LED signal modules shall be taken immediately after the modules are energized. The ambient temperature for these measurements shall be 25°C. Test results for this testing shall record the current, voltage, total harmonic distortion (THD) and power factor (PF) associated with each measurement.

LED signal modules shall be tested by measuring for chromaticity (color) in conformance with the provisions in "Photometric Requirements." A spectra radiometer shall be used for this measurement. The ambient temperature for this measurement shall be 25°C.

LED signal modules shall be tested by measuring the current flow in amperes. The measured current values shall be used for quality comparison of production quality assurance on production modules.

LED signal modules shall be tested by measuring the power factor. A commercially available power factor meter may be used to perform this measurement.

LED signal modules shall be tested by measuring the total harmonic distortion. A commercially available total harmonic distortion meter may be used to perform this measurement.

LED signal modules shall be tested in conformance with the provisions in "Electrical," with reference to Class A emission limits referenced in Federal Communications Commission (FCC) Title 47, SubPart B, Section 15.

LED signal modules shall be tested for compatibility with the controller unit, conflict monitor and load switch. Each signal module shall be connected to the output of a standard load switch connected to an alternating current voltage supply between the values of 95 and 135 V (ac) with the input to the load switch in the "OFF" position. The alternating current voltage developed across each LED signal module so connected shall not exceed 15 V rms as the input alternating current voltage is varied from 95 V (ac) rms to 135 V (ac) rms.

LED signal modules shall be tested for transient immunity in conformance with the provisions in "Electrical," and conforming to the procedure described in NEMA Standard TS2-1992.

Mechanical vibration testing shall be performed on LED signal modules in conformance with the requirements in MIL-STD-883, Test Method 2007, using three 4-minute cycles along each x, y, and z-axis, at a force of 2.5 Gs, with a frequency sweep from 2 Hz to 120 Hz. The loosening of the lens, internal components, or other physical damage shall be cause for rejection.

Temperature cycling shall be performed on LED signal modules in conformance with the requirements of MIL-STD-883, Test Method 1010. The temperature range shall conform to the provisions in "Environmental Requirements." A minimum of 20 cycles shall be performed with a 30-minute transfer time between temperature extremes and a 30-minute dwell time at each temperature. LED signal module under test shall be non-operating. Failure of LED signal modules to function properly or evidence of cracking of LED signal module lenses or housings after temperature cycling shall be cause for rejection.

Moisture resistance testing shall be performed on LED signal modules in conformance with the requirements in NEMA Standard 250-1991 for Type 4 enclosures. Evidence of internal moisture after testing shall be cause for rejection.

PRODUCTION QUALITY TESTING

Production quality testing shall be performed on each LED signal module prior to shipment. Failure to conform to the requirements of any production quality test shall be cause for rejection. The manufacturer shall retain test results for seven years for warranty purposes.

LED signal modules shall be tested for rated initial intensity after burn-in. The burn-in period shall consist of signal modules being energized at rated voltage for a 30-minute stabilization period before the measurements are made. A single point measurement with a correlation to the minimum initial luminous intensity requirements of "Photometric Requirements" for circular modules may be used. The ambient temperature for this measurement shall be +25°C.

LED signal modules shall be tested for luminous intensity requirements in "Photometric Requirements."

LED signal modules shall be tested for required power factor after burn-in.

LED signal modules shall be tested by measuring current flow in amperes after burn-in. The measured current values shall be compared against current values resulting from design qualification measurements under "Design Qualification Testing." The current flow shall not exceed the rated value. The measured ampere values with rated voltage shall be recorded as volt-ampere (VA) on the product labels.

LED signal modules shall be visually inspected for any exterior physical damage or assembly anomalies. The surface of the lens shall be free of scratches, abrasions, cracks, chips, discoloration, or other defects. Any such defects shall be cause for rejection.

CERTIFICATE OF COMPLIANCE

The Contractor shall provide the City Engineer a Certificate of Compliance from the manufacturer, in conformance with the provisions of Section 6-1.07, "Certificates of Compliance," of the State Standard Specifications. The certificate shall certify that the LED signal modules comply with the requirements of these specifications. The certificate shall also include a copy of all applicable test reports on the LED signal modules.

WARRANTY

The manufacturer shall provide a written warranty against defects in materials and workmanship for LED signal modules for a period of 36 months after installation of LED signal modules. Replacement LED signal modules shall be provided within 5 days after receipt of failed LED signal modules at no cost to the City, except the cost of shipping the failed modules. All warranty documentation shall be given to the City Engineer prior to installation.

21.15 LIGHT EMITTING DIODE PEDESTRIAN SIGNAL FACE MODULES

Light emitting diode (LED) pedestrian signal face (PSF) modules shall be furnished and installed in standard Type A pedestrian signal housing, "UPRAISED HAND" and "WALKING PERSON," and shall use light emitting diodes as the light source in conformance with the following requirements.

GENERAL

PSF modules shall be designed to mount in standard Type A housings. PSF modules shall be designed to mount behind or replace face plates of standard Type A housings in conformance with the requirements of the Institute of Transportation Engineers (ITE) Standards: "Pedestrian Traffic Control Signal Indications" and the "Manual on Uniform Traffic Control Devices" (MUTCD).

PSF modules shall be from a single manufacturer.

Circuit boards and power supplies shall be contained inside the LED modules. Circuit boards shall conform to the requirements in Chapter 1, Section 6 of the "Transportation Electrical Equipment Specifications," (TEES) published by the California Department of Transportation.

PSF modules shall fit into existing Type A housings and shall not require a specific mounting orientation and shall not vary in light output, pattern or visibility for any mounting orientation.

LEDs for "UPRAISED HAND" symbols shall utilize Aluminum Indium Gallium Phosphide (AlInGaP) technology and shall be the ultra bright type rated for 100,000 hours of continuous operation from -40°C to +74°C.

Individual LEDs shall be wired so that a total failure of one LED will result in the loss of not more than 5 percent of the PSF module light output. Failure of an individual LED in a string shall not result in the loss of the entire string or any other indication.

PSF modules tested and those submitted for testing shall be representative of typical production units. PSF modules shall be tested in conformance with California Test 610 and as specified herein.

Luminance Requirements

Luminance of the "UPRAISED HAND" symbol shall be 3750 cd/m² minimum. Color of "UPRAISED HAND" shall be Portland orange conforming to the requirements of the ITE Standards: "Pedestrian Traffic Control Signal Indications" and the MUTCD.

Luminance of the "WALKING PERSON" symbol shall be 5300 cd/m² minimum. Color of "WALKING PERSON" shall be white (Luminous Tubing) conforming to the requirements of the ITE Standards: "Pedestrian Traffic Control Signal Indications" and the MUTCD.

Height and width of each symbol shall not be less than 250 mm and 165 mm respectively. Uniformity ratio of illuminated symbols shall not exceed 4 to 1 between the highest luminance area and the lowest luminance area.

PSF modules shall be rated for a minimum useful life of 36 months and shall maintain at least 85 percent of 3750 cd/m² for "UPRAISED HAND" symbols and 85 percent of 5300 cd/m² for "WALKING PERSON" symbols after 36 months of continuous use in traffic signal operation over a temperature range of -40°C to +74°C.

PHYSICAL AND MECHANICAL REQUIREMENTS

PSF modules shall be designed as retrofit replacement for existing optical units of signal lamps, or existing pedestrian signal faces with both LED and incandescent light sources, and shall not require special tools for installation. PSF modules shall fit into pedestrian signal section housings built in conformance with the ITE Publication: Equipment and Materials Standards, Chapter 2 "Vehicle Traffic Control Signal Heads" (VTCSH) without modification to the housing.

ENVIRONMENTAL REQUIREMENTS

PSF modules shall be rated for use in the operating temperature range of -40°C to +74°C.

CONSTRUCTION

PSF modules shall be single, self-contained devices, not requiring on-site assembly for installation into standard Type A housings. Power supplies for PSF modules shall be integral to the modules.

Assembly and manufacturing processes for PSF modules shall be designed to assure all internal components will be adequately supported to withstand mechanical shock and vibration from high winds and other sources.

MATERIALS

Material used for PSF modules shall conform to the requirements in ASTM specifications for the materials.

Enclosures containing either the power supply or electronic components of the PSF module shall be made of UL94VO flame-retardant materials.

MODULE IDENTIFICATION

PSF modules shall have the manufacturer's name, trademark, model number, serial number, lot number, month and year of manufacture, and required operating characteristics permanently marked on the back of the module. Required operating characteristics shall include rated voltage, power consumption and volt-ampere (VA).

Type A pedestrian signal face, combination "UPRAISED HAND"/"WALKING PERSON" section, housings without the reflectors shall be used for PSF modules.

PHOTOMETRIC REQUIREMENTS

PSF modules shall maintain at least 85 percent of the following luminous intensity values over 36 months of continuous use in signal operation over the temperature range of -40°C to +74°C. In addition, PSF modules shall meet or exceed the following luminous intensity values upon initial testing at 25°C.

PSF module	Luminous Intensity
UPRAISED HAND	3750 cd/m ²
WALKING PERSON	5300 cd/m ²

The measured chromaticity coordinates of PSF modules shall conform to the requirements for chromaticity in Section 5.3.2.1 and Figure C of the VTCSH standards.

ELECTRICAL

PSF module power consumption shall not exceed the following maximum values:

PSF module	Power Consumption @ 25°C	Power Consumption @ 74°C
UPRAISED HAND	10.0 W	12.0 W
WALKING PERSON	12.0 W	15.0 W

PSF modules shall operate at a frequency of 60 Hz ± 3 Hz over a voltage range from 95 V (ac) to 135 V (ac) without perceptible flicker. Fluctuations of line voltage shall have no visible effect on the luminous intensity of the indications. Rated voltage for all measurements shall be 120 V (ac).

PSF module on-board circuitry shall include voltage surge protection to withstand high-repetition noise transients in conformance with the requirements in Section 2.1.6 of NEMA Standard TS2-1992.

Wiring and terminal blocks shall conform to the requirements of Section 13.02 of the ITE Publication: Equipment and Material Standards, "Vehicle Traffic Control Signal Heads."

PSF modules shall be operationally compatible with currently used controller assemblies including solid-state load switches, flashers and conflict monitors. When a current of 20 milliamperes (ac) or less is applied to the unit, the voltage read across the two leads shall be 15 V (ac) or less.

PSF modules and associated on-board circuitry shall conform to the requirements in Federal Communications Commission (FCC) Title 47, SubPart B, Section 15 regulations concerning the emission of electronic noise.

PSF modules shall provide a power factor of 0.90 or greater.

Total harmonic distortion from current and voltage induced into an alternating current power line by PSF modules shall not exceed 20 percent at an operating temperature of 25°C.

QUALITY CONTROL PROGRAM

PSF modules shall be manufactured in conformance with a vendor quality control (QC) program. The QC program shall include two types of testing: (1) design qualification and (2) production quality. Production quality testing shall include statistically controlled routine tests to ensure minimum performance levels of PSF modules built to meet these specifications.

Documentation of the QC process and test results shall be kept on file for a minimum period of seven years.

PSF module designs not satisfying design qualification testing and the production quality testing performance requirements specified herein shall not be labeled, advertised or sold as conforming to these specifications.

Identification of components and subassemblies of PSF modules, which may affect reliability and performance, shall be traceable to the original manufacturers.

DESIGN QUALIFICATION TESTING

Design qualification testing (DQT) shall be performed by the manufacturer or an independent testing lab hired by the manufacturer on new PSF module designs, and on existing designs when a major design change has been implemented. Failure to conform to the requirements of any design qualification test shall be cause for rejection.

A major design change is defined as a design change, electrical or physical, which changes any of the performance characteristics of the PSF module, results in a different circuit configuration for the power supply, or changes the layout of the individual LEDs in the PSF module.

Two PSF modules for each design shall be used for DQT. The two PSF modules shall be selected at random. These PSF modules shall be submitted to the California Department of Transportation Laboratory, Sacramento, CA, after the DQT is complete. The testing data shall be submitted with the PSF modules to the California Department of Transportation Laboratory for verification of DQT data.

The PSF modules shall be energized for a minimum of 24 hours, at 100 percent on-time duty cycle, at a temperature of 74°C before performing any DQT.

After burn-in, the PSF modules shall be tested for rated initial luminous intensity in conformance with the provisions in "Photometric Requirements." Before measurement, PSF modules shall be energized at rated voltage, with 100 percent on-time duty cycle, for a time period of 30 minutes. The ambient temperature for these measurements shall be 25°C. The test results shall include the recorded current, voltage, total harmonic distortion (THD) and power factor (PF) associated with each measurement.

PSF modules shall be tested by measuring for chromaticity (color) in conformance with the provisions in "Photometric Requirements." A spectra radiometer shall be used for these measurements. The ambient temperature for these measurements shall be 25°C.

PSF modules shall be tested by measuring for current flow in amperes. The measured current values shall be used for comparison of production quality assurance on production modules.

PSF modules shall be tested by measuring for power factor. A commercially available power factor meter may be used to perform this measurement.

PSF modules shall be tested by measuring for total harmonic distortion. A commercially available total harmonic distortion meter may be used to perform this measurement.

PSF modules shall be tested in conformance with the provisions in "Electrical," with reference to Class A emission limits referenced in Federal Communications Commission (FCC) Title 47, SubPart B, Section 15.

PSF modules shall be tested for compatibility with the controller unit, conflict monitor and load switch. Each PSF module shall be connected to the output of a standard load switch connected to an alternating current voltage supply between the values of 95 and 135 V (ac) with the input to the load switch in the "OFF" position. The alternating current voltage developed across each PSF module shall not exceed 10 V rms as the input alternating current voltage is varied from 95 V (ac) rms to 135 V (ac) rms.

PSF modules shall be tested for transient immunity in conformance with the provisions in "Electrical" and conforming to the procedure described in NEMA Standard TS2-1992.

Mechanical vibration testing shall be performed on PSF modules in conformance with the requirements in MIL-STD-883, Test Method 2007, using three 4-minute cycles along each x, y, and z-axis, at a force of 2.5 Gs, with a frequency sweep from 2 Hz to 120 Hz. The loosening of the lens, of any internal components, or other physical damage shall be cause for rejection.

Temperature cycling shall be performed on PSF modules in conformance with the requirements of MIL-STD-883, Test Method 1010. The temperature range shall conform to the provisions in "Environmental Requirements." A minimum of 20 cycles shall be performed with a 30-minute transfer time between temperature extremes and a 30-minute dwell time at each temperature. Signal under test shall be non-operating. Failure of PSF modules to function properly or evidence of cracking of PSF module lenses or housings after temperature cycling shall be cause for rejection.

Moisture resistance testing shall be performed on PSF modules in conformance with the requirements in NEMA Standard 250-1991 for Type 4 enclosures. Evidence of internal moisture after testing shall be cause for rejection.

PRODUCTION QUALITY TESTING

Production quality tests shall be performed on each PSF module prior to shipment. Failure to conform to the requirements of any production quality tests shall be cause for rejection. The manufacturer shall retain test results for seven years for warranty purposes.

PSF modules shall be tested for rated initial intensity after burn-in. The burn-in period shall consist of signal modules being energized at rated voltage for a 30-minute stabilization period before the measurements are made.

PSF modules shall be tested for luminous intensity requirements in "Photometric Requirements."

PSF modules shall be tested for required power factor after burn-in.

PSF modules shall be tested by measuring current flow in amperes after burn-in. The measured current values shall be compared against current values resulting from design qualification measurements under "Design Qualification Testing." The current flow shall not exceed the rated value. The measured ampere values with rated voltage shall be recorded as volt-ampere (VA) on the product labels.

PSF modules shall be visually inspected for any exterior physical damage or assembly anomalies. The surface of the lens shall be free of scratches, abrasions, cracks, chips, discoloration, or other defects. Any such defects shall be cause for rejection.

CERTIFICATE OF COMPLIANCE

The Contractor shall provide the City Engineer a Certificate of Compliance from the manufacturer, in conformance with the provisions of Section 6-1.07, "Certificates of Compliance," of the State Standard Specifications. The certificate shall certify that the PSF modules comply with the requirements of these specifications. The certificate shall also include a copy of all applicable test reports on the PSF modules.

WARRANTY

The manufacturer shall provide a written warranty against defects in materials and workmanship for the PSF modules for a period of 36 months after installation of the PSF modules. Replacement PSF modules shall be provided within 5 days after receipt of failed PSF modules at no cost to the City, except the cost of shipping the failed modules. All warranty documentation shall be given to the City Engineer prior to installation.

21.16 PROGRAMMED VISIBILITY VEHICLE TRAFFIC SIGNAL HEADS

Programmed visibility vehicle traffic signal heads, when required, shall be 3M High Visibility Signal System. All integral signal assembly including mounting hardware, backplates, batten plates and lamps shall be furnished by the Contractor.

The Contractor shall, at his own expense, arrange to have a qualified signal technician from the manufacturer present to program the programmed visibility signal heads to the satisfaction of the City Engineer, at the time the signal heads are placed in operation.

The seventh paragraph of Section 86-4.04, "Programmed Visibility Vehicle Signal Faces", of the State Standard Specifications is amended to read:

"Prior to programming, each signal section with a yellow indication shall provide a minimum luminous intensity of 2,500 candela on the optical axis, and a maximum intensity of 100 candela at 15 degrees horizontal from the axis. Each such signal section shall be capable of having its visibility programmed to achieve the following luminous intensities; a minimum of 2,500 candela on the optical axis, a maximum of 100 candela from ½ to two degrees horizontal from the axis and a maximum of ten candela from two to 15 degrees horizontal from the axis. Under the conditions, the intensities of the red indication and the green indication shall be at least 19 and 38 percent, respectively, of the yellow indication".

21.17 PEDESTRIAN SIGNALS AND PUSH BUTTONS

Type SP-1-T pedestrian signal mountings shall have an upper and lower mounting bracket attached to the pedestrian signal housing in the same manner as that shown on the plans for Type SP-2-T mounting.

Pedestrian push buttons shall be in compliance with current Federal Americans with Disabilities Act requirements. The contractor shall submit shop drawings and specifications to the City Engineer for approval.

21.18 DETECTORS

Loop wire shall be Type 2.

Loop detector lead-in cable shall be Type B.

Residue resulting from slot cutting operations shall not be permitted to flow across shoulders or lanes occupied by public traffic and shall be removed from the pavement surface.

Slots shall be filled with elastomeric sealant or hot-melt rubberized asphalt sealant.

The second sentence of Note 14 of the Loop Installation Procedure on State Standard Plan ES-5A, regarding loop circuit resistance, is deleted.

Splices in detector circuits shall be insulated as provided in "Conductors and Wiring" of the Special Provisions of the State Standard Specifications.

Where sawed slots cross two different types of pavement material or two different panels of P.C.C. pavement, a ¾-inch PVC pipe shall be installed across the joint, as shown in "Curb Termination Details-Type B" on State Standard Plan ES-5E to contain the loop conductors and act as an expansion/deflection fitting.

All detector lead-in cables (DLC) shall be terminated at the controller cabinet field terminals with non-insulated, crimp-on, spade or loop connectors and soldered.

The ends of all detector lead-in cables and loop conductors shall be taped and made waterproof by dipping in an electrically insulating liquid to seal the ends prior to being installed in conduit and prior to being left overnight.

Type A loop detectors shall be used in accordance with these specifications, with the exception that the first loop shall be Type D.

Detector handholes shall be Type A.

Each loop detector shall be tested for insulation resistance at the termination pull box prior to connection to the detector lead-in cable, and again at the controller cabinet after connection to the detector lead-in cable.

Loop detector lead-in cable shall be run continuously without splices from the detector termination pull box to the field terminals in the controller cabinet.

21.19 EMERGENCY VEHICLE PRE-EMPTION SYSTEM

Each emergency vehicle pre-emption system shall permit detection of Class II (emergency) vehicles at any range up to 1,800 feet from the optical detector. The emergency vehicle pre-emption system shall conform to the details shown on the plans and as specified herein.

The discriminator modules shall be 3M Opticom Phase Selector Model 752 or the most current model.

The optical detectors shall be 3M Opticom Model 721 or the most current series.

The optical detector cable shall meet the requirements of IPCEA-S-61-402/NEMA WC 5, Section 7.4, 600-volt control cable, 75° C., Type B, and the following:

The cable shall contain three conductors, each of which shall be No. 20 (7 x 28) stranded, tinned copper with low-density polyethylene insulation. Minimum average insulation thickness shall be 25 mil. Insulation of individual conductors shall be color coded: 1-yellow, 1-blue, 1-orange.

The shield shall be either tinned copper braid or aluminized polyester film with a nominal 20 percent overlap. Where the film is used, a No. 20 (7 x 28) stranded, tinned, bare drain wire shall be placed between the insulated conductors and the shield and in contact with the conductive surface of the shield.

The jacket shall be black polyvinyl chloride with minimum ratings of 600 volts and 80° C and a minimum average thickness of 45 mil: The jacket shall be marked as required by IPCEA/NEMA.

The finished outside diameter of the cable shall not exceed 0.35-inch.

The capacitance, as measured between any conductor and the other conductors and the shield, shall not exceed 48 picofarads per foot at 1,000 Hz.

The cable run between each detector and the controller cabinet shall be continuous without splices or shall be spliced only as directed by the detector manufacturer.

The total call hold time for the emergency vehicle pre-emption system shall be pre-set at six seconds prior to system operation.

The Contractor shall demonstrate that all of the components of each system are compatible and will perform satisfactorily as a system. Satisfactory performance shall be determined using the following test procedure:

1. All range adjustments on the module shall be set to "Maximum" for the test.
2. The City of West Sacramento Engineering Division and Fire Department will conduct an operational test.

21.20 LUMINAIRES AND BALLAST

Luminaries for safety lighting at the signalized intersection shall be 200-watt high pressure sodium with Type III, medium cutoff distribution. Ballasts shall be the lag or lead regulator type.

21.21 PHOTOELECTRIC CONTROLS

Photoelectric control for intersection safety lighting and internally illuminated street name signs shall be operated together with a Type II Photoelectric control. Contactors shall be the mechanical armature type.

21.22 TESTING

The first paragraph in Section 86-2.14B, "Field Testing", of the State Standard Specifications is amended to read:

Prior to start of functional testing, the Contractor shall perform the following tests on all circuits, in the presence of the City Engineer.

The first paragraph in Section 86-2.14B(3), "Insulation Resistance", is amended by the addition of the following two sentences:

An initial insulation resistance test shall be performed on each inductive loop detector at the pull-box adjacent to the loop.

A final insulation resistance test shall be performed on the inductive loop detectors at the controller cabinet after said detectors have been installed in accordance with the details shown on the plans and the final splices have been made between the loop conductors and the lead-in cables.

21.23 RECORD DRAWINGS

The Contractor shall keep accurate records on a set of project blue line prints (24" x 36") of all additions and deletions to the work, and of all changes in location, elevation and character of the work not otherwise shown or noted on contract plans.

"Record Drawings" construction plans shall be provided with changes to the original contract work shown in red color. The Contractor shall transmit the "As-Built" plans to the City Engineer for approval. Details to be shown on the "As-Built" plans shall include, but not be limited to, type and installed depth and location of conduit runs, location of pull boxes, location of foundations and changes made to any facilities.

"Record Drawings" plans shall be signed and dated by the Contractor or the Subcontractor that actually constructed the facility. In addition, company names of the Contractor and Subcontractors shall be shown.

The costs of record keeping to provide and preparing accurate "Record Drawings" field prints shall be considered as included in the contract lump sum price paid for various contract items of electrical works involved and no additional compensation will be allowed therefore.

21.24 COST BREAKDOWN

The Contractor shall, prior to commencement of work, furnish to the City Engineer a cost breakdown for the contract lump sum items of electrical work as specified in the contract documents.

The Contractor shall determine the quantities of the items required to complete all work shown on the plans. Such quantities and their values (including labor, equipment and materials) shall be included in the cost breakdown submitted to the City Engineer for approval. The sum of the quantity unit's times the unit prices shall equal the contract lump-sum bid for each item of electrical work. The Contractor shall be responsible for the accuracy of the quantities and values used in the cost breakdown submitted for approval. Unbalancing of the unit prices will not be allowed.

Overhead, profit, bond premium, temporary construction facilities and other such items shall be included in each individual unit listed in the cost breakdown, however, costs for traffic control system shall not be included.

No adjustment of compensation will be made in the contract lump sum price paid for various items of electrical work due to any differences between the quantities shown in the cost breakdown furnished by the Contractor and the quantities required to complete the work.

The cost breakdown shall, as a minimum, include the following items:

- Foundations – each type including controller foundation
- Standards and poles – list by each type
- Conduit – list by each size and installation method
- Trenching by method and depth
- Pull boxes – each type
- Conductors – each size and type
- Service equipment enclosure each type by wiring diagram
- Model 170E Controller assembly including cabinet – list each type
- Emergency vehicle pre-emption discrimination modules – each type
- Emergency vehicle pre-emption optical detectors – each type
- Signal heads and hardware – list each type
- Pedestrian signal heads – each type
- Pedestrian push buttons – each
- Loop detectors – list by type and size
- Luminaires – each type
- Detector handholes – each
- Internally Illuminated Street Name Signs – each type
- Lighting Protection – each type

The costs of preparing the cost breakdown for each lump sum item of electrical works shall be considered as included in the contract lump sum price paid for various items of electrical works involved and no additional compensation will be allowed therefor.

21.25 REMOVING, REINSTALLING OR SALVAGING ELECTRICAL EQUIPMENT

Salvaged electrical materials shall be hauled to the City of West Sacramento, Corporate Yard, 1951 South River Road, West Sacramento, California 95691. Deliveries shall be coordinated by contacting the Utilities Maintenance Superintendent at (916) 373-5850 between 8:00 a.m. and 3:30 p.m., Monday through Friday, a minimum of two working days prior to delivery of material.

The Contractor shall provide equipment, as necessary, to safely unload and stockpile the material at his own expense.

21.26 DISPOSING OF ELECTRICAL EQUIPMENT

All ballasts and transformers and all fluorescent and mercury lamps shall be disposed of in accordance with California Department of Health Services Regulations set forth in Title 22, Division 4, Chapter 30, of the California Code of Regulations (CCR.)

The Contractor shall package and ship recyclable hazardous waste via a currently certified hauler in conformance with Article 12, Chapter 30 of Title 22 CCR and all other applicable local, State, and Federal regulations.

The Contractor shall furnish the City Engineer with a statement as to which certified hauler and which certified recycler he proposes to utilize, together with a copy of the recycler's interim status document and/or a copy of the variance letter

from the Department of Health Services. Said statement shall be furnished to the City prior to the removal of the recyclable hazardous waste.

The City of West Sacramento assumes generator responsibility for these wastes. The City Engineer will prepare the Hazardous Waste Manifest for Shipment.

Full compensation for hauling, stockpiling, and disposal of fluorescent and mercury lamps shall be considered as included in the contract lump sum price paid for various items of electrical works involved and no additional compensation will be allowed therefor.

Handling and disposing of electrical material containing PCB, after removal, will be paid for as extra work as provided in Section 4-1.03D of the State Standard Specifications.

21.27 PAYMENT

The contract lump sum price paid for signal and lighting shall include all labor, materials, tools, and equipment to furnish and install traffic signal, internally illuminated street name signs, and intersection safety lighting at each location.

All other highway and street lighting work shall be considered as included in the contract price paid for various items of electrical works as indicated in Section 18.23 "Measurement and Payment" of Street lighting.

Signal interconnect work shall be considered as included in the contract lump sum price paid for signal interconnect and no additional compensation will be allowed therefor.

Full compensation for hauling and stockpiling electrical materials shall be considered as included in the contract lump sum price paid for various items of electrical works involved and no additional compensation will be allowed therefor.