SECTION 770 – TRAFFIC SIGNAL MATERIALS

770.01 Traffic Signal Standards.

(A) Type I Traffic Signal Standards. Steel Type I traffic signal standards shall be furnished. Each traffic signal standard shall be furnished with anchor base; uniform, continuously tapered steel shaft; anchor bolts and nuts; handhole and handhole cover; and other associated hardware necessary to make each traffic signal standard complete. Entire assembly shall have no rough edges or surfaces, depressions, or other defects.

1. Shaft. Shaft shall be constructed of minimum No. 10 gage material from open hearth, hot rolled steel or high tensile low alloy steel conforming to ASTM A 1011 or ASTM A 595, with one-piece construction. Shaft length with 10-foot mounting height shall be provided.

2. Handhole. Shaft shall have reinforced opening for a handhole, located approximately 9 inches above bottom surface of anchor base plate. Reinforced opening shall be furnished with gasket, cover plate, and non-slip fastener. Opening shall have 3-inch by 5-inch minimum inside measurement. A 1/4-inch by 1-inch long bolt, with nut and washer, shall be welded inside shaft opposite handhole.

3. Anchor Base. Steel casting, steel forging, or steel plate anchor base shall be integral part of standard. Anchor base shall be of sufficient strength to support standard. Anchor base shall have four holes, on 8-1/2 inch diameter bolt circle (6 inches square), sized to accommodate anchor bolts provided. Base plate shall be secured to lower end of shaft with continuous arc welds.

4. Anchor Bolts. Anchor bolts shall have size, strength, and length in accordance with manufacturer’s recommendations and shall conform to Subsection 718.01 - Standard Fasteners. Anchor bolts shall have "L" bends or plate washers at bottom. Each anchor base shall have four anchor bolts, with leveling nut, top nut, and two washers for each anchor bolt. Anchor bolts, washers, and nuts shall be zinc-coated.

5. Finish. Complete standard and other ferrous material after fabrication shall be hot-dipped and zinc-coated, internally and externally in accordance with AASHTO M 232 and AASHTO M 111.

(B) Type II and Type III Traffic Signal Standards. Type II and Type III traffic signal standards shall accommodate mast arm mounting of traffic signals, with or without bracket-mounted traffic signals.
(1) **Description.** Traffic signal standards with single tapered tube mast arm shall include the following:

(a) Tapered steel shaft complete with anchor base, anchor bolts, handhole, ground lug, cast pole top, and flange plate near top of pole for mounting mast arm.

(b) Tapered steel arm complete with mounting flange plate, hanger clamp, and outlet having 1-inch I.D. rubber grommet to accommodate wiring each signal, and removable end cap.

(c) Steel castings conforming to ASTM A 27, grade 65-35, and gray iron castings conforming to ASTM A 126, Class A. Steel castings shall be clean and smooth with details well defined and true to pattern.

(2) **Design.** Traffic signal standards shall be designed to support traffic signals mounted on mast arm. Traffic signal mounting height shall be 25 feet unless otherwise indicated in the contract documents.

(3) **Shaft.** Shaft shall be constructed of No. 10 gage minimum, hot-rolled sheet steel conforming to ASTM A 1011 or ASTM A 595. Silicon content shall be kept to less than 0.06 percent, and boron shall not be added. Transverse seams shall be perpendicular to shaft axis. Reinforce transverse seams with internal sleeves welded in place. Shaft size shall be minimum of 9-3/8 inches outside diameter (bottom of shaft) by 5-1/4 inches outside diameter (top of shaft) by 20 feet long.

Four inch by 6-1/2 inch reinforced handhole frame shall be welded, complete with cover, into shaft approximately 9 inches above bottom of base. Reinforced handhole frame shall be tapped for cap screws to secure cover plate.

Flange plate of thickness recommended by manufacturer shall be welded to pole near top. Flange plate shall be supported with side plates tangent to pole, and gusset plates at top and bottom. Flange plates shall have deburred 2-1/2 inch-diameter wiring hole and four tapped bolt holes. Welding shall be performed in accordance with Subsection 501.03(D) - Shop Work and Fabrication.

J-hook wire support shall be welded near top of shaft. Top of shaft shall be capped with cast pole top, secured in place with setscrews.

(4) **Anchor Base.** Single-piece steel anchor base of sufficient strength, shape, and size to support standard shall be secured to lower end of shaft by two continuous electric arc welds. Shaft shall
telescope with base. One weld shall be on inner portion of base at end of shaft and another weld shall be on outside at top of base. An approximately 2-inch separation shall be provided between the two welds.

Base shall have four holes sized to accommodate anchor bolts.

(5) **Tapered Mast Arm.** Mast arm shall be made from material from single length of No. 10 gage minimum hot rolled sheet steel conforming to ASTM A 1011 or ASTM A 595. Silicon content shall be kept to less than 0.06 percent, and boron shall not be added.

Large end of mast arm shall telescope with flange plate of thickness recommended by manufacturer. Flange plate shall be welded to mast arm by two continuous electric arc welds. One weld shall be on outer portion of plate next to shaft and another weld shall be on inner portion at end of tubular cross section. Four holes in flange plate shall match four tapped holes in mounting plate on pole.

(6) **Anchor Bolts.** Each pole shall have four steel anchor bolts, with each bolt fitted with two hex or heavy hex nuts. Each anchor bolt shall have "L" bend or plate washer welded to bottom. Anchor bolts shall be threaded at top end. Bolts shall be of strength, size, and length recommended by manufacturer and as specified in Subsection 718.01 - Standard Fasteners, to support pole shaft, mast arm, and mounted signal heads.

(7) **Zinc-coating.** Steel and iron parts of base, shaft and mast arm shall be zinc-coated in accordance with AASHTO 232. Washers and nuts may be hot-dip zinc-coated or electro-zinc-coated.

(C) **Standard Specifications.** Design of traffic signal standards and appurtenances shall conform to AASHTO publication, *Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals.*

(D) **Certification and Mill Test Reports.** Certification and mill test reports shall be submitted with the following information:

(1) List of component parts including the following:

(a) Description of each part.

(b) Materials manufacturing location (including ASTM number where applicable).

(c) Certificate of compliance.
(2) Shop drawings accompanied by complete and detailed engineering computations that justify selection of dimensions and material. Hawaii Licensed Professional Engineer (Structural) shall certify computations.

(3) Copy of mill test report for structural members (posts and beams), including physical and chemical descriptions of material incorporated.

770.02 Traffic Signal Heads.

(A) Standard Traffic Signal Heads. Each signal head shall conform to the following characteristics: adjustable, light-colored, vertical-type, with number and type of sections as specified; indications in one direction only; and adjustable through 360 degrees about its vertical axis.

Vertical signal heads shall contain three sections with the following configuration:

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<th>TABLE 770.02-1 - STANDARD TRAFFIC SIGNAL HEAD CONFIGURATION</th>
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<td>Yellow</td>
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(1) Optical Units. Each optical unit shall include lens, reflector, lampholder, and clear traffic signal lamp.

Standard lenses shall be of color specified, circular in shape, and have diameter of approximately 12 inches. Lenses shall be true to color, free from imperfections, and of high luminous transmission. Lens may be made of glass or of polycarbonate resin. Glass lens shall conform to latest ANSI standard for glass lens. Polycarbonate lens shall be molded of ultraviolet, pre-tinted transparent polycarbonate.

Each reflector shall have one-piece, clear glass parabolic reflector, free from bubbles and striae, or Alzak (proprietary anodizing process) processed aluminum alloy. Convex surface of clear glass shall be coated by silver using chemical deposition. Reflector shall be of sufficient thickness such that lighted filament of 150-watt incandescent lamp is not visible through silver layer. Silvered surface shall be protected by additional coating of electrolytically deposited
copper. Opening in back of reflector for lampholder shall cause no dark spots cast on lens.

Lampholder shall be weatherproof, of molded construction, immune to operating temperatures in unit, vibration-proof, and substantially supported. Lampholder shall have two wires of sufficient length so that lampholder may be connected to terminal block specified herein. Lamp filament shall be positioned at focal center of reflector.

Each reflector, lens, and hood shall be designed to minimize sun phantom.

Lamps shall be 135 watts, 120 volt, 5000-hour rated life, clear, traffic signal lamps conforming to ITE Standard for Traffic Signal Lamps.

Incandescent, non-programmable vehicle signal shall conform to the following requirements:

(a) Replace incandescent signal of vehicle signal head with Light-Emitting Diode (LED) signal assembly comprised of high-out LED light source protected by impact-resistant polycarbonate lens. LED head assembly shall replace standard 12-inch incandescent polycarbonate signal head. Operating at 60 to 135 volts and with maximum power consumption of 22 watts.

(b) To ensure quality and performance, LED head shall have prior history of testing and use by CALTRANS and shall exceed ITE standards. Failure on one LED shall not affect other LED. LED head shall have fully-encapsulated electronic circuitry and configuration for 12-inch ball. LED head shall be McCain Traffic Supply 12-inch LED Traffic Head or equal.

(2) Housing. Signal head housing or case shall be assembly of separate interchangeable sections. Interchangeable sections shall be expandable type for vertical mounting without tie rods, and shall be secured together in watertight manner to form unit. Individual optical units shall be housed in each section. The side of housing or door containing lens shall be square. Housing may be of aluminum or polycarbonate resin.

Die cast aluminum housing shall conform to ASTM B 85 with aluminum doors and end plates. Parts shall be clean, smooth and free of flaws, cracks, blowholes, and other imperfections.
Polycarbonate housing shall be ultra-violet-stabilized virgin polycarbonate resin of specified color, injection molded, complete with integral top, bottom, and sides; and shall have minimum thickness of 0.09 inch.

Each section shall be furnished complete with one-piece hinged door mounting for lens and other parts of optical system, watertight gaskets, and simple door-locking device. Optical system shall be mounted to allow for swinging various parts open for ready access or removal. Sections shall be interchangeable and designed to permit removing or adding of sections. Round opening shall be provided in top and bottom of each section face to receive 1-1/2 inch supporting pipe frame.

Exposed bolts, screws, hinge pins, and door-locking devices shall be made of stainless steel. Interior screws and fittings shall be made of stainless steel or other corrosion-resistant material accepted by the Engineer.

Gaskets, including door, lens and reflector gaskets, shall be of neoprene. Lampholder gaskets shall be heat-resistant.

Lampholders shall be wired to provide for connection of white wire to shell of lampholder and black or colored wire to bottom or end terminal of lampholder. These wires shall connect to terminal block mounted inside at back of housing. Each terminal block shall be furnished with sufficient screw-type terminals spaced to terminate all field conductors and lamp conductors independently. Terminals to which field conductors are attached shall be permanently identified or conductors shall be color-coded to aid field wiring.

Each lens shall be furnished with removable tunnel-type hood made of 0.030-inch-thick sheet aluminum or of polycarbonate with minimum thickness of 0.060 inch. Hoods shall be 11 inches minimum in length.

Aluminum housing shall be painted with one coat of alkyd, corrosion-inhibiting, lead and chromate free, VOC (volatile organic compound) -compliant primer coating, Society for Protective Coatings Specification SSPC-25; and one coat of medium gray enamel alkyd, semi-gloss, low VOC content, Master Painters Institute (MPI) Standard No. 94. Dark green enamel finish coat shall be Alkyd Urea Exterior Baking Enamel, Federal Standard FED-STD-595B. Dark green enamel shall match color chip on file with the Department. Signal face housing and entire surface of hood used in front of signal lens shall be painted dull black. Polycarbonate housing shall be painted dark green.
(3) **Directional Louvers.** Directional louvers shall be constructed to fit snugly in signal hoods. Outside cylinder and vanes shall be constructed of No. 22 U.S. gage sheet steel, and vanes constructed of No. 27 U.S. gage sheet steel; or cylinder and vanes of aluminum alloy 3003-H14 sheet of similar construction. Sheet steel louvers shall be zinc-coated after fabrication. Louvers shall be painted dull black.

(4) **Back Plates.** Back plates shall be furnished and installed on signal heads. Back plates shall be constructed of aluminum alloy 3003-H14 sheet having minimum thickness of 0.058 inch and minimum dimensions equal to signal head size plus eight-inch border. Back plates shall be painted dull black.

(B) **Signal Head Mounting.** Top of pole, bracket, cantilever, and underslung-mounted signal faces shall be supported by watertight assemblies of 1-1/2 inch standard steel pipe and malleable iron, or brass pipe fittings and hardware as specified. Mounting assembly members shall be plumb or level, symmetrically arranged and securely assembled. Conductors shall be concealed within assemblies. Pipe slipfitter assemblies shall be of cast-iron, bronze, or malleable iron. Slipfitters shall fit over 4-1/2 inch outside diameter standard pipe for top of pole mountings or 2-3/8 inch outside diameter tenon at end of mast arms. Mast arm end mounting fittings shall be 90-degree-type or elevator-type, as specified. Each slipfitter shall be provided with at least two cadmium-plated steel setscrews to secure assembly in plumb position. Each pipe bracket assembly shall be attached to traffic signal standard with 1-1/2 inch pipe couplings. Caps shall seal unused mounting holes in traffic signal housing.

Signal faces shall be equipped with positive, non-ferrous, lock rings and fittings that are designed to prevent signal faces from turning by external forces. Lock ring and connection fittings shall have serrated contacts. Fittings shall permit fastening at increments of less than 7 degrees.

Mountings shall be painted with one coat of zinc-coated metal primer and two coats of dark green enamel, as specified for signal housings.

Mark various parts of each mounting for easy assembly, if mountings are delivered disassembled.

Signal heads mounted at intermediate points on mast arms shall be equipped with mast arm mounting bracket. Component parts of mast arm mounting shall include bracket with vertical tube. Vertical tube shall have upper and lower devices to fasten signal face at bottom and top of mast arm face. Vertical tube shall be connected to mast arm with clamp casting and two high-strength stainless steel bands. Stainless steel bands shall be
tightened by screw assembly (one per stainless steel band). Signal face shall rotate through mounting assembly. Signal face shall rotate about mast arm, and right and left from vertical plane.

Polycarbonate traffic signal heads shall be equipped for post top mounting, with internal reinforcement for mounting base; or shall be equipped for Type IA mounting.

(C) Programmed Visibility Traffic Signal Heads.

(1) General. Signal heads shall permit visibility zone of indication to be determined optically and require no hoods or louvers. Projection indication may be selectively visible or veiled anywhere within 15 degrees of optical axis. No indication shall result from external illumination, nor shall one light unit illuminate another light unit.

(2) Optical System. Components of optical system shall include lamp, lamp collar, optical limiter-diffuser, and objective lens.

Lamps shall be nominal 150-watt, 120-volt AC, 3-prong, sealed beam having integral reflector with stippled cover and average rated life of at least 6,000 hours. Lamps shall be coupled to diffusing element with collar including specular inner surface. Diffusing element may be discrete or integral with convex surface of optical limiter.

Optical limiter shall provide accessible imaging surface at focus on optical axis for objects 900 to 1,200 feet away, and permit effective veiling mask to be variously applied as determined by desired visibility zone. Optical limiter shall include heat-resisting glass with positive indexing means.

Objective lens shall be high-resolution, planar incremental lens, hermetically sealed within flat laminate of weather-resistant acrylic or accepted equal. Lens shall be symmetrical in outline. Lens shall be rotated to 90-degree orientation about optical axis without displacing primary image.

Optical system shall accommodate projection of diverse, selected indication to separate portions of roadway such that only one indication will be simultaneously apparent to viewer. Projected indication shall conform to ITE transmittance and chromaticity standards.

(3) Construction. Die cast aluminum parts shall conform to ITE alloy and tensile requirements and have chromate preparatory treatment. Exterior of signal case, lamp housing, and mounting flanges shall have finish of high-quality baked enamel prime and finish paint (dark green exterior enamel). Lens holder and interior of case
shall be optical black.

Signal case and lamp holder shall be predrilled for backplates and visors. Hinges and latch pins shall be made of stainless steel. Access openings shall be sealed with weather-resistant rubber gaskets.

Visors shall conform to ITE material requirements and include chromate-preparatory treatment and optical black on surfaces. Cutaway-type visors shall be 9-1/2 inches.

(4) Electrical. Lamp fixture shall include separately accessible housing and integral lamp support, indexed ceramic socket, and self-aligning, quick-release lamp retainer. Electrical connection between case and lamp housing shall be made with interlock assembly that disconnects lamp holder when opened. Each signal section shall have covered terminal block for clip or screw attachment of lead wires. Sections shall be interconnected with concealed No. 18 AWM, stranded and coded wires.

(5) Photo Controls. Each signal section shall have integral means for regulating intensity between limits as function of individual background illumination. Lamp intensity shall have more than 97 percent of uncontrolled intensity at 1,000 foot-candles, and reduce to 15 percent ±2 percent of maximum at less than one foot-candle. Response shall be proportional and essentially instantaneous to detectable increase of illumination from darkness to 1,000 foot-candles, and damped for decrease from 1,000 foot-candles.

Intensity controller shall include an integrated directional light-sensing and regulating device interposed between lamp and line wires. Intensity controller shall be compatible with 60 Hz input and responsive within range of 105 to 135 volts. Output may be phase controlled, but device shall provide nominal terminal impedance of 1,200 ohms open circuit and corresponding holding current.

(6) Mounting. Signal shall be mounted to standard 1-1/2-inch fittings as single section, multiple section face, or in combination with other signals. Signal section shall have adjustable connection that permits incremental tilting from 0 degree to 10 degrees above or below horizontal axis while maintaining common vertical axis through couplers and mounting.

Terminal connection shall permit external adjustment about mounting axis in 5-degree increments. Signal shall be mountable with ordinary tools and serviceable without tools.

Pedestal adapter shall fit Type I signal standard with each
programmed visibility signal. Four-section heads shall be mounted using Type IA mounting.

Visor shall conform to existing mounting surfaces and fasten to existing mounting surfaces without affecting water and light integrity of signal.

(7) **Miscellaneous.** Roll of optical masking tape, applicator, and instruction manual shall be furnished with each face.

### 770.03 Dual Indication Unit (Fiberoptics).

**(A) Functional Requirements.** Dual indication unit shall conform to the following:

1. Display two alternately colored legends of green arrow or yellow arrow. Color filters installed shall be changed in unit to provide combinations of colors.

2. Have clearly visible legend under all lighting conditions. Visor shall be furnished with unit.

3. Be visible at full intensity everywhere within 20-degree cone centered about optical axis.

### 770.04 Pedestrian Signal.** Pedestrian signal shall be designed to fit mountings provided for vehicular signals as specified.

**(A) Features.** Provide the following features:

1. Elimination of sun phantom.

2. Improved light output.

3. Protection from vandalism.

4. Simplified maintenance.

5. Improved low-temperature operation.

6. Simplified handling.

7. Elimination of high-tension leads.

8. Operation at 90-volt applied line voltage.

Neon tubing shall be enclosed in single plug-in plastic module. Neon tubing shall be protected from shocks generated during shipping, handling,
and installing.

Maximum overall signal dimension shall be 19 inches wide, 19 inches high, and 9-1/4 inches deep, including egg-crate-type visor and hinge. Signal shall be furnished complete with transformers and tubing installed. Installation and maintenance of signal shall be facilitated by designing signal door that provides front access to components.

(B) Messages. Messages shall be Portland orange "HAND" and Lunar white "WALKING PERSON" illuminated by multiple configuration neon tubes encased in molded plug-in plastic message module.

"HAND" and "WALKING PERSON" symbols shall be minimum 12 inches in height, 7 inches in width, and uniformly illuminated with no dark spots.

Inside face of message lens shall be painted except where desired symbols are formed. First coating of paint shall be black. Second coating of paint shall be white.

(C) Message Module. Message module shall have two neon gas tubes enclosed. Message module shall be protected by housing made of white acrylonitrile butadiene styrene or polycarbonate plastic and screened message lens made of polycarbonate plastic. Ten-millimeter diameter tube shall be used for "HAND" symbol. Tube used on inside shall be coated with fluorescent material producing desired Portland orange output. Nine-millimeter diameter tube shall be used for "WALKING PERSON" symbol. Tubing shall be coated on inside with fluorescent material producing desired Lunar white output. Tubing shall be formed to approximate shape of "WALKING PERSON" and positioned for maximum Lunar white intensity.

Two neon tubes shall be mounted to plastic housing via resilient rubber adhesive to prevent transfer of mechanical strain to glass tubing and to provide effective shock absorbing mounting. Plastic housing shall be molded to provide positive location of neon tubing in relation to screened message lens.

Message lens shall be of 1/8-inch minimum thickness, clear, U.V. stabilized, refractor-type, and polycarbonate plastic with outer prisms. Lens shall be weather-resistant, craze-resistant, and heat-resistant. Prism pattern (designed as C-4) shall be one that faces outside of module with screened message enclosed within module.

Message module shall be sealed into integral assembly with one-piece sponge, neoprene gasket fitted around perimeter to provide positive protection of neon tubing from handling, weather, and moisture.

Message module shall have electrical contacts that plug directly into
recessed contacts in transformer enclosure when module is in proper position. Message module shall not require use of tools for insertion or removal.

**(D) Case.** Case shall be one-piece, corrosion-resistant, die-cast aluminum alloy that is complete with integrally cast top, bottom, sides, and back. Four integrally cast hinge lug pairs shall facilitate operation of swing open door.

Case for pedestrian signals shall be dust-proof, weatherproof, and corrosion-resistant. Case shall provide for easy access and replacement of components.

Case shall be suitable for post-top or bracket mounting.

Top and bottom of case shall have opening to adjust standard 1-1/2 inch pipe brackets. Bottom opening of signal case shall be furnished with "Shurlock" boss integrally cast into the case. Dimensions of "Shurlock" boss shall be as follows: outside diameter – 2-5/8 inches, inside diameter – 1-31/32 inches, number of teeth – 72, angle of teeth – 90 degrees, depth of teeth – 5/64 inch. Teeth shall be clean, sharp, and provide full engagement. Radial angular grooves of "Shurlock" boss, when used with "Shurlock" fittings, shall provide positive positioning of entire signal to eliminate rotation or misalignment of signal.

**(E) Door Frame.** One-piece corrosion-resistant, aluminum alloy casting doorframe shall be furnished complete with two hinge lugs and two latch slots for each door. Door shall be attached to case by two Type 304 stainless steel spring pins. Two stainless steel hinged bolts with captive stainless steel wing nuts and washer shall be attached to case with use of stainless steel spring pins. Latching or unlatching of door shall require no special tools.

**(F) Z-Crate Visor.** Each signal shall be furnished with Z-crate type visor designed to eliminate sun phantom. Z-crate type sunshield shall be installed parallel to face of "HAND" and "WALKING PERSON" messages. Z-crate visor assembly shall be held in place by stainless steel screws. Z-crate assembly shall be furnished with minimum of 20 straight horizontal louvers and 21 horizontal louvers, each one formed in zigzag pattern.

Every other formed louver shall be reserved to form cells 1-inch square but rotated 45 degrees from horizontal to provide diamond-shaped cells when assembled. Each diamond shall be bisected by insertion of straight louver interspersed between each pair of formed zigzag louvers. If each apex of each formed louver comes in contact with interspersed straight louver, entire length of joint shall be chemically welded. Basic material used in construction of Z-crate visor shall be nominally 0.030 inch thick and 100 percent impregnated black polycarbonate plastic processed with flat finish on both sides.
Assembly shall be enclosed in mounting frame constructed of minimum 0.040-inch-thick aluminum. Frame shall be 1-1/2 inches deep and contain mounting holes for direct insertion in pedestrian signal doorframe.

**(G) Transformers.** Two transformers shall be furnished with recessed secondary contacts and integral Pyrex glass electrode housing. Transformers shall be mechanically locked together, requiring four mounting bolts for mounting entire transformer assembly. Both transformers shall be furnished with 4000-volt, 30-milliampere secondary.

Each transformer shall be furnished with 120-volt (nominal) primary windings and power factor of 90 percent, minimum. Transformers shall nominally require only 39 watts each at 115VAC.

**(H) Fused Switch.** Fused switch shall be furnished inside case on terminal blocks for de-energizing transformer primary circuit. Fused switch shall include two cartridge fuses and lever for disconnecting fuses.

**(I) Painting.** Before final assembly, case, doorframe, and Z-crate visor (aluminum portion only) shall be cleaned and a chromate conversion coating applied inside and out, in accordance with Military Specification MIL-C-5541E. Synthetic enamel, alkyd, semi-gloss, low VOC content, conforming to Master Painters Institute (MPI) Standard No. 94, shall be applied electrostatically. Color shall be same as standard traffic signal head. Finish shall be oven-cleaned for minimum of 20 minutes at 350 degrees F.

**(J) Pedestrian Signal Push Button with Integral Sign.** Pedestrian push buttons shall be tamperproof, weatherproof, and constructed to prevent electrical shocks.

One-half-inch threaded opening shall be furnished at bottom of housing for conduit connection. Raised drip shield shall be furnished around push button.

Sign shall be non-reflectorized and shall conform to requirements of Section 631 – Traffic Control Regulatory, Warning, and Miscellaneous Signs.

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**770.05 Controller Equipment.**

**(A) Controller Assembly.** Controller assembly shall include Model 170E controller, cabinet, and auxiliary equipment. Unless otherwise indicated in the contract documents, only manufacturers and products listed for Model 170E Controller Unit on State of California Department of Transportation (CALTRANS) “Qualified Products List (QPL) for Controller Assemblies for the Model 170/2070 Traffic Controller” shall be acceptable. Copy of QPL is available from City & County of Honolulu, Department of Transportation Services, phone (808) 527-6988.
Testing and quality control requirements shall be as specified in Subsection 623.03(G)(2)(a).

Controller assemblies are described and shall be supplied as follows:

(1) Model 170E controller assembly and Model 332A controller cabinet refers to latest Model 170E controller assembly and Model 332A controller cabinet listed on CALTRANS QPL.

(2) Each controller assembly listed in Table 770.05-1 - Controller Assembly Requirements contains sufficient equipment for full 8-vehicle, 4-pedestrian, and 4-preemption phase intersection, even though the contract documents may not require it.

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<th>TABLE 770.05-1 - CONTROLLER ASSEMBLY REQUIREMENTS</th>
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<tr>
<td>Model 412D prom module</td>
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<td>332A aluminum cabinet</td>
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<td>Model UTS (Non-QPL)</td>
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</table>
(B) Model 170E Controller. Model 170E controller shall meet the following additional requirements:

1. Model 412D PROM module shall include 27256 EPROM chip.

2. Supercap shall replace battery as standby power supply to keep detector amplifier (DTA) and RAM on CPU board powered for at least eight hours during AC power loss.

3. Controller boards shall be mounted vertically.

4. One installation manual shall be submitted with each controller.

5. Documented validation testing shall be performed in accordance with CALTRANS test specifications.

6. Display panel shall be menu-driven.

(C) Cabinet. Each 332A cabinet shall meet the following additional requirements:

1. Cabinets shall be wired for minimum eight vehicle phases, four pedestrian phases, and four preemption phases.

2. Cabinets shall be fabricated from 0.125-inch-thick anodized aluminum.

3. Cabinet’s main breakers shall be rated at 50 amps.

4. Entire output file copper hard-wire shall be of sufficient gage to withstand current surges before circuit breakers or surge protectors trip.

5. LED display for modem transmit, receive, and carrier-detect status shall be clearly visible after opening cabinet’s front door. Indicators mounted on 0.75-inch by 2-inch aluminum assembly shall be attached to top center of cabinet’s rack. Indicators shall derive signals from C2 ACIA. Wires shall be bundled with protective jacket.

6. C2 terminal blocks shall be protected from current surges by EDCO PC642 or equal.

7. Input file and field terminal blocks shall be wired for 3M 752 Opticom Priority Module EVA, EVB, EVC, and EVD.

8. Power supply surge protector shall be furnished.
(9) Front and back fluorescent lights shall be activated upon opening either door.

(10) Convenience ground-fault circuit interrupter (GFCI) receptacles shall be provided.

(11) Door locks shall be of solid brass rim Best Lock Series 516RL3XA7559-606 and includes two keys.

(12) Labeling shall be by silk screening only.

(13) Output file terminal blocks shall be labeled in reference to its assigned phase and signal indications.

(14) One each 24-inch by 36-inch cabinet print shall be attached in weatherproof plastic jacket to front and back cabinet doors.

(15) Documented validation testing of cabinet and conflict monitor shall be performed in accordance with CALTRANS test specifications.

(D) Auxiliary Equipment. Controller unit shall be delivered supplied with the following auxiliary equipment:

(1) Model M752 Optical Preemption Module. M752 shall be card-type and shall interface with Model 170E cabinet preemption slots of input file. Each M752 Module shall have two channels of preemption. M752 shall include firmware to discriminate between two valid priority signals, to prioritize valid same priority signals on a first come, first served basis, and to override low priority signal if high priority is received. M762 Module shall receive input signals (9.639 and 14.035 Hz) to permit priority preemption operation within 170E local intersection program. M762 shall optically isolate output signals and shall trigger active low signal to controller for high priority and pulsed active low signal for low priority. The State’s preemption systems employ the 3M Opticom System. New preemption equipment shall be 3M Opticom or accepted equal that is fully compatible with 3M Opticom.

(2) Universal Time Standard (UTS) Module. UTS Module shall be a stand-alone precision clock, located in controller cabinet. UTS Module shall be used to update internal clock of Model 170E controller by decoding five broadcast frequencies (2.5, 5, 10, 15, 20 MHz) transmitted by WWVH (radio station) of the U.S. National Institute of Standards and Technology. Hardware and software of UTS equipment shall be compatible without modification to Model 170E hardware or software. UTS Module shall meet the following specifications:
(a) 1.5 ms time accuracy.

(b) 2 to 4 minutes time to acquire.

(c) Minimum 5 Frequency, AM, crystal-controlled, dual conversion, super heterodyne receiver, automatic scan 5 frequencies.

(d) Data output RS-232C, 1200 and 2400 baud rate, no parity, 8 data bits, 1 stop bit.

(e) One-hour selectable time zones and daylight saving time option.

(f) 24-hour time format.

(g) Month, day, and year date.

(h) DB25-RS232 and BNC antenna connector.

(i) DB25 to Model 170E C2 cable and connectors.

(j) 2-foot outdoor whip antenna with pole adapter bracket.

(k) 100 linear feet of RG-58 coaxial cable with connectors.

(l) Approximate size: 1-1/2-inch high x 8-inch wide x 9-inch deep; and weight 1-1/2 pounds.

(m) 24 VDC.

(n) Traconex / Multisonics UTS Model 1010 or equal.

770.06 Conductors and Cables. Cables shall conform to IMSA Specification Reference and be certified in writing by IPSA as meeting requirements of the contract documents.

(A) Type 1 - Signal-Loop Cable for Load Circuits from the Cabinet Looped to Field Pullboxes. Polyethylene insulated, stranded, 14 AWG copper; 26 conductor cable; polyethylene jacketed; color-coded; IMSA Specification No. 20-1 certified.

Use one - 26C #14 cable for five phases or less. Use two - 26C #14 cables for six or more phases.

(B) Type 2 - Home-Run Cable Tie-In Loop Detector Stubs or Pedestrian Push Buttons to the Cabinet. Polyethylene insulated, stranded-tinned-copper 14 AWG; two conductor cable; polyethylene jacketed; 600 Volts rated; IMSA Specification No. 50-2 certified.
(C) Type 3 - Inter-Connect Cable Tie-in One Signalized Intersection to Another. Polyethylene insulated, solid copper, 19 AWG; 24 conductor (12 twisted pairs) cable; copper shielded with polyethylene jacketed; 300 volts rated; color-coded; IMSA Specification No. 40-2 certified.

Use one - 12 pairs, #19 continuous run from one controller to the next controller. Splicing between controllers will not be allowed.

(D) Type 4 - Detector-Loop Cable for Installation into the Roadway Sawcut. 12 AWG stranded THHN conductor; 600 volts; inserted into polyethylene tube, 0.25-inch maximum diameter; IMSA Specification No. 51-5 certified.

(E) Type 5 - Signal-Drop Cable from 3-Section, RYG Traffic Signal Heads and FDW-W (Pedestrian Signal Head) Dropped from Signal Head on Traffic Signal Standard to Pullbox for Splicing. Polyethylene insulated, stranded; 14 AWG copper; four conductor cable; 600 Volts, color-coded; IMSA Specification No. 20-1 certified.

Use one - 4C #14 cable for 3-section traffic signal head, programmable signal head, and pedestrian signal head.

Use two - 4C #14 cables for fiber optic signal head.

(F) Type 6 - Electrical Service Cable from Electrical Company Secondary Lines to Traffic Signal Meter to Controller Cabinet. RHW-USE; neoprene insulated; three conductors each; size as indicated in the contract documents; BRW color-coded.

(G) Type 7 - Preemption Detector (Opticom) Cables. Preemption detector (Opticom) cables are specific cables that run continuously from optical detectors mounted on traffic signal standards to terminal blocks for M752 phase module located in controller cabinet. Each detector shall be furnished with its own cable running back to controller cabinet. 3M's M138 Optical Detector Cable shall be furnished for detector cable because it is compatible and consistent with requirements for Opticom Preemption System. M138 cable shall be furnished that is BerkTek Type B, shield jacket, three - insulated conductor cable, 20 AWG, one - 20 AWG bare stranded ground, 600 Volts, orange-blue-yellow color coded and 5/16 inch diameter.

(H) Ground Wire. Ground wire shall be single conductor, sized as indicated in the contract documents, solid electrolytic bare copper medium-hard-drawn, weighing approximately 49.9 pounds per 1,000 feet, and suitable for grounded wire. Conductor shall conform to ASTM B 2.
(I) Overhead Construction. Messenger for overhead interconnect system shall be 0.25-inch, 7-wire strand conforming to ASTM A 475, extra galvanized Siemens-Martin grade with breaking strength of 6,000 pounds. Messenger hangars shall be universal type suitable for 0.25-inch bolts. Use 0.045-inch diameter stainless steel lashing wire. Conductors shall be as indicated in the contract documents.

770.07 Epoxy Sealer. Epoxy sealer shall be high-viscosity, liquid epoxy formulated primarily for use in sealing inductive wire loops and leads imbedded in HMA and portland cement concrete for traffic signal controls and vehicle counters. Epoxy sealer shall be used for repair work on existing spalls, cracks, and other deformations in and around saw cuts, housing inductive loops, and leads. Epoxy sealers shall cure rapidly. Sealant shall be placed on grades up to 15 percent without excessive flow of material.

(A) Composition.

<table>
<thead>
<tr>
<th>TABLE 770.07-1 - EPOXY SEALER COMPONENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Component A</td>
</tr>
<tr>
<td>Epoxy Resin$^1$</td>
</tr>
<tr>
<td>Orthocresol Glycidyl Ether$^2$</td>
</tr>
<tr>
<td>Titanium Dioxide (ASTM D 476 Type III or IV)</td>
</tr>
<tr>
<td>Colloidal Silica$^3$</td>
</tr>
<tr>
<td>Glycerine (ASTM D 1257)</td>
</tr>
<tr>
<td>Silicone Anti-Foam, Type Q</td>
</tr>
<tr>
<td>Component B</td>
</tr>
<tr>
<td>High Functionality Polymercaptan Hardener$^4$</td>
</tr>
<tr>
<td>N-Aminoethyl Piperazine$^5$</td>
</tr>
<tr>
<td>2, 4, 6-Tri (Dimethyl-aminomethyl) Phenol$^6$</td>
</tr>
<tr>
<td>Polysulfide Polymer$^7$</td>
</tr>
<tr>
<td>Colloidal Silica$^3$</td>
</tr>
<tr>
<td>Glycerine (ASTM D 1257)$^8$</td>
</tr>
<tr>
<td>TABLE 770.07-1 - EPOXY SEALER COMPOSITION (CONTINUED)</td>
</tr>
<tr>
<td>---------------------------------</td>
</tr>
<tr>
<td>Carbon Black</td>
</tr>
<tr>
<td>Silicone Anti-Foam, Type Q</td>
</tr>
</tbody>
</table>

3. SiO₂, (moisture-free basis), 99 percent minimum; refractive index, 1.46; surface area, 175-225 square meters per gram; particle size 0.015 microns; pH (4 percent aqueous dispersion), 3.5-4.2; pour density, 2.3 lbs./cu. ft. maximum; free moisture at 105 degrees C., 1 percent maximum.
4. Liquid polymercaptan resin, viscosity 100-130 poise at 25 degrees C; specific gravity 1.14-1.16; mercaptan value, 3.6 meg/gram. Color, Gardner 1933, 1.
5. Color (APHA) 50 maximum, amine value 1250-1350 based on titration that reacts with the 3 nitrogens in the molecule; appearance clean and substantially free of suspended matter.
6. Formula weight 265; specific gravity at 25 degrees C; distillation range 96 percent at 130 degrees C to 160 degrees C (0.5-1.5 mm.); flash point, Tag Open Cup, 300 degrees F minimum; water content 0.06 percent maximum.
7. Specific gravity, 1.24-1.30 at 20 degrees/20 degrees C; viscosity, 700-1200 centipoises, Brookfield at 25 degrees C; pH water extract, 6.0-8.0; moisture content, 0.1 percent maximum; pour point, -15 degrees F; average molecular weight, 1000; flash point, degrees F, Cleveland Open Cup, 390 minimum; sulfur content, percent, 36-40; color, Hellige, 9-12. The product shall be difunctional mercaptan made from 8 mole percent of bis (2-chloroethyl) phenol and 2 mole percent of trichloropropane.
8. Surface area, square meters/gram, 80-150; particle diameter millicrons, 18-30; pH, 7.0-8.5; fixed carbon (moisture free), percent, 96-98; volatile matter, 1-4; oil absorption, stiff past endpoint, cc/gram, 0.75-0.90.
(B) Characteristics of Components.

**TABLE 770.07-2 - EPOXY SEALER COMPONENT CHARACTERISTICS**

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Component A</th>
<th>Component B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viscosity, Poise, Brookfield</td>
<td>100 – 250</td>
<td>100 - 250</td>
</tr>
<tr>
<td>Shear Ratio (minimum)</td>
<td>2.0</td>
<td>1.8</td>
</tr>
</tbody>
</table>

(C) Characteristics of Combined Components.

**TABLE 770.07-2 - EPOXY SEALER COMBINED COMPONENT CHARACTERISTICS**

<table>
<thead>
<tr>
<th>Characteristics</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Gel Time, minutes (minimum)</td>
<td>13 to 18</td>
</tr>
<tr>
<td>On 1/8-inch cast sheet, cured 18</td>
<td></td>
</tr>
<tr>
<td>hours at 77 degrees F ±5 hours at</td>
<td></td>
</tr>
<tr>
<td>158 degrees F.</td>
<td></td>
</tr>
<tr>
<td>Tensile Strength, psi (minimum)</td>
<td>400</td>
</tr>
<tr>
<td>Elongation, percent (minimum)</td>
<td>90</td>
</tr>
<tr>
<td>Shore D Hardness (minimum)</td>
<td>45</td>
</tr>
<tr>
<td>Color of Mixed Components</td>
<td>Color No. 26081 to Color No. 26173 of Federal Standard No. 595B</td>
</tr>
</tbody>
</table>

(D) Directions for Use. Sawcuts shall be cleaned and dried with compressed air to remove excess moisture and debris. For repairing damaged sawcuts, loose, spalled material shall be cleaned away from saw cut, chipping back to sound asphalt concrete or portland cement concrete, and loose material shall be cleaned from loop wires. Mixing ratio by volume shall be one part of Component "A" to one part of Component "B". Only the amount that can be used within 10 minutes shall be mixed from the time mixing operation starts.

**770.08 Hot Applied Rubberized Sealant.** Hot applied rubberized sealant shall be flexible and suitable to seal inductive wire loops imbedded in HMA and portland cement concrete pavements for traffic signal work and vehicle counters. Sealant shall be non-tracking under traffic; and at application temperatures, sealant shall be
a thin, free-flowing fluid that penetrates saw cuts and self-levels to permit uniform
applications. Sealant shall be melted and applied to pavements using pressurized
application unit. Sealant shall be relatively stiff but remain flexible at low pavement
surface temperatures. Test results shall conform to the following:

<table>
<thead>
<tr>
<th>TABLE 770.08 - 1 - HOT APPLIED RUBBERIZED SEALANT</th>
</tr>
</thead>
<tbody>
<tr>
<td>TESTS</td>
</tr>
<tr>
<td>Penetration, 77 degrees F (maximum)</td>
</tr>
<tr>
<td>Flow, 140 degrees F, mm (maximum)</td>
</tr>
<tr>
<td>Resilience, 77 degrees F, percent (minimum)</td>
</tr>
<tr>
<td>Softening Point, degrees F (minimum)</td>
</tr>
<tr>
<td>Ductility, 77 degrees F, cm, (minimum)</td>
</tr>
<tr>
<td>Mandrel Bend, 0 degrees F, 180 degrees 5s, 1/2-Inch Diameter</td>
</tr>
<tr>
<td>Recommended Pour Temperature, degrees F</td>
</tr>
<tr>
<td>Safe Heating Temperature, degrees F</td>
</tr>
<tr>
<td>Viscosity, 375 degrees F, poise</td>
</tr>
<tr>
<td>Unit Weight, pounds/gallon</td>
</tr>
<tr>
<td>Coverage, 1/2-Inch x 1/2-Inch Crack, pounds per 100 foot</td>
</tr>
</tbody>
</table>
770.09 High Performance Detector Loop Sealant. Sealant shall provide environmental protection for loop vehicle detection system wires. Sealant material shall have sufficient compressive yield strength to withstand normal vehicular traffic and shall have sufficient flexibility to withstand normal movement in asphalt and concrete road pavements. Sealant material shall protect loop wire from moisture, penetration, fracture, and shear forces.

(A) General. Sealant shall have the following characteristics:

(1) One-part elastomeric compound requiring no mixing, measuring, or application of heat prior to or during its installation.

(2) Cure only in presence of moisture when within its stated shelf life and when contained in original undamaged packaging. Rate of cure depends upon temperature and relative humidity at time of installation. Cool, dry weather will slow curing; warm, humid weather will accelerate curing.

(3) Flow characteristics that ensure complete encapsulation of wires.

(4) Viscosity such that sealant remains in detector sawcut in sloped roadbed areas during or after application.

(5) Enables vehicular traffic to pass over properly filled 1/4-inch- to 3/8-inch-wide sawcut immediately after installation. Sealant shall not pull out of sawcut during curing.

(6) Exhibits minimal shrinkage during curing.

(7) Sealant shelf life, in undamaged containers when stored below 80 degrees F, shall be as follows:

   (a) Liter ply packs: Nine months after receipt.

   (b) Five gallon pails (containing 4.5 U.S. gallons): 12 months after receipt.

   (c) Gallon drums (containing 50 U.S. gallons): 12 months after receipt.

(8) Permits cleanup with cleaner that shall not threaten or cause harm to workers or environment.

(B) Retention Test. Percent by weight retention test used to measure non-flow properties of one-component sealant shall conform to the following.
(1) Equipment and Materials:

(a) Balance.

(b) Tongue Depressor.

(c) Two ounce ointment cans or equivalent.

(d) One-inch wide masking tape.

(e) Percent retention (aluminum) test fixture.

(f) Becton Dickinson (B-D) 10 c.c. syringe.

(g) Sample of sealant to be tested.

(2) Procedure:

(a) Put strip of masking tape on both ends of test fixture completely covering slot.

(b) Weigh fixture with masking tape.

(c) Stir sample for one minute prior to testing. Test sample of sealant at 75 to 79 degrees F.

(d) Fill syringe with sample and inject sample into test fixture slot.

(e) Scrape off excess sealant from top of test fixture with tongue depressor. Sealant shall fill test fixture slot and shall be level with top of test fixture.

(f) Re-weigh test fixture with sample material filling slot.

(g) Put fixture on top of two-ounce ointment cans and remove masking tape from sides.

(h) Wipe off and discard sealant on pieces of masking tape. Do not discard pieces of masking tape.

770.10 Approach-Only Microwave Vehicle Detector. Approach-Only Microwave Vehicle Detector is vehicle detection unit for computerized signals. System shall detect motion of every vehicle type, including mopeds moving in only one direction, utilizing very low-power microwave beam.

Detector shall have range of 3 feet to 100 feet or greater. Base cone of detector on 16-degree field of view with maximum width of 18-1/2 feet at 60 feet.
Detector shall have field adjustment controls for range control and time delay extension.

Extension timer shall be capable of extending detector output from at least 0.5 to 7.5 seconds. Extension shall begin with termination of detected vehicle output and continue for duration of selected extension time interval.

Microwave unit shall have Federal Communication Commission (FCC) certification. Detector shall operate at frequency of 10.525 GHz as allowed under FCC Rules, Part 15. Detector shall be self-contained, except for power source that shall operate at both 10 VAC to 24 VAC and 12 VDC.

Unit shall have electro-mechanical two-amp, single-pole, double-throw (SPDT) relay that sends signal to controller. The unit shall employ power-failure circuit that closes relay (recall) during power failure.

Detector shall have monitoring circuit for transceiver (Gunn diodes) that shall failsafe relay to closed position (recall). Except for range adjustment, tuning shall be automatic. Five-minute warm-up period for diodes will be allowed. There shall be no tuning controls of any kind that require an operator.

Detector shall function while installed on side of pole, on top of pole, or overhead, at height between 12 to 18 feet above pavement. Each detector shall be encased in finished fabricated aluminum case with no larger than 4-inch square, high-impact plastic opening in front of antenna.

Each detector case shall be water-resistant without use of silicone gels or other materials that deteriorate with ultra-violet rays. Maximum size of detector shall be as follows:

- Height: 4-1/2 inches
- Width: 4-1/2 inches
- Depth: 7-1/2 inches

Mounting bracket shall be furnished for side, top, or overhead mounting. Detector shall be capable of continuous operation over temperature range of -35 degrees F to 165 degrees F.

Detector shall be temporarily mounted on side of existing traffic signal standard, highway light standard, or location accepted by the Engineer. The Contractor shall ensure that detectors are operational before disabling existing pavement loop detectors. Required conductors shall be installed in existing conduits and controller or at location accepted by the Engineer. After permanent pavement loop detectors become operational, microwave detectors and conductors shall be removed and delivered to location accepted by the Engineer. Holes and damage caused by mounting detector to existing traffic signal and highway lighting standards shall be repaired.
The Contractor shall test microwave units to meet FCC specifications. The Contractor shall provide medical statement as to safety of unit to general public, specifically to persons with pacemakers.

770.11 Preemption Detectors.

(A) Description. Preemption Detectors shall be located on traffic signal standards to convert optical signals emitted from an emergency vehicle to electrical pulses for emergency preemption of traffic signals. Electrical signals from optical detector shall be transmitted by 4-conductor cable to preemption module M752 located in input slot of controller cabinet. M752 preemption module shall direct and hold controller in preemption mode until signal disappears. Preprogrammed selection of phases and signal displays shall be controlled by Local Intersection Program. The State’s preemption system employ 3M Opticom System. New preemption equipment shall be by 3M Opticom or equal accepted by the Engineer, that is fully compatible with 3M Opticom. Astro-mini brackets or similar device for attaching preemption detector to poles shall be included.

(B) Materials.

(1) Type 7 Cable. Type 7 preemption detector (Opticom) cables shall be specific cables that run continuously from optical detectors mounted on traffic signal standards to terminal blocks for M752 phase module in controller cabinet. Type 7 preemption detector cable shall be compatible with 3M’s M138 Optical Detector cable and shall be consistent with requirements for Opticom Preemption System. M138 cable shall be BerkTek Type B, shield jacket, 3-insulated conductor, 20AWG stranded copper, 1-20AWG bare stranded ground, 600 volts, orange-blue-yellow color coded, and 5/16-inch diameter.

(2) M752 Optical Preemption Module. M752 Module shall conform to Subsection 770.05(D) - Auxiliary Equipment.

(3) Model 711 Preemption Detector. Optical detector shall be designed and installed for uni-direction signal reception and single channel-phase operation. Signal reception shall be adjustable up to 2500 feet. Detector shall be constructed from high-impact polycarbonate.

END OF SECTION 770