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723-1 STANDARD TRAFFIC SIGNAL HEADS

723-1.01 All the components of standard traffic signal heads shall conform to the latest edition of "A Standard for Adjustable Face Vehicular Traffic Control Signal Heads", published by the Institute of Transportation Engineers (ITE) as modified and supplemented by the plans and these specifications.

723-1.02 Each vehicle signal face shall be made up of the number of separate signal indication sections of the nominal sizes, 200 millimeters (8 inches), 300 millimeters (12 inches), 450 millimeters (18 inches), or 450 millimeters (24 inches), and in the arrangement required by the plans. They shall be of the adjustable type permitting rotation of 360 degrees about a vertical axis.

723-1.03 Each vehicle signal indication section shall consist of the housing, visor, louvers when required, optical unit and necessary wiring. They shall be designed for operation on a nominal 120 volt, 60 Hertz, single phase AC power supply unless otherwise indicated.

723-1.04 Signal heads shall include the slip-fitter adapter, trunions, brackets, backplate and mounting hardware as required by the plans. They shall be designed for a wind speed of 90 mph with a gust factor of 1.3 in accordance with the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signals.

723-1.05 Painting – All metallic heads and mounting attachments shall have three coats of paint each of which shall be baked at the factory after application. The first or prime coat shall be a zinc chromate paint. The second and third coats shall be flat black enamel unless otherwise specified.

723-1.06 Mounting Hardware

a. For span wire mounting the signal head shall be provided with a span wire clamp and wire outlet fitting. The span wire clamp shall be comprised of a shoe, lockbar and two "U" or "J" bolts. A 12 or 18 circuit disconnect hanger shall be supplied if specified in the contract documents. The head shall be assembled so that it hangs plumb. A hot-dip galvanized extension pipe shall be provided for double span wire mounting.

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b. Signal heads for midmast arm mounting shall be furnished with a mount consisting of upper and lower horizontal arms attaching to the top and bottom of the signal head housing. The horizontal arms shall attach to a vertical member which in turn clamps to the mast arm. The mast arm mount shall have provision for adjusting the vertical, angular and rotational positioning of the head in relation to the mast arm so that it is plumb, in line with other signal heads and properly oriented in relation to traffic. Wiring shall be concealed within the mount.

c. Signal heads to be mounted at the end of mast arms shall be provided with an aluminum spring loaded hanger of the design shown on the plans or an alternate design approved by the Engineer. However, when the mast arm exceeds 40 feet in length the end mounting will be of a free swinging design.

d. Post top mounted signal heads shall be furnished with a post top type slipfitter mounting.

e. Vertical pole bracket mount signal heads shall be equipped with upper and lower horizontal brackets equipped with pole plates for attachment to the pole with stainless steel bands.

f. Unless otherwise specified, all bolts, washers and nuts shall be of chromium-nickel stainless steel alloy.

723-1.07 Housing

a. Traffic signal head housings shall be made of die cast aluminum or of structural plastic as specified in the contract documents. When not specified, aluminum housings shall be provided.

b. Aluminum housings shall conform to the following requirements.

1. Aluminum die castings shall be made of ingots in accordance with ASTM B85 - Alloys SC84A, SC84B, SG100A, SG100B, or S12B.

2. Each signal section shall be a one-piece casting with front, sides, top and bottom integrally cast. They shall be clean, smooth and free from flaws, cracks, blow holes and other imperfections.

3. The housing for each face shall be of unitized sectional construction and shall consist of as many sections as necessary to provide

the indications shown on the plan. All sections shall be rigidly and securely fastened together into one weather-tight signal face.

4. Each housing shall be arranged with openings in the top and bottom so that it may be rotated about a vertical axis between waterproof supporting brackets or trunnions and shall be capable of being securely fastened at increments of not more than 7 degrees of rotation. The top and bottom of each housing shall have integrally cast locking rings or other provisions to provide positive interlocking and indexing.

5. The top and bottom of each housing shall be provided with tees or crosses equipped with pipeplug knobs or caps which can be removed to assist in wiring.

6. Flat arms or spiders will be accepted as an alternative for use on the bottom of adjustable signals. One-section adjustable beacons may be supplied without bottom bracket arms.

7. Housings shall be so designed that additional sections may be added. The construction shall permit the assembly of 300 millimeters (12 inch) signal sections with 200 millimeters (8 inch) sections of the same manufacturer. The assembly shall permit the joining of 300 millimeters (12 inch) sections either above or below the 200 millimeters (8 inch) sections.

8. The door shall be of cast aluminum alloy and shall provide mounting for the lens and visor. Neoprene gasketing shall be provided between the body of the housing and the doors. The doors shall be suitably hinged and shall be forced tightly against the gasket and the housing by simple stainless steel locking devices. All other exterior hardware such as hinge pins, lens clips, etc. shall be of stainless steel. The locking device shall be capable of being operated without the use of tools. Hinges shall be arranged to allow convenient relamping. On the outside of the door, there shall be a rim encircling the lens opening to prevent any light leakage between optical systems.

9. The visors shall be separate and removable from the doors, held in place by stainless steel fastenings attached to the door in such a manner as to prevent the possibility of any light leakage between the door and hood which might be discernible from the side. Visors shall be of sheet

aluminum, not less than 0.05 inches, and shall be equipped with bayonet slots or other provision to permit firm attachment and rotation of the visor.

10. Visors shall be the tunnel type. The insides of visors and the entire surface of louvers or fins used in front of signal lenses shall be painted a flat black to minimize light reflection to the sides of the signals. Visors shall tilt down from the horizontal a minimum of 3 ½ degrees and shall be a minimum of 240 millimeters (9 1/2 inches) in length for 300 millimeters (12 inch) diameter lenses and 180 millimeters (7 inches) in length for 200 millimeters (8 inch) diameter lenses.

c. Structural plastic housings shall conform to the following requirements:

1. The signal sections shall be molded in one piece from a polycarbonate material having ultraviolet stability and remaining unaffected by the heat of the lamps used such as G.E. Lexan or approved equal. The sections may be fabricated from two or more pieces if joined into a single piece using thermal, chemical or ultrasonic bonding.

2. The unit shall be molded in a homogeneous color, flat black, unless otherwise specified.

3. Signal housing and door elements shall be nominally 0.100 inch thick, but shall not exceed 3 millimeters (0.125 inch). Stiffening webs and gussets may be 1.5 millimeter (0.060 inch) thick up to 2.5 millimeters (0.100 inch) maximum.

4. The housing of each signal section shall be designed to permit access to the section for relamping without the use of tools. The door shall be secured by a method that will hold the door closed when the section is subjected to the wind load test specified. Metal door hardware, including hinge pins, shall be made from Type 304 or 305 Stainless Steel.

5. Each signal section in a face shall, in addition to the fastening through the housing opening, be joined to the adjacent section with at least 2 stainless steel carriage bolts placed through holes near the front of the 2 housings. Each bolt shall be provided with 2 stainless steel washers, lockwasher and nut.

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6. The supporting section of each signal face supported solely at the top or bottom shall be provided with 2 aluminum reinforcing plates. One plate shall be placed inside the housing; the other plate shall be placed outside. Three stainless steel carriage bolts shall be installed through holes in each of the plates and matching holes in the housing. Each bolt shall have a lock washer and a nut. Each plate shall be a minimum of 3 millimeters (0.125 inch) thick and shall be painted to match the housing. Each plate shall have a hole in line with the mounting hole in the housing; the hole in the outside plate shall be large enough to avoid interference with locking serrations.

7. Tunnel visors shall be thermal formed polycarbonate 1.5 millimeter (0.060 inch) thick in flat black but the inside of the visors shall be painted flat black. Visors shall meet the same dimensional requirements given for metal visors in paragraph 723-1.07b(10) above.

723-1.08 Directional Louvers – Directional louvers shall be installed in signal visors when called for in the plans. The cylinder and vanes shall be constructed of aluminum alloy of the dimensions and arrangement shown on the plans.

723-1.09 Back Plates

a. Backplates shall be furnished and installed on signal heads when shown on the plans. Dimensions, materials and installation details shall be as indicated below unless otherwise specified.

b. Metallic back plates shall be made of flat sheet aluminum with a minimum thickness of 1.5 millimeter (0.060 inch) and provided with a dull black paint finish. They shall be designed to be attached to the signal head without interfering with the opening and closing of the housing doors. Where a metal back plate consists of 2 or more sections, the sections shall be fastened with aluminum rivets or with aluminum bolts peened after assembly to prevent loosening.

c. Plastic backplates shall be either formed from sheet plastic or assembled from extruded, molded or cast sections. Sections shall be joined using appropriate solvent cement or with aluminum rivets and washers. Backplates shall be of black homogeneous colored material with a lusterless finish. Each plastic backplate shall be secured to the plastic signal face in a manner that will prevent its removal or permanent deformation.

d. All backplates for signal heads mounted in mast arms 12 meters (40 feet) or longer shall be of the louvered type. For shorter mast arms and for span wire mountings, the use of louvered backplates is optional.

d. Backplates shall extend 127 millimeters (5 inches) on each side of the signal face and 4 inches on the top and bottom unless otherwise shown on the plans.

723-1.10 Connection Blocks – Each signal face shall be equipped with a 5-point heat resistant terminal block. It shall have five terminals with connectors for receptacle leads and screw terminals for field wires. The individual connection blocks in the separate faces of a signal head shall be interconnected.

723-1.11 Optical Units

a. The optical unit of each vehicle signal indication shall consist of a glass lens, a reflector, a lamp receptacle and a clear traffic signal lamp. The unit shall be properly gasketed to exclude dust and dirt from the reflecting surface of the reflector and the inner surface of the lens. Plastic lenses are not acceptable.

b. Lenses shall be red, yellow, or green glass and shall conform to the ITE standards requirements. Except for reversible lane control signals and pedestrian signals, all lenses shall be circular in shape with nominal diameters of 300 millimeters (12 inch). Each 300 millimeters (12 inch) lens shall be standard wide angle and be clearly marked as such.

c. Reflectors shall be parabolic and mathematically designed to put the filament of the appropriate lamp at the focal point of the reflector. The reflector material will be 1 millimeter (0.036 inch) min. reflector aluminum with a bright specular Alzak finish on the reflecting surface. The reflector shall be hinged with simple holding devices (catches or friction fits) and, when opened, shall expose the rear of the lamp receptacle and the wiring terminal block.

d. The lamp receptacle shall be so mounted that it can be rotated to various positions to permit proper orientation of the lamp filament. The receptacle positioning shall be maintained by the friction of a retaining spring.

e. Traffic signal lamps for 300 millimeters (12 inch) lenses shall be clear, 120 volts AC, 1950 rated initial lumens output, with a rated average life of 8000 hours. Lamps and the intensity and distribution of light from each illuminated

signal lens shall conform to the requirements of the ITE "Standards for Traffic Signal Lamps".

723-1.12 Standard LED Signal Heads and LED Pedestrian Signal Heads

a. Signal indication sections shall consist of the housing, visor, louver, Light Emitting Diode (LED) Traffic Signal Module and all necessary wiring. Signal indication sections shall be designed for operation of 120 volts, 60 Hertz, single-phase AC power supply unless otherwise indicated. Screwed LED modules are not acceptable.

b. LED Signal heads shall include the housing, back plates, visors, louvers when required, LED Traffic Signal Modules, necessary wiring and brackets that support the head on the pole's arm, span wire, post, or as specified on the plans.

c. Traffic signal supports shall conform to section 723-4 Traffic Signal Supports of the PRHTA Standard Specifications for Road and Bridge Construction. Traffic Signal supports shall be designed to withstand wind speeds of 110 MPH with a gust factor of 1.3 in accordance with AASTHO Standard Specification for Structural Supports for Highway Signs, Luminaries and Traffic Signals.

d. Performance Requirements –

1. LED signal lamp units shall meet or exceed all the requirements of the current ITE publication Pedestrian Traffic Control Signal Indications - Part 2: Light Emitting Diode (LED) Pedestrian Traffic Signal Modules and the current ITE specifications for Vehicle Traffic Control Signal Heads: Light Emitting Diode Circular Signal Supplement (VTCSH-EED) and Light Emitting Diode Vehicle Arrow Traffic Signal Supplement, unless otherwise stated in the specifications herein.

2. Use new signal modules units that are of the latest model and currently in production. The equipment shall include manufacturing date, input voltage, 60 Hz cycle, power consumption in watts and a serial number on equipment's back plate.

3. LED modules shall fit into existing traffic signal housings built to VTCSH Standard without modification to the Standard.

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e. Physical and Mechanical Requirements –

1. LED traffic signal head and pedestrian signal head units shall be designed as a retrofit replacement for existing incandescent signal lamps and shall not require any special tools for installation. The retrofit replacement LED traffic signal lamp units shall be designed to fit into existing traffic signal housings built to ITE VTCSH and PTCSI standards without modifications.

2. Installation of a retrofit replacement LED traffic signal module unit into existing signal housing requires only the removal of the existing lens and incandescent lamp. New units fit weather proof securely in the housing door and connect to existing electrical wiring or terminal block by means of simple connectors. Removal of the reflector is required.

3. Identify LED signal module units on the backside with the following information:

i. Manufacturer's name

ii. Part number

iii. Serial number

iv. Voltage rating

v. Power consumption (watts and volt-ampere)

vi. Vertical indexing indicator (i.e., "up arrow", or the word "UP" or "TOP") if specific orientation of the module is required.

vii. Date of manufacture (minimum information required – month and year)

viii. Mark single units as to the type and color of the module (Mark Bi-Modals with module type)

ix. Certification of compliance to ITE standards for color and luminance.

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4. The LED traffic signal module unit shall be a single, self-contained device, not requiring onsite assembly for installation into existing traffic signal housing.

5. Firmly fix signal module to withstand mechanical shock and vibration from high winds and other sources.

6. Use LED traffic signal module units designed for universal installation according to specification 723-4.

7. LED traffic signal module units shall be visible at 137 meters (450 feet) during sway conditions (extended view) until obscured by the visor.

8. LED's for arrow indications shall spread evenly across the illuminated portion of the arrow area and shall have two or three LED lines. Test arrow LED traffic signal lamp units in conformance with ITE LED standards.

9. Arrow LED traffic signal lamp units shall be designed so that when operated over the specified ambient temperature and voltage ranges, the signal is clearly visible and draws attention for a distance of at least 400 meters (1,300 feet) under normal atmospheric conditions.

10. The arrow pattern produced by the Arrow LED traffic signal module units must conform to the VTCSH standard for color, size and shape. Arrow LED traffic signal module units shall not require a specific orientation or have a variance in light output, pattern or visibility for any mounting orientation.

11. Use tinted lenses that match the wavelength (chromaticity) of its corresponding LED's.

12. Lenses of the LED signal module unit shall be capable of withstanding ultraviolet light (direct sunlight) exposure for a minimum period of five years without exhibiting evidence of deterioration.

13. Lenses shall be able to withstand a 1.0 meter (6 inches) drop test, and have a minimum of 3 mm (1/8 inch) thick, free of bubbles and

imperfections. The lenses shall be smooth on the outside with no external facets to prevent build up of dirt and debris.

14. Optical assemblies shall diffuse the light output, provide uniform illumination across the entire surface of the lens, and eliminate the visibility of the individual LED's to the observer. Use an optical assembly for ball modules and as an option on arrow and pedestrian modules.

f. Optical and Light Output Requirements –

1. Use red, yellow, and orange lamps manufactured using AlInGaP (Aluminum-Indium-Gallium-Phosphide) technology or other LED's with lower susceptibility to temperature degradation than AlGaS (Aluminum-Gallium-Arsenic). AlGaS LEDs will not be accepted. Use green lamps manufactured using Indium Gallium Nitride.

2. LED traffic signal module units shall meet minimum laboratory light intensity values, color (chromaticity), and light output distribution as described in specifications 6.4.2.1, 6.4.4.1, 6.4.4.2, 6.4.4.3, 6.4.5, and 6.4.6 of part 2 of ITE's Vehicle Traffic Control Signal Head (VTCSH). The table below replaces the values in Table 1 of Section 4.1.1 of the ITE's VTCSH. The test mentioned in section 6.4.2.1 includes an expanded view for the red and green ball indications with the following minimums for a period of 60 months.

3. The measured chromaticity coordinates of LED traffic signal module units shall conform to the chromaticity requirements of the table below (Table 1), for a minimum period of 60 months.

TABLE 1

Minimum Luminous Values (In Candelas)				
Vertical Angle	**Horizontal Angle (Left/Right)**	**RED**	**YELLOW**	**GREEN**
-17.5	2.5	10	20	20
	17.5	3	7	7
-12.5	2.5	20	41	41
	17.5	14	27	27

-7.5	2.5	54	108	108
	17.5	20	41	41
-2.5	2.5	220	441	441
	17.5	58	115	115
2.5	2.5	339	678	678
	7.5	251	501	501
	12.5	141	283	283
	17.5	77	154	154
7.5	2.5	226	452	452
	7.5	202	404	404
	12.5	145	291	291
	17.5	89	178	178
	22.5	38	77	77
	27.5	16	32	32
12.5	2.5	50	101	101
	7.5	48	97	97
	12.5	44	89	89
	17.5	34	69	69
	22.5	22	44	44
	27.5	16	32	32
17.5	2.5	22	44	44
	7.5	22	44	44
	12.5	22	44	44
	17.5	22	44	44
	22.5	20	41	41
	27.5	16	32	32
22.5	2.5	10	20	20
	17.5	7	14	14

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4. LEDs for arrow indications shall spread evenly across the illuminated portion of the arrow area. Test arrow LED traffic signal module units in conformance with CALTRANS method 606 or similar procedure. Arrow LED traffic signal module units shall be designed so that when operated over the specified ambient temperature and voltage ranges, the signal is clearly visible and attracts attention from a distance of at least 400 meters (1300 feet) under normal atmospheric conditions.

5. The measured chromaticity coordinates of LED traffic signal lamp units shall conform to the chromaticity requirements of the table shown below (Table 2), for a minimum period of 60 months, over an operating temperature range specified in section "D". LED traffic signal lamp units shall meet the minimum requirements for light output for the entire range from 80 to 135 volts.

TABLE 2

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

6. Pedestrian LED signal lamp units shall be designed so that when operated over the specified ambient temperature and voltage ranges, the signal attracts the attention and is readable to a viewer (during both day and night) at all distances from 3 meters (10 feet) to the full width of the area to be crossed.

7. The measured chromaticity coordinates of LED pedestrian signal module units shall conform to the chromaticity requirements of color and associated Figure C of Section 5.3 of the PTCSI (Pedestrian Traffic Control Signal Indicators) standard, for a minimum period of 60 months, over an operating temperature range specified in section "D". LED traffic

signal lamp units shall meet the minimum requirements for light output for the entire range from 80 to 135 volts.

g. Electrical Requirements

1. Each unit incorporates a regulated power supply engineered to electrically protect the LEDs and maintain a safe and reliable Operation. Furnish a power supply that provides capacitor filtered DC regulated current to the LEDs per the LED manufacturer's specification. Design the power supply such that the failure of an individual component or any combination of components cannot cause the signal to be illuminated after AC power is removed.

2. The LED traffic signal lamp unit operates on a 60 Hz AC line voltage ranging from 80 volts RMS to 135 volts RMS. Furnish circuitry that prevents flickering over this voltage range. Nominal rated voltage for all measurements shall be 120 +/- 3 volts RMS.

3. Furnish unit types that are operationally compatible with the traffic signal equipment that each type is designed and intended to interface with. This equipment includes all controllers, conflict monitors, current monitors, switch pack and flashers currently in use by the Puerto Rico Department of Transportation and Public Works (DTOP) and the Puerto Rico Highway and Transportation Authority (PRHTA). Furnish LED traffic signal module units that are operationally compatible with all TS-1, TS-2, controllers, NEMA TS-1 conflict monitors (including NEMA plus features such as dual indication detection and short yellow time detection); NEMA TS-2 Malfunction Management Units. In the case of conflicts between specifications, the latest PRHTA specifications will control.

4. NEMA TS-2 Malfunction Management Units (MMU). The MMU shall comply with the following features.

i. Liquid Crystal display (LCD), show full intersection status with an active red, yellow, and green and walk indicators for each channel. Event log, providing, time, date, and event type plus a replay of the screens prior to any fault.

ii. Record high and low voltage conditions. NEMA 16 channel. Dedicated reset button for simplicity.

iii. Wire the individual LED light sources so that a catastrophic failure of one LED light source will not result in the loss of more than 1 LED light source in the LED signal lamp unit.

iv. Provide two, captive, color coded, 600 V, 20 AWG minimum jacketed wires, 0.9 meters (3 feet) long, conforming to the National Electric Code, rated for service at 105 degrees Celsius (221 degrees Fahrenheit) for an electrical connection.

5. Furnish LED signals that operate with a minimum 0.90 power factor.

6. Furnish LED signals whose total harmonic distortion (current and voltage) induced into an AC power line do not exceed 20 percent.

7. Furnish LED signal module units and associated on-board circuitry that conform to the requirements in Federal Communications Commission (FCC) Title 47, Subpart B, and Section 15 regulations concerning the emission of electronic noise.

8. Furnish LED signal module units that incorporate circuitry to ensure that they show no evidence of illumination for input voltages below 35 volts.

9. Furnish LED signal module units that are illuminated (unregulated illumination) for all input voltages higher than 45 volts AC but less than 80 volts AC.

10. Furnish LED units that have fully regulated illumination for applied voltages of 80 volts through 135 volts AC.

11. Test the intended function of this circuitry by connecting the lamps to a variable voltage source and slowly raising the applied voltage from zero volts up to 135 volts, and then slowly lowering the applied voltage from 135 volts to zero volts.

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12. Furnish and install LED signal lamp units with less than or equal to the base wattage shown below (Table 3) at 77 degrees Fahrenheit (25 degrees Celsius).

TABLE 3

Retrofit	Wattage
12” Red Ball	12 or less
12” Yellow Ball	22 or less
12” Green Ball	15 or less
12” Red Arrow	10 or less
12” Yellow Arrow	9 or less
12” Green Arrow	5 or less

723-3 PEDESTRIAN SIGNAL HEADS

723-3.01 All the components and indications of pedestrian signal heads shall conform to the requirements of the ITE “Standard for Adjustable Face. Pedestrian Signal Heads” as modified and supplemented by the plans and these specifications.

723-3.02 Housing

a. The pedestrian signal head housing shall be constructed of die cast aluminum or of structural plastic as specified in the contract documents. When not specified, aluminum housing shall be provided.

b. Aluminum housings shall conform to the applicable requirements of paragraph 723-1.07b. Painting shall be as specified in paragraph 723-1.05.

c. Structural plastic housing shall conform to the applicable requirements of paragraph 723-1.07c.

723-3.03 Lenses shall be made of vandal resistant polycarbonate or acrylic plastic, square in shape, 9” or 12” on a side, as called for in the plans. Each lens shall be opaque

except for the specified word message or symbol and shall comply with the ITE standards. The message or symbol shall be as indicated on the plans.

723-3.04 Lamps shall be clear traffic signal lamps. For 9" lenses the lamps shall be 120 volts AC, 665 rated initial lumens and with a rated average life of 8,000 hours. For 12" lenses the lamps shall be 120 volts AC, 1950 rated initial lumens and with a rated average life of 8,000 hours.

723-3.05 Each signal lens shall be equipped with a visor which encloses the top and both sides of the lens.

723-3.06 All traffic signal and pedestrian heads shall comply with the following specifications for paint and supply certification to engineer. All interior and exterior parts of the housing, door backplate, and visor shall be pre-body, treated for painting in the following stages: de-grease, rinse, etch with an iron phosphate solution, rinse, final dionized water rinse, and then dry for 10 minutes at 300 degrees Fahrenheit. The parts shall then be painted with a single coat of environmentally safe, ultraviolet resistant, polyester powder coating, which will be applied electrostatically. All housing shall be finished on gloss black except inside of the visor and the backplate shall be painted dull black. The manufacturer shall guarantee the paint quality for 12 months from date of delivery to project. The guarantee and agree to replace promptly without cost of any nature to the Puerto Rico highway & transportation authority during the period of 12 months from date of delivery to project any and all parts failing because of defects in design and/or construction. The warranty for led module shall be 5 years from date of delivery to project and shall be replacing without cost to Puerto Rico highway & transportation authority if any ones fail during this period.

723-4 TRAFFIC SIGNAL SUPPORTS

723-4.01 Traffic signal supports include the following types:

a. Post Top Mount - Aluminum pole for mounting the signal head directly on its top.

b. Bracket Mount - Signal heads and other items bracketed from or attached to the side of an aluminum or concrete pole.

c. Mast Arm - Consist of an aluminum vertical shaft to which a mast arm is attached for mounting signal heads and overhead traffic signs.

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d. Overhead Bridge - Consist of a galvanized steel structure made of two vertical tubular poles and a horizontal tubular cross beam to which are attached signal heads and overhead signs.

e. Span Wire Assembly - Self-supporting standard reinforced concrete or prestressed concrete poles supporting steel cable or cables span to which are attached signal heads and overhead signs.

f. Pedestrian Push Button Post - Galvanized steel pipe support for pedestrian push button signal activator and sign.

723-4.02 The traffic signal support structure of each type shall comprise all the necessary items to provide a complete installation including poles, mast arms, brackets, cables, bases, foundations, hardware, fittings, internal wiring and all other required appurtenances, as per Specification 654 and the contract documents, except for signal heads, signs and pedestrian push button units which are separate units.

723-4.03 Each complete signal support assembly shall be fabricated of the materials called for in the contract documents and shall be designed in accordance with the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signs (hereinafter referred to as the AASHTO Signal Support Specification), the details shown on the plans, and the requirements of these specifications. Each assembly, including the signal heads, signs and other mounted equipment shall be designed to withstand 90mph wind loads, with a gust speed factor of 1.3, without permanent deformation, rupture, or other structural failure. Ice loads need not be considered.

723-4.04 Shop drawings and structural design computations for each traffic signal support structure shall be submitted for review and approval by the Authority prior to purchase.

723-4.05 Aluminum for the various components of signal support structures shall conform to the applicable ASTM specifications and Aluminum Association designations for aluminum alloys identified as acceptable in the AASHTO Signal Supports Specification.

723-4.06 Aluminum mast arm and pole assemblies shall comply with the following requirements:

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a. The mast arm and pole assemblies shall be designed to support clevis or rigid mounted traffic signals suspended from a structural assembly similar in appearance and construction to that shown on the plans and as specified herein.

b. The pole shaft shall be designed for mounting with or without a transformer base, as called for in the plans, and shall be made of ASTM Specification B221, aluminum alloy 6063, seamless tubing of sufficient diameter and wall thickness to properly withstand full design loads. The shaft shall be fabricated of tubing with a wall thickness of not less than 0.188" and the top and bottom of the shaft shall be a constant diameter to provide vertical adjustability of the arm and proper fitting of the base as required. After welding, the shaft shall be artificially aged to a T6 temper by means of heat treatment. It shall be free of longitudinal welds and shall be rotary sand finished and wrapped for protection during handling and shipping. The shaft shall be designed to support the mast arm in such a way that, when a traffic signal head is mounted at the end of the mast arm, the bottom of the signal head shall be 17 to 19 feet above the pavement. In addition:

1. Shafts to be mounted without a transformer base shall be equipped with a 4" x 6" oval shaped reinforced handhole as per ARTBA Technical Bulletin 270, centered 14" to 18" above the base of the shaft and located 90 degrees measured clockwise from the plane of the bracket arm as viewed from the top. Each handhole shall have an aluminum cover with stainless steel attachment screws to secure the cover. A grounding nut to accommodate a 1/2" threaded bolt shall be provided inside the shaft opposite the handhole.

2. A removable ornamental cast aluminum cap with three stainless steel (AISI 302) set screws to hold it in place shall be provided with each shaft.

3. A 1 1/2" diameter hole shall be drilled near the top of each shaft where the mast arm clamp is to be attached to provide for the signal wiring. This opening shall have a rubber or metal grommet to provide a smooth cable guide for pulling the electrical cables through.

4. The shaft anchor base shall be a one piece casting of 356-T6 aluminum alloy and shall be shop welded to the shaft.

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c. Aluminum transformer bases, when called for in the plans, shall be one-piece castings of 456-T6 aluminum alloy (ASTM B 26) of the dimensions shown on the plans and meeting the structural requirements specified in the AASHTO Signal Support Specifications. Bases shall be equipped as follows:

1. With a removable aluminum, trapezoidal shaped door, approximately 12” high, 9” wide at the top and 11” wide at the bottom. Door shall be secured to the base with stainless steel screws.

2. For attachment to shaft anchor base, each transformer base shall be supplied with four (4) loose bearing plates or other acceptable bearing surfaces and four (4) hot-dip galvanized high strength steel (ASTM A 325 - Type 3) hexhead machine bolts of the size needed to meet the structural design requirements but not less than 1 1/4” diameter.

3. With a grounding connection to accommodate a 1/2” threaded bolt or nut.

4. A template print giving complete information for setting the anchor bolts in the foundation.

d. Anchorage in the foundation shall consist of four hot rolled steel rods meeting the requirements of AASHTO M 255 (ASTM A 675) Grade 90. The threaded end shall be hot-dip galvanized for a minimum length of 12 inches. Hot-dip galvanized steel hex nuts, flat washers and lock washers shall be provided for each anchor bolt. Anchor rods shall be of the size and length required to meet the structural design requirements but not less than 1 1/4” diameter and 36” long.

e. The mast arm shall be a one piece welded assembly manufactured of 6063-T6 aluminum tubing and consisting of top and bottom members joined by vertical braces.

1. The mast arm assembly shall conform to the space and dimensions shown on the plans.

2. Clamps made of 6063-T6 or 6061-T6 aluminum shall be provided at the inboard end of the arm for attachment to the support pole.

3. Mast arms 40 feet or less in length shall be provided with a 2” slipfitter at the free-end for a fixed traffic signal head installation.

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4. Mast arms longer than 40 feet shall have a signal hanger strap welded at the outboard or free end for the installation of a free swinging traffic signal head. The upper arm member with the welded signal hanger shall have a 1 1/2" diameter hole lined with a rubber grommet forward of the hanger strap and the arm clamps at the inboard end shall have a smooth 1 1/2" diameter hole to allow the use of the mast arm as an internal raceway for the traffic signal wiring. The lower arm member shall have a safety chain lug for the traffic signal welded at the outboard end but inward of the hanger.

5. The outboard end of both the upper and lower arm members of a free swing installation (over 40 foot arms) shall be cupped. On fixed signal installations, the arm member not used for the signal mounting shall be capped.

6. Extruded aluminum clamps of alloys 6063-T6 or 6061-T6 shall be provided for attaching the mast arm to the shaft as shown on the plans. Clamp bolts, washers and nuts shall be of AISI Type 302 stainless steel of the required diameter to meet the structural design requirements.

f. Aluminum poles and mast arms shall be furnished with a polished surface finish and shall be wrapped with heavy water resistant paper by the fabricator for protection during shipping, storage and erection.

723-4.07 Aluminum poles for post top mounted traffic signal heads shall meet all the applicable requirements of paragraphs a, b, c, d and f of Article 723-4.06 above. In addition the pole shall be round in cross section with a uniform diameter of approximately 4 1/2" from butt to tip.

723-4.08 Steel overhead bridge structures shall comply with the following requirements:

a. Steel for the end poles and the cross beam shall be Grade 60 high-strength low alloy structural steel meeting the requirements of paragraph c. and d. of Article 715-1.01 of Specification 715 – Structural Metals. All steel shall be galvanized after fabrication in accordance with the requirements of AASHTO M 111.

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b. Steel bolts, washers and nuts shall be high-strength and hot-dipped galvanized meeting the requirements of AASHTO M 164 and M 111, and Article 715-2 of Specification 715.

c. End poles shall be either continuous or sectionalized. They shall be round in cross section and evenly cambered from one end to the other. Each pole shall include a removable pole top, and J-hook wire support welded inside near the top and one pinned joint assembly to match the butt end of the crossbeam. A reinforced handhole assembly, curved on the front to follow the contour of the pole, shall be welded into the shaft near the base of the pole which contains the controller. The handhole frame and cover shall be of gauge 11 steel having the same properties as the pole steel. The handhole reinforcing frame shall have a tapped hole to accommodate a grounding lug and the cover shall be secured to the frame by at least two stainless steel screws and a stainless steel captive chain. Each pole shall have a one piece anchor base welded to the butt end. This base shall be designed to secure the pole assembly to a concrete foundation by means of four L-bent anchor bolts, and shall be fitted with removable anchor bolt covers.

d. The crossbeam shall be a flexible member with a beam splice at the midpoint and connected to the upright end poles by pinned joints which shall not transmit any bending moments. Crossbeams shall be round in cross-section and shall be cambered to minimize sag. The entire assembly shall be constructed so that all wiring can be concealed internally. The crossbeam shall be connected to the upright poles at a height necessary to provide the specified clearance between the attached signal heads and/or signs and the highest elevation of the traveled roadway.

723-4.09 Self-supporting concrete poles for span wire assemblies shall conform to the design and details shown on the plans.

a. Concrete shall conform to the requirements of Specification 601 - Structural Concrete for the class indicated in the contract documents. When the concrete class is not specified, Class D concrete (5,000 psi) shall be provided.

b. Prestressed concrete poles shall conform to the requirement of Specification 630 - Prestressed Concrete Structure.

c. Reinforcing steel shall conform to Specification 602.

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723-3.10 Steel cable for span wire assemblies shall be either of the following, at the Contractor's option, unless otherwise specified in the contract documents.

a. Zinc-coated steel wire strand or cable conforming to the requirements of ASTM A 475 and, unless otherwise specified, meeting the requirements for the use listed below.

1. Strand for use as tie cables shall be seven wire "Common" grade with a Type "I" zinc coating.

2. Strand for use as span wire, messengers and guy wire shall be 3/8 inch diameter, seven wire, "High-Strength" grade cable with a Class "A" zinc coating.

3. Strand for use as traffic signal tie wire shall be 1/4 inch diameter, seven wire "Siemens-Martin" grade cable with a Class "A" zinc coating.

b. Aluminum-coated steel wire strand or cable shall conform to the requirements of ASTM A 474 and unless otherwise specified shall meet the strength grade requirements above.

723-3.11 The support post for pedestrian push button units shall be fa-bricated from 4-inch outside diameters, hot-dipped galvanized steel pipe meeting the requirements of ASTM A 120. The pipe shall have a nominal wall thickness of no less than 0.203 inch. It shall be furnished with a cap and the necessary openings to attach the push button detector and to permit the wiring.

723-5 INDUCTIVE LOOP VEHICLE DETECTOR SYSTEMS

723-5.01 An inductive loop vehicle detector system consists of a sensor loop or loop wire embedded in the pavement, a splice between the sensor loop lead-in wire and the lead-in cable running to the terminal strip in the controller cabinet, and the loop detector unit.

723-5.02 Sensor Loop - An electrical conductor wire loop or group of loops embedded in the roadway. The sensor loop wire for detectors shall be No. 14 RHW, cross-linked polyethylene insulated, stranded copper wire, rated at 600 volts and conforming to International Municipal Signal Association IMSA Spec No. 51-3.

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a. Precast Slab – A sensor loop prewound a specified number of turns, embedded in a heavily reinforced precast concrete slab.

b. Loop Wire – A sensor loop wound a specified number of turns, implanted in a saw cut under existing pavement.

c. Preformed Loop - A sensor loop prewound a specified number of turns, enclosed in a water-tight heavy wall PVC pipe, implanted in a saw cut under existing pavement, or under an asphalt or concrete overlay.

723-5.03 Lead-in Cable - Connect the two conductor lead-in cable to the terminal strip in the controller cabinet. The lead-in cable shall be stranded tinned copper conductors, polyethylene insulated, polyethylene jacketed cable conforming to the latest edition of International Municipal Signal Association specification IMSA Spec No. 50-2. The cable shall be AWG No. 14 shielded two conductor twisted pair wire.

723-5.04 Loop Detector Unit – The Loop detector unit shall meet the following requirements:

a. The loop detector unit for an inductive loop detector system shall be a solid state electronic device capable of providing closure and amplification of an output circuit when a vehicle stands or passes over a loop, or one of several loops, connected to its input circuitry. The unit shall meet the performance and design requirements for Inductive Loop Detectors with Delay and Extension Timing included in the latest edition of the NEMA Standards Publication for Traffic Control Systems.

b. The detector unit shall be type NEMA, shelf or rack mounted. It shall have NEMA connectors and output relay. The unit shall be a 1-channel for shelf mounted type or 2 channel for rack mounted type. If not specified in the plans, 2 channel rack mounted units shall be used.

c. Each shelf mounted unit shall be housed in dust proof sheet aluminum or other non corrosive metal enclosure with a durable protective finish. The enclosure shall be easily removed to permit access to the solid-state circuitry. All controls, indicator lights, meters and connectors shall be mounted on the front panel.

d. Shelf mounted loop detector units shall be provided with an integral 120 volts, nominal, AC power supply, and shall function normally over a power

voltage range of 100 to 130 volts. Input power shall be provided with overcurrent protection.

e. The output relay shall be of the plug-in type and shall be normally energized to provide fail-safe operation in the event of power failure. It shall also provide that when two sensor units are operated into one phase of a signal controller, almost simultaneous actuations from the two sensor units shall be separated to provide maximum detection accuracy.

f. The detector unit shall be capable of self-tuning to loop inductances within a range of 50 to 700 micro henries. It shall provide output closures for each vehicle passing through the response area of the detector loop at speeds from 5 to 80 mph.

g. Each detector unit channel shall be capable of providing a minimum of two modes of operation, Pulse Mode or Presence Mode.

1. Pulse Mode – The loop detector unit shall produce an output pulse of between 75 and 150 milliseconds duration for each vehicle entering the detection zone. Any vehicle stopped on the loop for 2 seconds or more shall be automatically tuned into the resonant circuit so that any unused portion of the loop may detect passing vehicles.

2. Presence Mode - The unit shall provide a detection output for as long as a vehicle remains in the detection area or for at least three minutes after which it shall be incorporated in the background inductance so that any unused portion of the loop may detect passing vehicles.

723-6 PEDESTRIAN PUSH BUTTON DETECTORS

723-6.01 A pedestrian push button detector assembly shall consist of the housing, the electrical contacts unit, the push button, and sign. The complete assembly shall be capable of completing an electrical circuit to the traffic controller to which it will be connected.

723-6.02 The housing shall be of cast aluminum, tamper proof, weather proof and so constructed that it will be impossible to receive any electrical shock under any weather conditions. In addition:

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a. It shall have two outlet taps for one-half inch pipe for wiring.

b. When intended for mounting on top of a post support, it shall be provided with a slip-fitter fitting and screws for securing rigidly to the post.

c. When intended for mounting attached to a pole it shall be of a design, or be provided with adaptors, to facilitate mounting securely on poles of different diameters. Saddles shall be provided to make a neat fit when required.

d. The housing shall be finished with three coats of paint which shall be baked at the factory after application. The first or prime coat shall be zinc chromate paint. The second and third coats shall be flat black enamel unless otherwise specified.

723-6.03 The contacts unit shall be entirely enclosed within, but insulated from, the housing. The contacts shall be open in normal position, closing only when the push button is depressed and returning to the open position upon release.

723-6.04 The push button shall be a direct push type sealed with a rubber membrane. The exposed exterior of the button shall be made of brass or other non-rusting alloy, or other durable material acceptable to the Engineer.

723-6.05 The sign may be either reflectorized or non-reflectorized with a legend and of the size shown on the plans, and in accordance with the DTPW's manual of uniform traffic control devices. It shall include the necessary mounting hardware.

723-7 LOCAL TRAFFIC SIGNAL CONTROLLER ASSEMBLY

723-7.01 Description - A local traffic signal controller assembly shall consist of a complete electrical mechanism for controlling the operation of traffic control signals, including the controller unit and all necessary auxiliary equipment, mounted in a cabinet. All the equipment required to provide the operation shown on the plans and described herein shall be provided in a complete assembly.

723-7.02 General Requirements - The controller assembly shall be modular, microprocessor controlled, fully traffic actuated, solid state in design and shall conform to the interface, physical and functional standards for two-phase through eight-phase solid state traffic signal controller units included in the NEMA Standards Publication for

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Traffic Control Systems, TS2 and ATC, latest edition, as supplemented and modified by these specifications.

a. Controller assemblies shall be furnished in a 16 channel chassis with a full complement of 16 channel modules, unless otherwise specified in the plans.

b. Only one type of controller unit, all from the same manufacturer, shall be installed, unless otherwise specified in the plans.

c. The type and make of controller assemblies to be installed shall have an experience record of satisfactory field operations in Puerto Rico or other US DOT, for at least six (6) months. The manufacturer shall submit data indicating locations and owners of previous installations to support the experience record.

d. All controller equipment and accessories to be supplied for an interconnected system shall be designed to insure full compatibility and interface of the master and secondary controller assemblies in the system.

e. Details of operation for the controller assembly shall be in accordance with the traffic phases, preferential phase sequence and concurrence, signal indications, signal indication sequence, detection requirements and other details specified in the contract documents.

f. Shop drawings and manufacturer's specifications on all the controller assembly equipment shall be submitted by the Contractor to the Authority for review and approval prior to purchase.

g. The Contractor shall submit to the Authority with each controller assembly three copies of each of the following documents which shall be furnished by the equipment manufacturer:

1. Dimensional, schematic and wiring diagrams.

2. Parts list.

3. Engineering data

4. Operations and Maintenance instructions.

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723-7.03 Controller Environmental Standards - The controller shall perform satisfactorily within the environmental and operating conditions specified in NEMA TS2 and ATC. The Contractor shall submit certification by the equipment manufacturer that the controller units comply with this requirement. In addition, the Authority may require the submittal of reports on TS2 and ATC tests performed by the manufacturer on sample units.

723-7.04 Controller Unit Interface Requirements - The controller shall comply with the interface standards specified in NEMA TS2 and ATC, including all the requirements on input-output electrical characteristics. Each unit shall be provided with the number of input/output terminals and pin connections specified for sixteen (16) phase controllers including the terminations indicated as reserved for future use and spares. Identification of pin connector terminations shall be as specified in NEMA TS2 and ATC.

723-7.05 Controller Unit Physical Standards - The controller shall comply with the physical standards on modular design, printed circuit assemblies, connectors and frame sizes specified in NEMA TS2 and ATC and the following additional requirements:

a. All active devices used for logic, timing or control functions shall be solid state in design, and shall be sufficiently derated to insure no material shortening of life under conditions of maximum power dissipation at maximum ambient temperatures.

b. Modular plug-in assemblies shall have a mean-time-to-failure of not less than three years. The design life of individual components under 24 hours per day operation in the circuit application shall not be less than five years.

c. All vehicle control elements or pedestrian control elements, or both, shall be directly interchangeable between controllers. Each element shall have a part number, serial number, and function description permanently attached on the equipment's main chassis.

d. The controller shall be designed with slide-ways and positive locking devices to insure proper pin alignment and pin contact area.

e. All solid state equipment shall be designed to prevent dust or dirt from entering the enclosed solid state components.

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723-7.06 Controller Functional Standards - The controller shall comply with the functional standards applicable to basic 8-phase units which are included in NEMA TS2 and ATC including the capability to provide all the specified features per phase, per ring and per unit.

a. Each phase shall have identical control capability, features, and options. The options and features for each phase may be exercised independently of the options and features exercised on other phases.

b. The time shall be displayed in seconds and tenths of seconds to be compatible with the interval assigned increments.

c. Each traffic signal phase shall have available the options indicated below which shall be selectable by keyboard on the front panel of the controller.

Vehicle Recall	Non-lock Detector Memory
Pedestrian Recall	Recall to Maximum

d. LED indicators or indications on a backlit Liquid Crystal Display (LCD), shall be provided within the controller assembly and appropriately labeled to facilitate the determination of the operation of the controller unit. These indications shall consist of the following as a minimum requirement:

1. Phase or phases in service

2. Phase or phases next to be serviced

3. Presence of vehicle call including memory and detector actuations

4. Presence of pedestrian call

e. The following interval information shall be displayed for the phase in service on a per ring basis:

1. Minimum green

2. Passage time

3. Yellow clearance

4. Red clearance

5. Walk

6. Pedestrian clearance

7. Reason for termination (gap-out, maximum timed out, force-off)

8. Rest state (dwell)

f. The controller's timing, decision making and control elements shall be run by a microcomputer system which will store the computer programs and data necessary to operate the unit, a clock generator that provides computer system real-time clock for traffic system timing, flexible input/output circuitry that provides interface to traffic sensors and signals.

723-7.07 Cabinet Construction - The controller assembly shall be housed in a weatherproof cabinet mounted on a concrete pedestal base and conforming to the following requirements:

a. Cabinet shall be fabricated from sheets of aluminum alloy, ASTM 6061-T6, 0.125 inch thick, adequately reinforced to provide a sturdy structure. It shall have the following minimum inside dimensions unless otherwise shown on the plans:

Width - 52" Height - 56" Depth - 15"

b. The cabinet exterior and interior shall be bare aluminum.

c. The main door of the cabinet shall substantially cover the full area of the front of the cabinet. This door shall be right hand hinged and permit complete access to the cabinet interior.

1. A weatherproof and dustproof seal shall be provided between the door and cabinet using neoprene sponge or other approved gasket material.

2. A door stop shall be provided for base a mounted cabinet which securely holds the door at open positions of 90 and 135 degrees.

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3. The door hinge pins shall be made of stainless steel.

4. The door shall be equipped with a keyed tumbler lock and two keys shall be provided.

5. An auxiliary police access, weatherproof design shall be provided on the front of the main door equipped with a standard police lock furnished with two keys.

d. The cabinet shall contain a minimum of two removable shelves securely fastened to the side walls. The height and position of the shelves shall be easily changed.

e. The cabinet shall be provided with a ventilation system as follows:

1. A thermostatically controlled, ducted fan unit with a minimum rating of 100 CFM in free air installed in the cabinet to provide forced air ventilation through the cabinet. The fan unit shall be mounted to the inside top of the cabinet and shall be easily removed and replaced without having to dismantle any part of the cabinet or exhaust duct systems.

2. The fan shall be manually adjustable to turn on between 90ºF and 150ºF. The fan circuit shall be fused at 125% of the capacity of the fan motor.

3. The fan shall intake air through filtered vents located near the bottom of the cabinet or cabinet door and exhaust it through a screened duct located near the top of the cabinet. Filter shall be of the permanent aluminum mesh type.

4. The fan shall be separately fused and wired after the main AC circuit breaker.

f. The cabinet shall be furnished with all of the hardware necessary for assembly and installation. The hardware shall include anchor bolts, anchor bolt template, and all nuts, bolts and washers necessary to assemble and install the cabinet as specified in the plans. A pliable seal, composed of non-hardening silicone sealant, shall be placed between the controller cabinet and the concrete base.

g. A heavy-duty clear plastic envelope, securely attached to the inside wall of the cabinet or cabinet door, shall be provided for stowing cabinet electrical prints. Minimum dimensions shall be 9" wide x 11" deep.

723-7.08 Cabinet Electrical Design

a. The controller and all auxiliary equipment housed within the cabinet shall be designed to operate from nominal 115V, 60 Hertz AC, single-phase power supply. Distribution of the electrical current throughout the cabinet shall not occur until it has first passed through the power protection devices specified herein.

b. Power Protection Devices - Shall include the main power circuit breakers, radio interference suppressors, lightning and surge protectors, and auxiliary equipment circuit breaker. These devices shall be in addition to any protection devices furnished with the controller and auxiliary equipment housed within the cabinet. The protection devices shall be mounted in a power distribution panel that is securely fastened to an interior wall of the cabinet.

1. The power service shall be connected directly to a main circuit breaker. This circuit breaker shall be a single pole, nonadjustable, magnetic breaker rated for 115V operation with a minimum rating of 60 amps. It shall be equipped with a solderless connector suitable for terminating No. 6 AWG wire. The circuit breaker shall be capable of manual operation and shall be clearly marked to indicate the "ON" and "OFF" positions.

2. Radio interference suppressors (RIS), adequate in number to handle the power requirements for the cabinet, shall be wired in series with and after the main circuit breaker. The RIS shall be designed to minimize interference in all broadcast, transmission and aircraft frequency bands.

3. As a minimum requirement, the lightning and voltage surge protectors shall be a combination of gas-type thyrectors, rated for 350 volts operation, and metal oxide varistors, rated for 150 volts. The combination shall be wired in advance of the main circuit breaker and shall provide a direct path to ground. Additional protection shall be provided on all loop detector input terminals.

4. Auxiliary equipment circuit breaker shall be rated at 15 amperes.

c. The power distribution panel shall also include:

1. A copper equipment grounding bus bar which shall be grounded to the cabinet and shall provide a minimum of 14 terminals.

2. A neutral bus bar isolated from cabinet ground and providing a minimum of 18 terminals.

3. A 60 amp mercury contactor power relay which shall be normally closed but capable of switching 60 amperes at 120 volts AC.

d. The regulated portion of the power supply shall furnish a voltage of sufficient amplitude to provide an adequate DC NOISE MARGIN to prevent transient voltage spiked from triggering components, internal to the controller, into conduction.

e. Cabinet Wiring - All cabinet wiring shall be neat, firm and routed to minimize cross talk and electrical interference. Printed circuit other boards may be used to eliminate or reduce cabinet wiring.

1. Wiring shall be attached to interior panels using non-conductive clamps or tie-wraps. Wiring containing AC shall be routed and bundled separately by function, from all low voltage control circuits.

2. All conductors and live terminals or parts which could be hazardous to maintenance personnel shall be covered with insulating material with a minimum rating of 600 volts.

3. The cabinet shall be wired for the maximum operation of the control unit including overlap and pedestrian phases. It shall only be necessary to add plug-in cabinet accessories (i.e. load switches, flash transfer relays, etc.) to obtain future operation.

f. Terminal Block Facilities - Molded composition barrier type terminal blocks shall be used for termination of the incoming and outgoing signals within the cabinet assembly. Each terminal block shall be one-piece construction with a minimum of twelve terminals. Each terminal shall have a threaded contact plate

with a binderhead screw. The terminal blocks shall have minimum rating of 600 volts.

1. All terminals shall be identified and labeled in accordance with the cabinet wiring diagram.

2. The terminal block facilities shall be arranged in function groupings and mounted to either panels or brackets fastened to the interior walls of the cabinet. Each terminal block shall be retained using either machine or self-tapping screws and shall be easily removed and replaced.

3. Terminals shall be provided for the vehicle and pedestrian signal circuits for each phase. These terminal blocks shall be of the barrier type using No. 8 or larger binderhead screws. These terminal blocks shall be located near the bottom of the cabinet, a minimum of six inches above the bottom surface for base mounted cabinets and two inches for pole mounted cabinets. A minimum number of two additional terminal blocks shall be provided for future expanded operation.

4. Terminals shall be provided and connected for all of the controller input and output circuits including those circuits which are not to be used on the project. These terminal blocks shall utilize No. 6 or larger binderhead screws.

5. A special panel shall be provided with terminal blocks for terminating all circuitry associated with vehicle detectors and pedestrian push buttons. These circuits shall be wired to their respective termination points within the cabinet and shall be operational. These terminal blocks shall use No. 8 binderhead screws. Terminals shall be provided for each vehicle detector including AC+, AC neutral, relay common, relay closure, and the loops or probes from the field. Solid state lightning protection devices shall be provided for each loop input from the field. A minimum number of two additional terminal blocks shall be provided for future expanded detection. Terminals shall be provided for each pedestrian pushbutton circuit from the field.

g. Detector Connecting Cables - The cabinet shall be furnished with loop amplifier connecting cables for controller phases as required by each controller as per NEMA TS2 and ATC standards.

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h. Polarity of Electrical Circuits - The outgoing signal indication conductors shall be of the same polarity as the line (+) side of the AC field service to the cabinet. The incoming signal indication conductors shall be common and of the same polarity as the neutral (-) side of the AC field service. The neutral (-) side of the AC field shall be connected to the cabinet in an approved manner usually to the copper ground bus. The cabinet shall, in turn, be connected to an earth ground through a ground rod.

i. Maintenance Panel - On the inside of the main door, accessible only when the main door is open, there shall be mounted a maintenance panel containing the following:

1. A stop time switch which shall be a three position toggle switch labeled ON, OFF and AUTO. In the ON position, stop timing power shall be applied to the controller. In the OFF position stop timing shall be removed from the controller if it has been applied by the conflict monitor or other auxiliary device. The AUTO position shall be the normal operating position and allow auxiliary devices to apply stop timing inputs to the controller.

2. A signals switch which shall be a two position toggle switch labeled ON and OFF. In the OFF position all signal displays shall be turned off and the controller allowed to run, subject to the position of other cabinet switches.

3. A controller test switch which shall allow the controller to be turned on for test purposes when the “AUTO-FLASH” switch on the Police panel has been placed in the “FLASH” position. The switch shall be labeled “CONTROLLER”, “TEST”, “NORMAL”.

4. Detector test switches which shall be used to manually place calls into the controller during actuated operation. These switches, one for each vehicle and pedestrian phase, shall be in parallel with the vehicle detector relay closure and pedestrian pushbutton circuits.

j. Convenience Outlet - A 3-wire ground fault type receptacle shall be provided at an easily accessible location. It shall be separately fused and wired in advance of the main AC circuit breaker.

k. Cabinet Illumination - An incandescent lamp, 60 watts, shall be provided near the top of the cabinet interior with a manual switch mounted on the maintenance panel.

723-7.09 Other Cabinet Auxiliary Equipment

a. Conflict Monitor - A self-contained solid state signal conflict and voltage monitor, meeting the standards included in NEMA TS2 and ATC, and capable of handling an 8-phase controller.

4. The unit shall monitor the green, amber, and walk of each phase, and be fully programmable to designate the conflicting phases. All monitoring shall be done on the field side of the cabinet field wiring terminals.

5. When the monitor is triggered as a result of sensing conflicting indications, it shall place the intersection into emergency flash and store and display the conflicting indications at the moment of conflict on the front of the unit. The monitor shall retain these operations until reset by a front panel push-button.

6. When the monitor is triggered as a result of sensing a supply voltage error, it shall place the intersection in emergency flash and retain this operation until reset by the front panel pushbutton or restoration of proper power.

b. Solid State Load Switches - The interface between the controller and the vehicle and pedestrian signals shall be accomplished with triple-signal solid state load switches which shall meet the requirements specified in NEMA TS2 and ATC. The controller cabinet shall be provided with twelve load switches wired to provide eight vehicle phases and four pedestrian phases. Each load switch pack shall have a dust proof metal cover enclosing all electrical parts and provided with a handle for easy removal.

c. Solid State Flasher - The cabinet shall be furnished with a dual circuit solid state flasher conforming to the standards included in NEMA TS2 and ATC. It shall be used for the alternate opening and closing of connections between the applied power and the signal lamps required for flashing operation. The unit shall commence flashing operation when AC power is applied to the input terminals. It shall be rated for 10 amperes unless otherwise specified.

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d. Power and Flash Transfer Relay Assembly - The controller assembly shall contain electromechanical relays used to manually transfer AC power and operation from the controller and load switches to the solid state flasher. This transfer relay assembly shall be controlled by either the "AUTO-FLASH" mode switch located on the Police Panel or the conflict monitor. The flasher shall remain operational with the controller removed from the cabinet.

1. The cabinet shall be wired to flash amber for the main street and red for the cross streets. The red-yellow-flash indications shall be easily changed with simple tools such as a screwdriver.

2. The plug-in transfer relays shall be enclosed in a transparent case for protection against dust and for visual observance of operations. They shall be insulated or so located that electrically live parts are not readily exposed.

3. All contact points which make, break and carry current to the signal lamps shall be of silver-cadmium, coin silver or equivalent materials. Contacts shall be capable of making, breaking, and carrying a current of 10 amperes, 120 volts, without undue pitting. Relay coils shall be designed for continuous duty.

4. The transfer relay shall withstand a potential of 1500 volts at 60 Hertz between insulated parts, and between current carrying parts and grounded and noncurrent carrying parts. Each relay shall have a one cycle surge rating of 175 amperes RMS (247.5 amperes peak) and shall be unaffected by electrical noise having a rise time of up to 200 volts per microsecond or by the 500 volt power noise transient test.

5. The transfer relay shall be provided with a connector Cinch-Jones Type #P-408-SB, or equivalent, and intermate with Cinch-Jones Type #S-408-SB, or equivalent. Socket assignments shall be as follows:

PIN	FUNCTION	PIN	FUNCTION
1	Relay Coil	5	Relay Common Ckt. #1
2	Relay Coil	6	Relay Common Ckt. #2
3	NC Ckt. #1	7	No Ckt. #1
4	NC Ckt. #2	8	No Ckt. #1

e. Secondary Coordination Unit - When the local controller is to function as a secondary controller under the supervision of a master controller, the secondary coordination function shall be provided as a built-in feature of the local controller unit.

f. Telemetry Module - When the local controller is to function under the supervision of a master controller, a telemetry module shall be included as a bult-in module in the local controller assembly for two way communications with the master controller. RS-232 ports for serial communications and fiber optic communication tru serial-fiber modems, and RJ-45 port for TCIP Ethernet communications shall be provided.

723-8 MASTER CONTROLLER ASSEMBLY

723-8.01 Description - A master controller assembly is a solid state electronic unit for providing supervision to a system of local controller assemblies. The master controller may be located near the system of local controllers which it supervises or in a control center.

723-8.02 Functional Requirements - The master controller unit shall:

a. Receive all timing and operating parameters for the intersections under its control and down load to the intersections. It shall also be capable of uploading and displaying all timing and operational parameters from all intersections under its control and of displaying the operational status of all controllers including real time intersection operations.

b. Receive and process data from lane detectors to determine volume and occupancy at strategic points within a coordinated network. It shall also compare the processed volume and occupancy against a number of sets of volume and/or occupancy data stored in memory and shall identify the set that most closely matches the actual traffic at the comparison time.

c. Be capable of selecting parameters not only by the traffic responsive method, but also by time-of-day, day-of-week, or by manual selection.

d. Provide the necessary interface circuitry to force the termination of any phase as determined by the programmed background coordinating scheme, if the

local controller is operating at or near its maximum limits and if there is demand on any other phase.

e. Be equipped with the necessary failsafe features to prevent the controller from terminating a phase when the phase timing is operating on the minimum green or pedestrian intervals, thus preventing abnormally short green or pedestrian periods while maintaining full traffic responsive control.

723-8.03 Design Requirements - The master controller shall meet the following design requirements:

a. The master units shall be self contained in their own separate housing and shall be capable of producing programmed coordination schemes at a minimum of three cycle lengths, three separate signal splits, and three off-set timing relationships per cycle.

b. The program information shall be easily changed by trained personnel without shutting down the local intersection controller.

c. The local controllers shall be connected to the master unit by means of a multi-conductor cable of the number of conductors, type, and gauge of wire for wired applications , or by category 6 Ethernet cable for wireless applications, as per plans for the master to local communications format to be employed. All conductors of this connecting cable for fiber optics communication applications shall be fused splice before their connection.

d. All connections from local controllers to master coordination unit shall be done in a separate electric terminal panel, and then routed into the master controller unit by the use of a multipin electric harness.

e. The master controller shall be mounted in one of the housings specified below as called for in the contract documents.

1. In its own metal cabinet and concrete pedestal base which shall comply with the requirements for controller cabinets specified in Article 723-7.07 except that the dimensions shall be as required to accommodate the master controller assembly but with the equipment occupying not more than 60% of the internal volume of the cabinet.

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2. In a separate concrete building erected in accordance with the plan details and the requirements of Specification 655 - Traffic Signals Master Controller Building.

a. All communications from master to local controller shall be accomplished thru RS-232 ports for serial communications and fiber optic communication tru serial-fiber modems, and RJ-45 port for TCIP Ethernet communications. System coordination and program changes, as well as any other system's functions as delineated in the design drawings, shall be carried out thru the above described type of communication. A telemetry module shall be included in each local controller as a built-in feature for two way communications with the master controller. When a master is in communication with Local controllers true TCIP Ethernet communications it shall complies with the protocol support for NTCIP 1201 level 1 & NTCIP 1202 level 2.

723-9 RIGID PLASTIC CONDUIT

723-9.01 Plastic conduit, couplings and fittings shall be UL approved non-sparking polyvinyl chloride (PVC) conduit DB-120 designed for direct burial in the ground or PVC Schedule 40; however, the use of PVC Schedule 40 conduit at exposed locations is mandatory. Solvent cement for joining conduits and fittings shall meet the requirements of ASTM D 2564. Conduit size shall be a minimum of 2 inches in diameter unless otherwise specified in the plans.

723-9.02 Conduit for Fiber Optic Systems

a. Conduits shall consist of four 1 inch ribbed pre-lubricated inner ducts preassembled in a protective outer duct.

b. The outer duct shall be an industry standard 4 inch PVC Schedule 40 duct with an extended 6 inch integral end bell supplied. Exposed outer ducts shall be galvanized steel.

c. The conduits shall be installed as a complete system with gasketed coupling body to assure proper interduct alignment throughout the system and to ensure air and water integrity.

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d. Conduits shall be provided with sized fixed radius bends and sweeps to match the various ranges and degrees and radii specified. All fixed radius bends and sweeps shall be supplied with coupling body in the bell end and spigots on the opposite end.

e. Conduits shall be installed with matching termination kits to terminate and seal both ends of each conduit.

1. All conduits will be installed with marked pull tapes

2. Plastic bushings and pull tapes will be provided

3. There will no more than two 90 degree bends between the pull box and the cabinet

4. The use of LB, LL, or LR fittings will not be approved

5. All metallic conduits must be installed in accordance with National Electric Code Article 800-12C

6. Contractor shall install a quantity of three (3) 1 1/4 inch plenum rated inner-ducts in entrance conduits, if those entrance conduits penetrate the building before entering the PDR

7. This includes at least one of the three four inch backbone and/or riser conduits from Telecom Room to Telecom Room or from entrance point (pull box) to main equipment room

8. If point of penetration into building to PDR exceeds 50 ft., then at least one of the quantity of four (4" conduits) must be rigid

9. Contractor shall with UNC Telecom when special pull boxes or junction boxes are required

10. All Telecommunications ductbank shall allow no more than 180 degrees of bends between manholes. Ductbank construction practices

11. No short radius 90 degree bends are allowed

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723-10 GALVANIZED STEEL CONDUIT

723-10.01 Galvanized steel electrical conduit and fittings shall conform to all requirements of the NEC and the details on the plans. Each conduit length shall bear the UL label. Exterior and interior surfaces, including threads (except field cuts) of all conduit and fittings shall be uniformly zinc coated by the hot-dip galvanizing process meeting the requirements of ASTM A 239. Where conduit expansion joints are called for on the plans, they shall be of the "XJ" type.

723-11 PULL BOXES AND JUNCTION BOXES

723-11.01 Concrete Pull Boxes - Shall be precast or cast-in-place meeting the requirements of Class A Concrete, Specification 601 - Structural Concrete, and built in conformance with the details and dimensions shown on the plans.

a. The cast iron frame and cover shall conform to the approximate dimensions and weights shown on the plans and shall conform to the Specifications for Gray Iron Castings, ASTM A 48.

b. Reinforcing steel shall be in accordance with the requirements of Specification 602 - Reinforcing Steel.

c. The aggregate drain in the bottom of the pull box shall be filled with aggregate conforming to the requirements of paragraph 209-2.01 of Specification 209 - Sheathing.

d. Conduit and fittings within the limits of the pull box shall comply with the same specification used for similar materials placed outside.

e. Cable hooks shall be provided and shall be either fabricated of bent reinforcement imbedded in the wall of the pull box or standard cleat type cable hangers used for racking cable.

f. The conduit bell shall be any non-metallic funnel shaped item.

723-11.02 Polymer Concrete Pull Boxes – Shall be precast, built in conformance with the details and dimensions shown on the plans and standard drawings.

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a. Polymer concrete pull boxes shall meet requirements of ASTM, NEC, ANSI/SCTE 77-2002, and UL standards for underground enclosures

b. The drain

c. Conduit fittings

d. Cable hooks

e. The Conduit

723-11.03 Metallic Pull and Junction Boxes - May be cast iron or cast aluminum unless otherwise specified in the plans.

a. Cast iron box shall be of the dimensions specified and shall conform to paragraph 715-5.03 of Specification 715 - Structural Metals. The cover shall be cast steel conforming to AASHTO M 103 (ASTM A27), Grade 60-30, or ductile iron casting conforming to paragraph 715-5.04 of Specification 715. The box and cover shall be hot-dipped galvanized in accordance with AASHTO M 111 (ASTM A 123) after fabrication.

b. Cast aluminum box shall meet the requirements of ASTM B 26 for Aluminum Alloy Sand Castings, Grade CS 43A with a normal tensile strength of 25,000 psi and a yield strength of 12-15,000 psi.

c. Box and cover shall be neatly finished. The thicknesses as given shall be uniform throughout. Completed assembly shall be as approved by the Engineer.

d. All nuts, bolts and screws shall be recessed and of stainless steel meeting the requirements of AISI 300 Series Commercial Grade.

e. The box cover shall be gasketed so that when the cover is in place it shall have a watertight fit.

723-12 ELECTRICAL CONDUCTORS

723-12.01 Traffic Signal Cable - Electrical conductors for use as traffic signal cable in underground conduits and overhead messenger supported installations shall be of the size and number of conductors specified in the plans.

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a. Individual conductors shall be stranded copper wire polyethylene insulated, polyethylene jacketed, UL listed and labeled, rated for 600-volt operation, and conforming to the requirements of the International Municipal Signal Association (IMSA) Specification 20-1, latest edition.

b. When the conductor sizes are not specified in the plans, the Contractor shall furnish conductors of adequate size to meet NEC requirements and the total number of conductors required to service the signals installation.

c. Each shipping length of cable shall show the name of the manufacturer, the year of manufacture and the IMSA specification number. The above information shall be applied every two feet or less to the outer surface of the jacket by indent printing.

d. The cable shall be factory tested for each conductor insulation resistance and also for continuity of conductors. The Manufacturer shall furnish a certified report of compliance with the IMSA specifications and shall include the factory test results for conductor insulation resistance and continuity. This report shall be submitted by the Contractor in advance of shipment of the cable together with a sample of the cable covered by this report.

723-12.02 Detector Lead-In Cable - The loop detector lead-in cables to the controllers shall be stranded tinned copper conductors, polyethylene insulated, polyethylene jacketed cable conforming to the latest edition of IMSA Specification 50-2. The cable shall be AWG No. 14, two conductor, twisted pair, shielded wire, unless otherwise shown on the plans.

b. Each shipping length of cable shall show the name of the manufacturer, the year of manufacture, and the IMSA specification number on a tape under the outer jacket.

c. The Contractor shall, when requested by the Authority, furnish a certified report of the tests made on the cable to show compliance with the IMSA specifications.

723-12.03 Electrical Service Cable - Conductors and cable for the electrical connections to the PREPA system shall comply with the PREPA standards and regulations.

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723-13 TRAFFIC SIGNALS TELECOMMUNICATIONS

723-13.01 Metallic Cables

a. The cable used for the low voltage telecommunication interconnect system shall conform to the requirements of REA Specification PE-22 for polyethylene insulated, polyethylene jacketed communication cable with corrugated aluminum electrical shielding tape. The conductor's size shall be AWG-19 and the number of pairs shall be 12 unless otherwise specified in the plans.

b. The conductor insulation shall be colored so as to identify (1) the wire and mate conductor of each pair and (2) each pair in the completed cable. Each conductor shall consist of stranded copper wire.

c. The cable shall be factory tested for each conductor insulation resistance and also for continuity of conductors. The manufacturer shall furnish a certified report on the cable to show compliance with the specifications. This report shall be submitted by the Contractor in advance of shipment of the cable together with a sample of the cable covered by this report.

723-13.02 Fiber Optic Systems

a. Acceptable systems include that of any manufacturer, provided such equipment meets all qualifying specifications identified herein. All items and materials furnished shall be new, unused, current production models installed and operational in a user environment and shall be items currently in distribution. The proposed equipment shall have a proven record of field use at other USDOT installations for at least three (3) years of service i.e., not including prototype field trials prior to installation. The entire system shall consist of the following, but not be limited to: optical fiber cable, active devices, conduits with inner ducts, patch panels and connectors, and all other equipment and accessories necessary for a complete system.

b. Provide splicing kits, fiber optic cable caps, moisture and water sealants, terminators, splice trays, fiber distribution housings, fiber distribution unit, fiber interconnect housing, fiber optic jumpers, and accessories to complete the fiber optic system.

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c. Provide corrosion resistant materials that comply with the details shown on the plans and these specifications.

d. Use Polyurethane (PU) Buffered Jacket for underground duct installations. Use Polyethylene (PE) Buffered Jacket for aerial installations.

e. Optical Fiber Cable Configuration:

Cable type		Single-mode
Number of strands		24
Core Diameter (microns)		8.3 ± 1
Cladding Diameter (microns)		125 ± 1
Attenuation (dB/km)	1300/1310 nm	0.4 Or less
	1550 nm	0.3 Or less
Dispersion (ps/nm-km)	1310 nm	3.2
	1550 nm	17
Splicing Loss (dB/connection)		0.75 (maximum)
Weight per meter		20 Kg
Light Source		Laser Diode
Connector Type		FC
Maximum Macro Bend Loss at 1625 nm (dB)		0.5
Maximum Attenuation Coefficient (dB/Km)		0.3 – 0.5
Maximum Cabled PMD-Q (ps/√km)		0.2 – 0.5
Wavelength		1310 – 1550 nm
Bend Radius Dynamic		20 X OD
Bend Radius Static		10 X OD
Tensile Rating Installing (N)		2700
Tensile Rating Static (N)		500

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723-13.03 Wireless Communication Systems

a. Acceptable systems include that of any manufacturer, provided such equipment meets all qualifying specifications identified herein. The proposed equipment shall have a proven record of field use in Puerto Rico or other USDOT installations for at least one (1) year of service i.e., not including prototype field trials prior to installation. The entire system shall consist of the following, but not be limited to: radio transceivers, access points, antennas, repeaters, network devices, surge suppressors to protect from lightning and power surges, network management software, and all other equipment necessary for operation.

b. Radio transceivers shall provide the following Configurations:

1. Access point/Remote Dual Gateway

2. Remote Dual Gateway (both serial and Ethernet connections)

c. All items and materials furnished shall be new, unused, current production models installed and operational in a user environment and shall be items currently in distribution.

d. Communications equipment shall comply with Federal Communications Commission (FCC), Industry Canada (IC), and Underwriter Laboratories (UL) standards.

723-14 SEALANT FOR LOOP DETECTORS

a. These specifications describe the minimum acceptable physical and performance properties of sealants used to seal loop detector slots. Sealant shall be rapid cure, high viscosity polyester, liquid epoxy, urethane (moisture cure), urethane (two-component), solvent-release rubber base, or cartridge. Sealant shall be formulated for use in sealing inductive wire loops and leads embedded in asphaltic concrete and Portland cement concrete. Sealant shall be two-component system, which consists of a resin constituent identified as pourable, and a hardener identified as quick setting.

b. Sealant shall be usable on grades of 15 percent or less without excessive flow of material.

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c. Cured sealant shall be unaffected by oils, gasoline, grease, acids and most alkalis. The mixing of components and the filling of the sawcut shall be in accordance with the directions of the manufacturer.

d. Sealant shall be suitable for use in filling sawcut made in concrete or bituminous concrete pavement in which electrical wire has been installed. The sealant shall have no detrimental effect to the cross-linked polyethylene or thermoplastic insulation on the cable and bond with minimal shrinkage to either concrete or bituminous concrete roadways. The cured joint sealant material shall not tack in hot weather and shall be suitable for use at temperatures as low as 45 degrees Fahrenheit.

1. Sealant designed for use with bituminous concrete pavement may be utilized on either concrete or bituminous type of roadway. Joint sealant designed for use with concrete roadways may only be utilized on that type of pavement.

2. Sealant shall cure to a tough rubber-like seal that will not embrittle with age. It shall resist weather conditions, abrasions, oils, gasoline, anti-freeze solutions, brake fluids and road salt normally encountered under typical road situations.

3. Sealant shall be the type approved through submittals.

e. Instructions and Guarantee

1. Installation instructions shall be provided with each container of sealant and with each carton containing any number of containers.

2. No changes or substitutions in these requirements will be accepted unless authorized in writing. Inquiries regarding this specification shall be addressed to the director, Office of Traffic Signal Division.

3. A shelf-life expiration date shall appear on all containers.

4. The contractor agrees upon the request of the director, Office of Traffic Signal Division to deliver a sample of the sealant to be supplied in compliance with these specifications for inspection and test before acceptance. After completion of the test, the sample shall be returned.

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723-15 VIDEO IMAGE DETECTION SYSTEMS

a. All items and materials furnished shall be new, unused, current production models installed and operational in a user environment and shall be items currently in distribution. The detection equipment and algorithms shall have a proven record of field use in Puerto Rico or other USDOT installations for at least six (6) months of service i.e., not including prototype field trials prior to installation. The entire system shall consist of the following, but not be limited to:

1. Video Image Processors

2. Video System Communication Modules

3. Video cameras with IR filters, lens, pressurized enclosures, and sun shields

4. Brackets for camera installations on signal mast arms, posts, buildings, or other structures

5. Surge Suppressors to protect from lightning and power surges

6. Devices for system set up and programming

7. Traffic Management Software

8. Coaxial and power cables

9. All other equipment necessary for operation

723-15.01 Video Image Processor

a. A Video Image Processor (VIP) is a standard detector board which runs detection software. The VIP uses video signal from cameras monitoring the traffic as its input. Detection lines or zones are superposed onto the video image. Vehicles crossing these lines or zones are detected. The VIP analyzes the video images to generate traffic data and alarms. VIP boards shall handle compression of images and transmission of data, alarms, and images. VIP boards shall be grouped in rack systems.

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b. Install video image processors that are modular by design and housed in either a self-contained stand-alone unit or fit directly into NEMA TS1 and TS2 type cabinet. The VIP shall be interchangeable between a shelf or rack mount installation without replacing or modifying the existing VIP units.

c. The VIP shall be designed to operate reliably in the adverse environment of roadside cabinets and shall meet or exceed all NEMA TS1 and TS2 environmental specifications.

d. Ambient operating temperature shall be from –34 to +74 degrees Centigrade at 0 to 95 percent relative humidity non-condensing.

e. The VIP shall utilize cabinet 24 VDC for rack mount installations or external 24 VDC for stand-alone installations.

f. Surge ratings shall be set forth in the NEMA TS1 and TS2 specifications. External surge suppression, independent of the VIP board shall separate the VIP from the camera.

g. Serial communication shall be through an RS232 port. This port can be used for communication to a laptop to upload and download detector configurations, traffic data, technical events, send software upgrades, and do remote setup of detectors. RS485 on the rear edge connector shall facilitate communication to other VIP boards.

h. Each VIP shall have error detection. An output shall be activated if the video signal is bad or the VIP is not functioning properly. A user defined quality level will automatically put the video image processor into a recall state in cases of severe degraded visibility (i.e. heavy rain or fog). Normal detection resumes when visibility improves above the user defined image quality level threshold.

i. Process the video signal of at least one camera and analyze the video signal in real time (30 frames per second).

j. Be expandable up to 12 cameras that may be connected to different VIP units and programmed independently.

k. Operator selectable recall shall be available via the VIP's front panel. The operator should have the ability to assign selectable outputs for recall.

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l. The VIP board shall have a reset button on the front panel to reset video detectors to "relearn" the roadway image. During "relearn", selectable recall can be enabled or disabled for immediate operation. Learning time of video detectors shall be less than six (6) minutes.

m. The VIP board shall have at least one video input (RS-170 NTSC composite video) and at least one video output with an overlay of detection lines or zones and system data.

n. The VIP board shall have separate light emitting diodes (LEDs) to indicate the following, but not be limited to: power status, communications, video input, and active detection group.

o. A video select button on the VIP front panel will switch between camera images of the VIP.

p. The VIP board shall also have separate buttons for the following, but not be limited to: manually place call or select video on detectors, manually reset detectors to "learn" new background, and activate video out on female RCA style connector.

q. Each VIP board shall be able to store data intervals in non-volatile memory.

r. The number of opto-isolated open collector outputs shall equal to the detection loops shown on the plans plus one spare output for every approach. Each VIP board shall allow for additional digital inputs and outputs via an expansion port.

s. VIP expansion ports shall have a means to define or setup inputs and outputs used (range: 1-12 or 13-24). The outputs shall be programmed for signaling the presence, the arrival, or the departure of vehicles in a minimum of 64 detection zones.

t. VIP expansion ports shall have separate LEDs that include, but are not limited to: power status, communications to VIP board, and active detection group.

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723-15.02 Video System Communication Module

a. Communications modules provide the ability to remotely monitor, set up, and modify detector configurations. Install communication modules that are modular by design and housed in either a self-contained stand-alone unit or fit directly into NEMA TS1 and TS2 type racks.

b. The communications module shall control from 1 to 8 VIP boards allowing for 1 to 16 cameras.

c. The communications module shall be designed to operate reliably in the adverse environment of roadside cabinets and shall meet or exceed all NEMA TS1 and TS2 environmental specifications.

d. Ambient operating temperature shall be from –34 to +74 degrees Centigrade at 0 to 95 percent relative humidity non-condensing.

e. The communications module shall be powered by 12-40 VDC and draw less than 750 milliamps.

f. Serial and Ethernet (TCP/IP) communications shall be through an RS232 serial port (F DB9 connector) and Ethernet port (RJ-45 connection), respectively. These ports can be used for communications to a laptop or modem to upload and download detector configurations, traffic data, technical events, send software upgrades, and do remote setup of detectors. RS485 on the rear edge connector shall facilitate communications to VIP boards.

1. Surge ratings shall be set forth in the NEMA TS1 and TS2 specifications.

2. The communications module shall have separate light emitting diodes (LEDs) that include, but are not limited to:

3. Power status

4. Ethernet communication activity over LAN

5. Video out to female RCA style connector

6. Manual reset to re-initialize communications

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7. Communication on serial and dial-up DB9 female

g. The communication module shall allow remote access to the video image detection system. Using video compression technology and remote access software, the communication module shall provide high video transmission over standard telephone lines to enable remote modification of detection zones on the video image.

h. The communication module shall provide serial and Ethernet interface communication to provide traffic data and allow remote configuration from the Traffic Operations Center.

i. The communication module shall control from 1 to 6 VIP modules allowing for 1 to 12 cameras and support all functions of the video image detection system.

j. The LAN port on the communication module shall meet IEEE 802.3 with TCP/IP based protocol using an RJ-45 connector and a data rate of 100 M bps.

k. All data transmissions shall be protected by CRC (cyclic redundancy checking) or an equivalent error detection method.

l. Be programmed without the use of a supervisor computer. A standard CCTV monitor and keypad plugged into the communication serial port will facilitate communication module programming.

m. The serial communication port on the communication module shall meet EIA-232-E and meet the following specifications:

1. Dial-up data rates for RS232 via Serial port: maximum 57600 bps

2. Direct data rates for RS232 via Serial port: maximum 115200 bps

3. Configurable mode of operation

4. Support streaming video over Ethernet and serial communication.

5. Streaming video frame rate: 5 to 30 frames per second

6. Over Ethernet: 10 frames per second

7. Over serial communication: guarantee of 1 frame per second

n. Password protected remote setup and monitoring of every connected VIP shall be possible. Remote setup comprises configuration upload and download, setup of detectors and detector parameters, setup of communication board parameters, firmware updates for communication and VIP modules.

o. Dialup shall be possible through PSTN modems.

p. The communication module shall log data and events provided by the VIP and transmit data and events to the HOST computer.

q. RS485 communication to every VIP shall be established via the Edge connector.

r. The communication module shall able to store on board pre-post video sequences of alarm triggered upon traffic user defined events. When connected to a HOST computer, the JPEG video sequences shall automatically be downloaded to the HOST computer.

s. The communication module shall be able to accept NTSC video format.

t. Connection to the Internet (via Ethernet) and use of a standard Internet browser shall be possible to communicate with the communication module for remote set-up, monitoring and real-time data of the VIP modules.

723-15.03 Video Cameras

a. The unit shall be a high resolution, 1/3 inches image format CCD camera, designed for professional video surveillance systems. Incorporating the latest in CCD technology, the video camera shall provide detailed video without lag, image retention or geometric distortion. The unit shall meet the following specifications:

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Temperature range	-20 to + 50 degrees Centigrade
Humidity	5 percent to 95 percent relative, non-condensing
Dimensions	58 X 66 X 122 millimeters
Weight	0.45 kg
Camera mounting slots	1/4-20, top and bottom
Connectors	BNC (RG–6) for video out
Finish	Off-white semi-gloss polyurethane
Construction	All metal housing
Rated input voltage	12VDC or 24 VAC +/-10 percent at 60Hz
Nominal power	4 Watts
Imager	Interline transfer CCD 1/3 inches format
Sync system	EIA RS-170
Active picture elements	768 H X 494 V
Horizontal resolution	380 TVL
Imager spectral response	100 percent at 550 nm
Imager	30 percent at 400 nm and 800 nm
Sensitivity (3200 K)	Usable Picture Full Video
Signal to noise ratio	50 dB minimum
AGC	21 dB, maximum
Electronic Shutter	1/60 to 1/600,000 seconds (EIA)

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Aperture Correction	Horizontal and vertical symmetrical		
Video out	1.0 volts peak-to-peak +/- 0.1 Volt at 75 Ohms		
Programmable Controls	Video level, shutter, AGC, BLC, Auto Black		
Scene Illumination	fc	0.01	0.048
	lx	0.12	0.48
Imager Illumination	fc	0.0024	0.010
	Lx	0.024	0.10

F1.2 lens at 89 percent highlight

723-15.04 Video Camera Lenses

a. The camera lens shall be a motorized variable focal length with auto iris.

Image format	1/3 inch
Focal length	6X zoom (6.5-39 millimeters)
Iris range	f 1.0 – Approx. 1200
Back focus distance	10.05 millimeters (0.4 inches) in air
Weight	500g
Size	60 X 70 X 89.9 millimeters
Lens mount	CS
Iris control	DC or Video 4-pin square
Focus control	Motorized

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Zoom	Motorized

723-15.05 Video Camera Housings

a. The environmentally protected housing shall be an aluminum enclosure designed for outdoor CCD camera installations.

Temperature range	-40 to +50 degrees Centigrade
Dimensions	449 x 97 x 112 millimeters
Weight	1.5 kg (maximum)
Housing mounting	Three 1/4-20 tapped holes
Camera mounting	Removable cradle assembly
Cable entry	hole
Finish	Off-white semi-gloss polyurethane
Construction	Extruded aluminum housing
	Aluminum rear-end cap
	Aluminum front cap with glass face plate, and cradle
	A sunshield shall be included
Window	3 millimeters thick glass that includes a Thermostatically-controlled window
Rated input voltage	115 VAC 60 Hertz
Voltage range	108 VAC to 132 VAC
Output voltage	24 VAC 60 Hertz

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Nominal power	30 Watts
Enclosure protection	Waterproof and dust-tight in a NEMA-4,IP65,enclosure Type 3

723-15.06 Video Camera Surge Protection

a. Video camera surge suppressors shall be available for installation inside the traffic signal controller cabinet. Each suppressor shall provide coaxial cable connection points to an EDCO CX06-BNCY or approved equal transient suppresser for each camera.

Peak Surge Current (8X20 US)	5 KA
Technology	Hybrid, Solid State
Attenuation	0.1db at 10 MHZ
Response Time	<1 nanosecond
Protection	Line to Ground
Shield to Ground	(isolated shield modules)
Clamp Voltage	6 volts
Connectors	BNC
Impedance	75 Ohms
Temperature	-40 to +85 degrees Centigrade
Humidity	0-95 percent non-condensing
Dimensions	4.5 x 1.5 x 1.25 inches
UL Listed	UL 497B

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TRAFFIC SIGNAL MATERIALS**

723-15.07 Video Camera Mounting Brackets

a. Mast arm installations shall be mounted at a sufficient height to prevent occlusion from cross traffic between the stop bar and the mast arm on which the camera is installed. A six (6) feet maximum length of internally reinforced tube shall be attached to the mast arm bracket for camera mounting above the mast arm. Camera shall be mounted to the top of the tube with the camera manufacturer's recommended bracket. Camera bracket shall provide adjustments for both vertical and horizontal positioning for the camera. Camera attachments shall be designed to securely fasten the camera to prevent the extension tube from falling into the path of vehicles and becoming loose. Miscellaneous hardware shall be stainless steel or galvanized steel. The cameras and associated pole or arm attachment unit shall be designed to withstand a wind load of 90 MPH with a 30 second gust factor.

b. Luminaire arm installations shall be installed on the luminaire arm, with the camera or video manufacturer's recommended brackets. Camera luminaire brackets shall provide adjustments for both vertical and horizontal positioning of the camera. Camera attachments shall be designed to securely fasten the camera to the luminaire arm. Miscellaneous hardware shall be stainless steel or galvanized steel. The cameras and associated pole/arm attachment unit shall be designed to withstand a wind load of 90 MPH with a 30 second gust factor.

723-15.08 Cables for Video Cameras (Power and Coaxial)

a. RG-6 100 percent reflective coaxial cable and power cable shall be installed in conduits or overhead as indicated in the plans. Coaxial cable shall be suitable for exterior use and in direct sunlight.

b. Coaxial cable will be terminated in the surge suppressor before being connected directly to VIP boards.

c. Power cable will be terminated into a fuse panel provided by the manufacturer and connected to 120 VAC in the controller cabinet. Power cable will have a minimum of 5 conductors.

d. Description of power cable: Composite, 6 Conductors 2 elements: 18 AWG 5 conductors 7/26 bare copper, 0.016 inches polyethylene, 20 AWG 1

conductor, solid bare copper, 0.056 inches foam polyethylene jacket black, overall 0.030 inches PVC jacket black.

e. Power cable physical characteristics

	Element 1	*Element 2*
Conductors/Pair Count	5	1
Guage and Stranding	18AWG 7/26 BC	20AWG Solid BC
Primary Insulation Type	Polyethylene	Foam PE
Insulation Thickness	0.016 Inches	0.056 Inches
Color Code	White,Red,Blue,Black,Brown	Natural
Braid	N/A	95 Percent BC
Jacket Type	N/A	Polyethylene
Jacket Color:	N/A	Black
Jacket Thickness	N/A	0.035 Inches
Nomimal OD	N/A	0.242 Inches

f. Overall assembly of wire

Jacket Thickness	0.030 Inches
Jacket Color	Black
Jacket Material	PVC
Ripcord	Yes

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Nominal OD	0.512 Inches
Voltage Rating	600 V
Temperature Rating	75 C
Print Legend	TBD
Packaging	TBA
Copper Weight	39.87 Lbs/Mft
Shipping Weight	100 Lbs/Mft

723-15.09 Installation and Training

a. A factory certified representative from the manufacturer shall be on-site during installation to supervise the installation and testing of the video equipment. The factory certified representative shall make fully operational and test the system as indicated on the intersection drawings and this specification.

b. Three (3) days of training shall be provided to personnel of the Authority in the operation, setup, and maintenance of the video image detection system. Instruction and materials shall be provided for a minimum of five (5) persons and shall be conducted at a location selected by the Authority. Training shall be considered a subsidiary obligation of the video image detection system.

723-15.10 Warranty

a. The video image detection system shall be warranted against manufacturing defects in materials and workmanship for a period of two (2) years from date of installation completion and acceptance by the Authority. The supplier of the video image detection system shall provide all documentation necessary to maintain and operate the system.

723-16 Battery Backup Systems

a. All items and materials furnished shall be new, unused, current production models installed and operational in a user environment and shall be items

currently in distribution. The proposed equipment shall have a proven record of field use in Puerto Rico or at other USDOT installations for at least six (6) months of service i.e., not including prototype field trials prior to installation. The BBS shall consist of, but not be limited to: Inverter-Charger module with software, manual bypass switch , transfer relay, sealed batteries, cables and connectors, enclosure, and other equipment necessary for operation

723-16.01 Inverter-Charger Module

a. The Inverter-Charger Module shall consist of the complete electrical mechanism, electronics, and software for controlling the operation of the battery backup system, including its necessary auxiliary equipment, mounted in its own enclosure.

b. Controls, ports, voltage level test points, and status displays shall be in the front panel of the Inverter-Charger module.

c. Front panel shall be Liquid Crystal Display (LCD) with

d. The Inverter-Charger module shall include a built-in transfer relay rated 240 VAC and 30 Amps.

e. Furnish and install a manual by pass switch rated 240 VAC and 30 Amps, separated from the Inverter-Charger Module.

f. Furnish and install battery backup systems with built-in Windows compatible software that allows setting up parameters and display status and logs.

g. The software shall be remotely accessible through a serial RS232 connection to obtain reports and event logs stamped with date and time.

723-16.02 Batteries

a. Furnish and install 12 VDC Sealed batteries to attain power demand specified on the plans.

b. Batteries shall be maintenance free and have a minimum useful life of three (3) years.

c. Each BBS installation requires power load analysis to determine the number of batteries required to supply appropriate power to the intersection.

d. Batteries shall be isolated and environmentally protected.

723-16.03 Enclosure

a. House battery backup systems in enclosures separated from traffic signal system cabinets.

b. Varying power demands may require enclosures with dimensions appropriate for the power demand specified at each intersection.

c. Secure batteries inside enclosures using special fixtures in such a way that theft and vandalism are avoided.

d. Build base foundations for cabinets according to specification 654-3 and 723-7.

e. Furnish and install cabinets according to specification 654-3 and 723-7.

f. Perform electrical connections using underground conduits of traffic signal cabinets.

g. On existing traffic signal installations

723-16.04 Cables and Connectors

a. Furnish and install cables and connectors necessary for a complete and fully operational battery backup system.

b. Cables connecting the battery backup system to the utility power shall be stranded AWG 6.

723-16.05 Installation and Training

a. Electrical works required for system installation shall be performed by a licensed electrician.

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b. A factory certified representative from the manufacturer shall be on-site during installation to supervise the installation and testing of the BBS. The factory certified representative shall make fully operational and test the system as indicated on the intersection drawings and this specification.

c. Two (2) days of training shall be provided to personnel of the Authority in the operation, setup, and maintenance of the BBS. Instruction and materials shall be provided for a minimum of five (5) persons and shall be conducted at a location selected by the Authority. Training shall be considered a subsidiary obligation of the video image detection system.

723-16.06 Warranty

a. The BBS shall be warranted against manufacturing defects in materials and workmanship for a period of two years from date of shipment. The supplier of the BBS shall provide all documentation necessary to maintain and operate the system.