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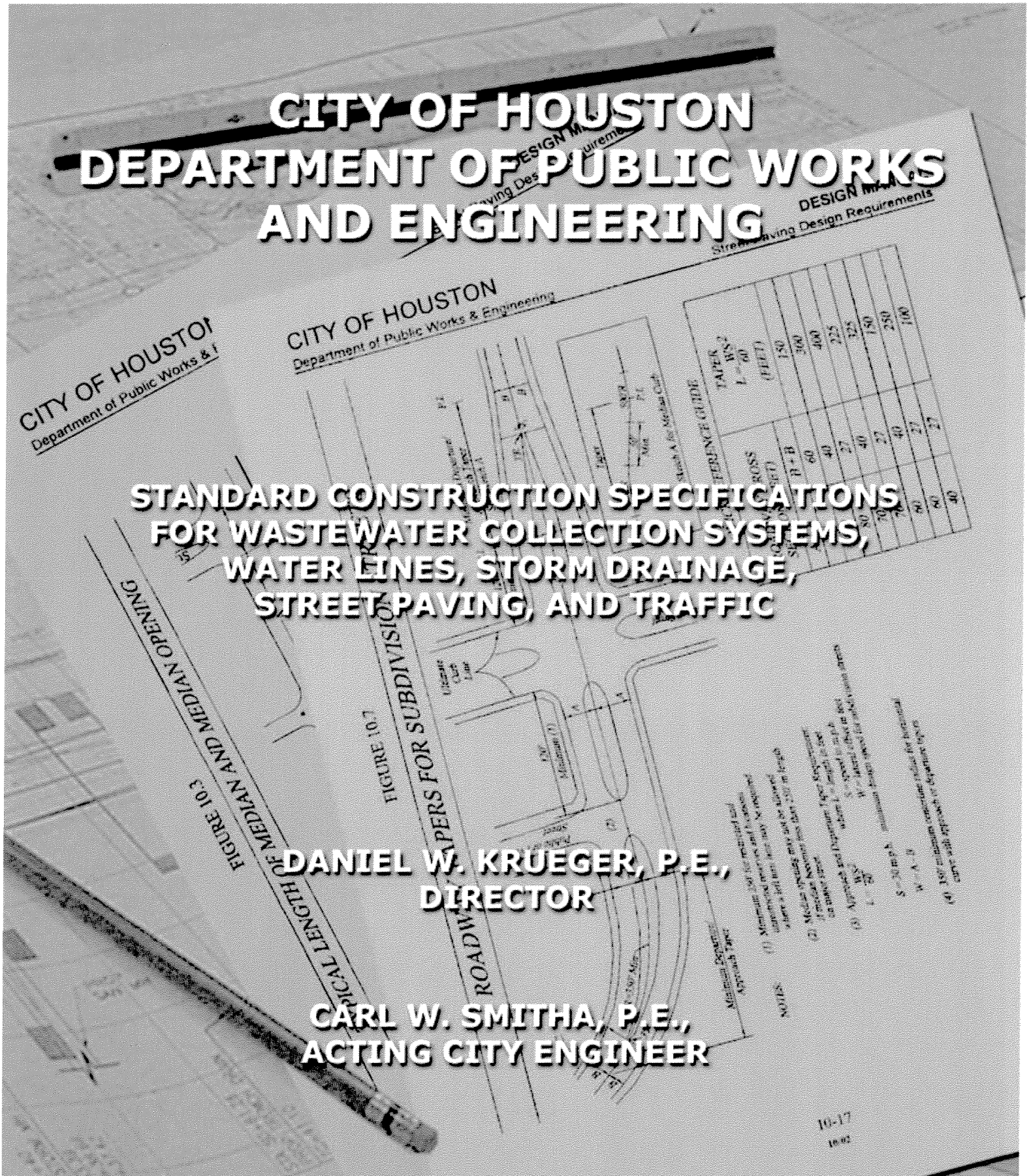

STANDARD CONSTRUCTION SPECIFICATIONS FOR WASTEWATER COLLECTION SYSTEMS, WATER LINES, STORM DRAINAGE, STREET PAVING, AND TRAFFIC

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Document Title Pages

SPECIFICATIONS

DIVISION 2- SITE WORK

***Bold Specifications have been revised.**

SECTION 16715

VEHICLE SIGNAL HEADS
(POLYCARBONATE)
(ADJUSTABLE, EXPANDABLE TYPE)

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Polycarbonate Vehicle Signal Heads with mounting attachments and light emitting diode (LED) lamp indications, louvered back plates, and Geometrically Programmed Louvers (GPL).

1.02 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment for Vehicle Signal Heads will be measured by each vehicle signal head assembly required with specified mounting hardware. Vehicle Signal Heads shall consist of one (1) or more sections with visor(s), mounting hardware, LED indication color(s) specified and louvered back plates. The Vehicle Signal Head housings, doors and visors shall be Federal Highway Yellow.

2. Payment for Geometrically Programmed Louver (GPL) and adjustable full-circle visor will be measured as each unit required.

3. Payment for the work performed and materials furnished in accordance with this item will be paid for at the unit price bid for "Vehicle Signal Head", of the various configurations complete with LED indication(s) and mounting hardware and louvered back plates as specified.

PART 2 PRODUCTS

2.01 MATERIALS

A. The traffic control signal heads shall be in accordance with the latest revision of ITE Technical Report No. 1.

B. Each traffic signal face shall consist of one or more signal sections rigidly fastened together as per manufacturer's recommendations in such a manner as to present a continuous pleasing appearance.

C. The electric and optical system of the signal head shall, unless otherwise specified, be designed for operation from a power supply of 115 volt, single phase, 60 Hz alternating current and LED displays.

D. Polycarbonate shall be used in fabricating the vehicle signal heads described herein. Structural requirements for polycarbonate materials are described in Paragraphs. 2.02 and 2.03

E. All material for the mounting attachments shall be metal.

2.02 HOUSINGS

A. The polycarbonate vehicle signal head housing cases shall be a one-piece polycarbonate resin material with sides, top, and bottom integrally molded. The housing shall be injection molded from ultraviolet and heat stabilized flame retardant, permanently colored polycarbonate resins. The housing shall be a minimum of 0.125 inches (3.18 mm) thick measured anywhere on the housing, and shall be internally ribbed so as to produce the strongest possible assembly consistent with lightweight. The terminal block shall either be securely mounted or integrally molded into the housing.

B. Provision shall be made for accommodation of the particular type of mounting specified and attachment of doors, optical units, and other such accessories as may be specified for the particular installation. All traffic signal housing cases, together with doors, lenses, and mounting attachments, shall comprise a dust and moisture proof housing for the optical units, connecting wiring, and terminal block. The housing cases shall be of such construction as to assure permanent alignment of the lens in the traffic signal face. Design of door, housing, and visor shall be such that no light is visible in the profile view of the traffic signal face.

C. Vehicle Signal Head housing cases shall be of the sectional, adjustable, expandable type. The assembled housings for each signal face shall consist of three or more individual dual sections, each designed for housing a single complete optical unit. Individual signal sections shall be rigidly attached to form a single head either with at least four machine screws between each section or by the bolt-and-washer conduit method. Complete signal heads shall provide positive locked positioning when used with serrated brackets, mast arm, or span wire fittings.

D. Portions of cases providing for attachment to supporting arms shall be molded with large bosses for the supporting arms. Each housing case shall be so attached to its supporting arm that it will be adjustable by rotation about its vertical axis in such a manner that any pair of adjacent cases may be adjusted individually to give indications in two directions as close as 15 degrees apart and may be rigidly clamped in any position throughout the range of

adjustment. Provision shall be made for carrying the traffic signal leads enclosed in the mounting attachment.

E. Both the top and bottom of each traffic signal housing case shall be provided with an opening of two inches (50 mm) in diameter to accommodate 1-1/2" (38 mm) pipe brackets. A locking ring shall be integrally cast or molded around the bottom opening. Around the top opening shall be either an integrally cast or molded locking ring or a separate splined locking ring designed to fit into notches. The locking rings shall have a minimum of 72 evenly spaced teeth and shall be so designed that the top and bottom rings will mate to provide a perfectly aligned signal head with flush connection between the outer circumference of the sections.

F. Any open end of an assembled signal housing shall be plugged with an ornamental cap and gasket of an approved type.

2.03 HOUSING DOOR

A. The housing door of each traffic signal housing shall be a one one-piece polycarbonate resin material with an approximate 12-inch (300 mm) diameter circular opening for the lens as specified. The housing door shall be a minimum of 0.125 inches (3.18mm) thick measured anywhere on the housing door. The door shall be attached to the housing by means of two stainless steel hinge pins.

B. Two stainless steel wing screws shall be installed on the side of the door to provide for opening and closing the door without the use of special tools. Wing screws shall have a flat-bearing surface or stainless steel flat washer to prevent gouging of the housing door by the wing screws. Wing screws shall remain captive in the housing door when the door is open.

2.04 VISORS

A. Each traffic signal housing door shall be equipped with an easily detachable standard tunnel visor (unless requested otherwise). The visor shall be a polycarbonate resin to match the housing and door. The visor shall be rigidly attached to the door with rust-resistant connections in a manner that will prevent the leakage of light and moisture throughout the periphery of attachment.

B. Unless requested otherwise , the visor on the front of each door shall:

1. Be circular in section

2. Have a downward tilt of 2 to 8 degrees

3. Encompass approximately 300 degrees of the lens

4. Extend outward from the face of the lens a minimum of 9-1/2" (240 mm) for 12-inch (300 mm) diameter lens, (measured at its outer visible circumference)

5. Be of such design that the encircled portion of the lens will not be visible in the profile view of the traffic signal face

6. Be open at the bottom so as to prevent the accumulation of snow, dirt, and rain.

C. Visors shall be easily removed and replaced without damage to visor or signal head.

D. The four (4) tabs used to mount the visor to the signal shall be slotted. It shall not be necessary to completely remove the mounting screws to remove or replace the visor.

2.05 OPTICAL SYSTEM

A. The Vehicular Light Emitting Diode (LED) Indications to be furnished with the Vehicle Signal Head shall meet the requirements of Specification Section 16718, "Vehicular LED Indications".

2.06 TERMINAL BLOCKS AND ELECTRICAL

A. Terminal blocks shall be either two or seven position and be double row, with each section consisting of two 8-32 x 5/16-in. binding screws and a conducting metal strip between the screws.

B. The terminal blocks shall be a one-piece molded construction using phenolic materials, rated for a minimum 20 amps, 250 volt service

C. Each LED module shall be wired to a two position terminal block located in that signal section. A seven position terminal block shall be furnished in the outermost signal section of any 3 or more section vehicle signal head assembly. All sections of the vehicle signal head assembly shall be wired to the seven position terminal block. All terminal blocks shall be securely mounted in an accessible position and shall be of weatherproof-molded construction, equipped with identified terminals. Binding screws shall be provided for the field and interior wires.

D. Maintain throughout the vehicle signal head the color coding for wires from the LED Module to the main terminal block as shown below:

Indication	**Color Code**
Red Ball / Arrow	Red
Yellow Ball	Yellow

Green Ball	Green
Yellow Arrow	Yellow with Blue or White Tracer
Green Arrow	Green with Blue or White Tracer
Neutral	White

2.07 MOUNTING ATTACHMENTS

A. All mounting attachments shall be aluminum. Provision shall be made for carrying the signal leads enclosed in the mounting attachment. The mounting attachment, together with supporting arms and assembled housings, shall comprise a dust-and-moisture-proof enclosure for optical units and lead wiring. Mounting attachments shall be of one of the following types as specified for the particular vehicle signal head required.

1. Span-Wire Mounting. The span-wire mounting attachment shall consist of a cable clamp to receive a suspension cable of 3/8" (10 mm) diameter together with a suitable connection to the signal head. The mounting shall provide a "balance adjuster" between the signal head and span wire capable of permitting freedom of movement with reference to the point of suspension. The signal head shall be adjustable by rotation about its vertical axis in a horizontal plane and the mounting attachment shall be so constructed that the head may be firmly clamped in any position throughout the range of adjustment. The mounting shall provide a suitable outlet for wiring from the signal head tilted downward and so constructed as to effectively seal the interior of the head from dust and moisture and prevent undue abrasion of signal wiring. Mountings for signal head units not balanced at the point of support shall be provided with a suitable compensating device to insure that the signal head will assume a normally vertical position.

2. Mast-Arm Mounting. The mast-arm vehicle signal head mounting hardware shall be Astro-brac Tenon Mount bracket assembly, or approved equal.

3. Side-of-Pole Mounting. Supports for side-of-pole mounting of the signal head in a vertical position shall be 1-1/2" standard pipe bracket arms, attached to the top and bottom of the signal head with pipe nipples, serrated elbows and collared / cast nipples and band-on pole plates. Pole plates shall be provided with a cable guide. The mounting assembly shall consist of two standard pipe sections extending 12-3/4" from and at right angles to the axis of rotational adjustment of the signal head. Both supports shall have running threads at least 1-1/4" long at the pole connection end. The signal head shall be adjustable, by rotation of the various signal faces about their vertical axis, throughout a radial angle of 360 degrees and shall be capable of being rigidly clamped in any position through the range of adjustment. The wiring from the signal head shall be able to be enclosed in the top or bottom support.

2.08 LOUVERED VEHICLE SIGNAL HEAD BACK PLATE

A. The back plate shall be attached to all new vehicle signals. Back plate shall be continuously louvered around its perimeter.

B. Back plates shall be vacuum formed ABS plastic or aluminum.

C. Vacuum formed ABS plastic back plates shall contain ultraviolet inhibitors and stabilizers for protection against UV degradation.

D. The back plate shall extend around the periphery of the signal face a distance of five (5) inches for faces with twelve (12) inch lenses, and shall have a 3" corner radius.

E. ABS vacuum formed back plates shall be black and color consistent throughout the entire piece without varying shades and tones.

F. The louvers shall be evenly spaced around the back plate, including the top and bottom. The number of louvers adjacent to the vehicle signal head shall be nine (9) per signal section per side. Both the top and bottom back plate sections shall have nine (9) louvers each. The louvers shall be at least 3-1/2" long by 5/8" wide with an opening of at least ¼". The back plate shall be pre-drilled to fit the vehicle signal head for which it is designed.

G. ABS vacuum formed back plates shall have a minimum thickness of .125". All outside edges shall be formed with a ½" to 5/8" flange (inside dimension) turned away from the front surface. The back plate shall have a haircell finish on the front side and smooth finish on the back side.

H. Aluminum back plates shall be fabricated from anodized sheet aluminum and be painted dull black.

I. Stainless steel hardware for attaching the back plate to the vehicle signal head shall be provided.

2.09 GEOMETRICALLY PROGRAMMED LOUVER (GPL)

A. The louver shall have the following capabilities:

1. Fit all manufacturers' 12" vehicle signal heads.
2. Retrofit into existing 12" vehicle signal heads.
3. Provide a full round ball display, with minimum slat effect, throughout the selected view range.
4. Provide an absolute exact visual cut-off.
5. Allow the view angle within each signal section to be adjusted to a designated area.

6. Have minimum glow outside the view range.
7. Allow for controlling either the horizontal or vertical view range within the signal visor.

B. The louver housing shall consist of a two-piece assembly injection molded from black UV inhibited ABS plastic. Two (2) brass inserts shall be molded into the bottom half allowing the assembly to be fastened together with two (2) stainless steel screws.

C. The louver housing O.D. shall be 11-1/2" and have spherical contour which allows the light beam from the signal section to be directed up to 10-degrees in all directions from the centerline of the visor/lens system.

D. The inside surface shall have a multiplicity of grooves for positioning light directing baffles. The remaining inside surface shall be grooved to prevent surface reflections of light.

E. Two (2) sponge neoprene O-rings shall be positioned in grooves on the outside surface to prevent light leakage between the housing and the visor.

F. The louver housing design shall allow the baffle positions to be changed in order to adjust the view angle.

G. The baffles shall be molded from flat black, 10% glass filled UV inhibited virgin polycarbonate.

H. Each baffle shall be thin opaque disc with a multiple of parallel evenly spaced apertures (openings). Each structural member forming the aperture shall have a cross section which allows for good stiffness and structural integrity, but shall have a thin edge to prevent reflection (glow) outside the desired viewing range.

I. All baffles shall be identical in design and interchangeable within the housing. The plane of each baffle shall be 90-degrees to the centerline axis of the housing.

J. The louver shall be supplied with the necessary self-threading screw hardware to attach the louver to the vehicle signal head visor.

K. The louver shall include an installation kit that includes installation instructions, adjustment tool, visor marking template, and all incidentals necessary for attachment and positioning of the louver.

END OF SECTION

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SECTION 16716

PEDESTRIAN SIGNAL HEADS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Pedestrian Signal Heads with mounting attachments and light emitting diode (LED) lamp indications.

1.02 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Pedestrian Signal Heads will be measured by each pedestrian signal head assembly required with specified mounting hardware. Pedestrian Signal Heads shall consist of each pedestrian signal housing assembly with mounting hardware and LED indications. The Pedestrian Signal Head housing shall be Federal Highway Yellow.

2. Payment for the work performed and materials furnished in accordance with this item will be paid for at the unit price bid for "Pedestrian Signal Head", complete with LED indications and mounting hardware as specified.

PART 2 PRODUCTS

2.01 MATERIALS

A. Manufacturers/suppliers furnishing these items shall be experienced in design and construction of such items and shall furnish evidence of having supplied similar items, which have been in successful operation for not less than three (3) years.

B. The lamp units shall be a single, self-contained device, not requiring on-site assembly for installation into an existing traffic signal housing. If proper orientation of the lamp units are required for optimum performance, prominent and permanent directional markings, i.e., UP ARROW or the word UP or TOP, for correct indexing shall be clearly marked on each unit as to configuration and mounting orientation.

2.04 GRID TYPE PEDESTRIAN SIGNAL – LED

It is the intent of this specification to describe minimum acceptable design and operating requirements for an LED illuminated grid type pedestrian signal.

A. General Design Requirements

1. Design, material and construction of LED pedestrian signal heads shall be in accordance with requirements set forth in "Adjustable Face Pedestrian Head Standard", of the Institute of Transportation Engineers and the "Texas Manual on Uniform Traffic Control Devices", latest revision.

2. The general construction shall include a single-piece cast aluminum housing, a solid state LED indication, message lens, a single-piece cast aluminum swing down door frame, a blank out Z-crate type sun visor, and appropriate other hardware. The design shall optimize performance per unit of energy consumed.

3. Optically, the pedestrian signal shall be capable of displaying brightly and uniformly, while being subject to strong ambient light conditions, the alternate symbol messages "HAND" and countdown numbers in Portland orange, and "WALKING PERSON" in lunar white. Under the same strong ambient light conditions, the messages shall blank out when signal is not energized.

4. The maximum overall dimensions of the signal housing shall be 19 inches wide, 18-3/4 inches high, and 9-1/2 inches deep including the Z-crate type sun visor and hinges.

B. Mechanical Construction

1. The housing shall be one-piece, corrosion-resistant, die-cast aluminum alloy.

2. The housing shall be designed in such a way that all components and wiring are readily accessible by means of a hinged door and legend cover plate of the full size of housing face.

3. Gasketing material suitable to maintain weather, dust-tight seal about door and cover plates shall be used.

4. The door frame shall be a one-piece, corrosion-resistant aluminum alloy die casting, complete with two-hinged lugs at the bottom and two-latch slots cast at the top of each door. Hinge pins shall be corrosion-resistant material. Two stainless steel wing nuts and washers shall be attached to the top of the cast with the use of stainless steel spring pins. Latching or unlatching of the door shall require no tools.

C. Z-Crate Visor

1. The face of the signal shall be furnished with suitable Z-crate visor baffle designed to prevent false indications, due to sunlight or other reflections, without the use of hoods.

2. The visor baffle shall have a high-grade, flat black finish.

D. Optical System-LED Pedestrian Signals

1. The LED indications to be furnished with the Pedestrian Signal Heads shall meet the requirements of Specification Section 16719, "Pedestrian & Countdown Signal Module".

E. Wiring

1. All wiring shall be Underwriters' Laboratories (UL) approved for voltages involved. Terminals for field wiring shall be suitable for #14 AWG wire.

2. Barrier type terminal block, minimum twelve (12) terminal plates with two (2) binding screws each, shall be mounted in each housing.

F. Mounting Attachments

1. Side-of-Pole Mounting. Supports for side-of-pole mounting of the signal head in a vertical position shall be 1-1/2" standard pipe bracket arms, attached to the top and bottom of the signal head with pipe nipples, serrated elbows and collared / cast nipples and band-on pole plates. Pole plates shall be provided with a cable guide. The mounting assembly shall consist of two standard pipe sections extending 12-3/4" from and at right angles to the axis of rotational adjustment of the signal head. Both supports shall have running threads at least 1-1/4" long at the pole connection end. The signal head shall be adjustable, by rotation of the various signal faces about their vertical axis, throughout a radial angle of 360 degrees and shall be capable of being rigidly clamped in any position through the range of adjustment. The wiring from the signal head shall be able to be enclosed in the top or bottom support.

G. Painting

Pedestrian signal housing and mounting attachments shall be available in two finishes.. If no color is indicated, a yellow coating, as specified below, shall be furnished.

1. Federal Highway Yellow Finish: Signal housing and mounting attachments shall be primed and electrostatically finished with a yellow coating, except for baffle with paint finish. Finish shall be cured for minimum of twenty (20) minutes at 350 degrees F.

2. Flat Black Finish: Signal housing and mounting attachments shall be primed and finished with a flat black paint finish. Finish shall be cured for a minimum of twenty (20) minutes at 350 degrees F.

END OF SECTION

SECTION 16717

PROGRAMMABLE VEHICLE SIGNAL HEADS

PART 1 GENERAL

1.01 SECTION INCLUDES

The intent of this specification is to describe a 12-inch adjustable programmable limiting traffic signal section which shall permit the visibility zone of the indication to be determined optically. Programmable vehicle signal sections shall be assembled into signal heads of three (3), four (4), or five (5) sections.

The head shall employ no louvers or hoods to obtain this programmable limitation, however, if required, hoods shall be provided to eliminate extraneous light falling on the lens.

The projected indication may be selectively visible or veiled anywhere within 15 degrees of the optical axis.

1.02 UNIT PRICES

A. Measurement
This Item will be measured by each programmable vehicle signal head consisting of the number of sections as called for on the plans (3-section, 4-section, or 5-section), complete in place.

B. Payment
The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Programmable Vehicle Signal Head" of the various size specified (3-section, 4-section, or 5-section). This price shall be full compensation for furnishing, assembling and installing the signal sections in a signal head, for all mounting attachments, including additional mounting hardware or supports required to support the assembled head; and for all labor, tools, equipment and incidentals necessary to complete the work.

PART 2 PRODUCTS

2.01 MATERIALS

A. The optical system shall consist of the following basic components:

1. Lamp

2. Lamp Collar

3. Optical Limiter-Diffuser

4. Objective Lens

All other minor components necessary for the full utilization of the programmable head shall be provided.

The lamp shall be a nominal 150 watt, 120 volt, A.C., seven prong, tungsten filament, 85% krypton gas filled, having an integral reflector and 3 inch center length. The lamp shall have an average rated life of at least 7500 hours.

The optical limiter shall provide an accessible imaging surface at focus on the optical axis for objects 900 to 1200 feet distance. It shall permit an effective veiling mask to be variously applied as determined by the desired visibility zone.

The objective lens shall be a high resolution planar incremental lens. The lens shall be symmetrical in outline so that it may be rotated to any 90 degree orientation about the optical axis.

The optical system shall accommodate projection of diverse, selected indicia to separate portions of the roadway such that only one indication will be simultaneously apparent to any viewer. The projected indication shall conform to ITE transmittance and chromaticity standards.

B. Signal housings shall be die-cast conforming to the latest ITE specification alloy and tensile requirements. The exterior of the signal housing, lamp housing and mounting flanges shall be finished with two coats of separately baked on high quality enamel paint. The exterior color of the signal head with the exception of the inside of the visors shall be Federal Yellow or Flat Black, as specified on the drawings. The inside of the visors shall be painted a flat black.

Hinges and latch pins shall be stainless steel.

All access openings not otherwise utilized for mounting hardware or other purposes, shall be sealed with weather resistant rubber gaskets so that the resulting housing shall be moisture and dust proof.

The complete signal head shall consist of three or more individual sections, as shown on the drawings. The lens to be furnished likewise, shall be as shown on the drawings. Heat resistant tape or other masking material shall be provided in sufficient quantity to adequately

tape or mask all sections as specified. Lamps as specified, shall be provided for each required signal section so that each signal head will be a complete unit.

If so specified on the drawings, each individual signal section shall be equipped with a photo-electrical cell. Lamp intensity shall not be less than 97 percent of uncontrolled intensity at 1000 ft-c and shall reduce 15 ± 2 percent of maximum at less than one ft-c. The photo-electric cell shall be responsive within the range of 105 to 135 VAC, 60 cycles.

Lamp fixture shall comprise a separately accessible housing and integral lamp support, ceramic socket and self-aligning, quick release lamp retainer. Each signal section shall include a terminal block for screw-type attachment of lead wires. Concealed No. 18 stranded and coded copper wire shall interconnect all sections to permit field connection within any section.

PART 3 EXECUTION

3.01 MOUNTING AND INSTALLATION

The signal shall mount to standard 1-1/2 inch fittings as a single section, multiple sections or in combination with other signals. The fittings shall be provided with the signal head and shall be mounted as indicated on the drawings. The signals shall be mountable with ordinary tools and capable of being serviced with no special tools. Contractor shall be responsible for properly mounting signal.

3.02 GUARANTEE

It is normal trade practice for the manufacturer to furnish a guarantee for the work provided herein. The Contractor shall turn this guarantee over to the City of Houston for potential dealing with the guarantor. The extent of such guarantee will not be a factor in selecting the successful bidder.

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SECTION 16718

VEHICLE TRAFFIC CONTROL SIGNAL HEADS –
Light Emitting Diode (LED) Circular Signal Supplement

PART 1 GENERAL

1.01 SECTION INCLUDES

The purpose of this specification is to provide the minimum performance requirements for a 300 mm (12 in) Light Emitting Diode (LED) vehicle traffic signal module while in service. This specification is not intended to impose restrictions upon specific designs and materials that conform to the purpose and the intent of this specification. This specification is not restricted to any specific LED technology.

1.02 DEFINITIONS

A. Catastrophic Failure: The total loss of visible illumination from an LED light source.

B. Chromaticity: The color of the light emitted by a module, specified by the x, y chromaticity coordinates on the 1931 Commission Internationale d'Eclairage (CIE) chromaticity diagram.

C. Conditioning: Energizing a LED signal module at a specified ambient temperature for a specified period of time, to cause any early electronic component mortality failures to occur and to detect any component reliability problems.

D. Duty Cycle: The amount of time during a specified time period that a module is energized, expressed as a percent of the specified time period.

E. Hard Coat: A surface coating or film to provide front surface abrasion resistance.

F. LED Light Source: A single light emitting diode (LED) or an array of LEDs.

G. LED Signal Module (module): A signaling unit comprised of an array of LEDs and related power supply, and any required lenses, which, when connected to appropriate power, provides a circular signal indication.

H. Luminance: The luminous flux emitted or reflected from a surface, in a given direction, per unit solid angle, divided by the area of the surface, expressed as cd/m^2.

I. Luminous Intensity: The luminous flux emitted in a given direction from a source, per unit solid angle, expressed in candelas (cd).

J. Minimum Maintained Luminous Intensity: The minimum luminous intensity a module is required to provide throughout service as a traffic control signal.

K. Nominal Operating Voltage: The AC RMS voltage, 120 VAC, at which photometric performance and power consumption are specified.

L. Power Consumption: The electrical power in Watts consumed by a module when operated at nominal operating voltage and ambient operating temperature range.

M. Power Factor: The power factor equals Watts divided by Volt-Ampere or the ratio of power consumption in Watts to Volt-Amperes.

N. Total Harmonic Distortion (THD): THD is the ratio of the root-mean-square (RMS) value of the harmonics to the amplitude of the fundamental component of the AC waveform.

O. Translate: To move an object along a linear vector, such that the orientation of the object does not rotate relative to the original frame of reference.

P. Turn OFF Time: The amount of time required after removal of the nominal operating voltage for the LED signal module to show no visible illumination.

Q. Turn OFF Voltage: The voltage below which the LED signal module emits no visible illumination.

R. Turn ON Time: The amount of time required for the LED signal module to reach 90% of full illumination.

S. Volt-Amperes: The product of the root-mean-square (RMS) line voltage and RMS line current, measured with true RMS meters.

T. Diffused: Lens must be designed to diffuse the light form the LED array over the surface of the lens.

1.03 ENVIRONMENTAL REQUIREMENTS

A. All exposed components of a module shall be suitable for prolonged exposure to the environment, without appreciable degradation that would interfere with function or appearance. As a minimum, selected materials shall be rated for service for a period of a minimum of 72 months in a south-facing Arizona Desert installation.

B. A module shall be rated for use throughout an ambient operating temperature range, measured at the exposed rear of the module, of -40°C (-40°F) to +74°C (+165°F).

C. A module shall be protected against dust and moisture intrusion, including rain and blowing rain.

D. The module lens shall not crack, craze or yellow due to solar UV irradiation typical for a south-facing Arizona Desert installation after a minimum of 72 months in service.

PART 2 PRODUCTS

2.01 MATERIALS

A. LED SIGNAL MODULE

1. A module shall be capable of replacing the existing optical components or signal module in a signal housing, or shall provide a complete replacement of the signal head.

2. The module lens shall be hard coated or otherwise made to comply with the material exposure and weathering effects requirements of the Society of Automotive Engineers (SAE) J576.

3. The module lens supplied shall be covered by transparent film or materials with similar color and transmissive characteristics.

4. The module lens may be a replaceable part, without the need to replace the complete LED signal module. Removal of lense will be with simple hand tools and such that no inclusion of additional adhesive, sealants, etc will be required to provide replacement of lense.

5. Materials used for the lens and module construction shall conform to ASTM specifications for the materials, where applicable.

6. Lens must diffuse the LED array over the entire surface of the lens.

7. LED Modules used for arrows must meet same photometric and chromaticity requirements as circular modules. (optional)

8. Enclosures containing either the power supply or electronic components of the signal module shall be made of UL94 flame retardant materials. The module lens is excluded from this requirement.

2.02 MODULE IDENTIFICATION

A. Each module shall be identified on the backside with the manufacturer's name, model, operating characteristics and serial number. The operating characteristics identified shall

include the nominal operating voltage and stabilized power consumption, in watts and Volt-Amperes.

B. Modules and removable lenses shall have a prominent and permanent vertical indexing indicator, i.e., UP Arrow, or the word UP or TOP, for correct indexing and orientation in the signal housing.

C. Modules conforming to all non-optional requirements of this specification may have the following statement on an attached label: "Manufactured in Conformance with the COH LED Circular Signal Supplement."

2.03 PHOTOMETRIC REQUIREMENTS

A. Luminous Intensity, Uniformity & Distribution.

1. Minimum maintained luminous intensity: When operated under the conditions defined in Sections 1.03-B and 2.04-A-1, the luminous intensity values for modules shall not be less than the values calculated using the method described below for a minimum period of 72 months.

2. Calculate the vertical intensity factor ($f(I_{Vert})$) for the range from 12.5 degrees up (+12.5) to 27.5 degrees down (-27.5), using the appropriate equation:

For $\theta_{Vert} > -2.5$ degrees:

$$f(I_{Vert}) = 0.05 + 0.9434 * e^{-\left(\frac{\theta_{Vert}+2.5}{5.3}\right)}$$

For $\theta_{Vert} \leq -2.5$ degrees:

$$f(I_{Vert}) = 0.26 + \left(\frac{\theta Vert}{143}\right) + 0.76 * \left[e^{-0.02\left(\theta_{Vert}+2.5\right)^2}\right]^{\left(-0.07*\theta_{Vert}\right)}$$

where: θ_{Vert} is the angle measured above or below a horizontal plane perpendicular to the face of the module lens. (Note: angles above the horizontal plane are positive, while angles below the horizontal plane are negative.)

3. Calculate the horizontal intensity factor ($f(I_{Horiz})$) for the range from 27.5 degrees left to 27.5 degrees right:

$$f(I_{Horiz}) = 0.05 + \left(0.95 * e^{\left(-\frac{1}{2} * \left(\frac{\theta_{Horiz}}{11} \right)^2 \right)} \right)$$

where: θ_{Horiz} is the angle measured from a vertical plane to the left or right, perpendicular to the face of the module lens.

4. Select the appropriate peak minimum maintained luminous intensity value for the specified module size and color:

Peak minimum maintained luminous intensity values, at $\theta_{Vert} = -2.5$ deg and $\theta_{Horiz} = 0$ deg [$\mathbf{I}_{(-2.5, 0)}$], by size and color of the module are:

Color	$\mathbf{I}_{(-2.5, 0)}$ 200m	300m
Red	165 cd	365 cd
Yello	410 cd	910 cd
Green	215 cd	475 cd

5. Multiply the vertical intensity factor times the horizontal intensity factor (for the selected pair of angles). Round the result to two significant figures, and multiply the combined angular intensity factor times the peak minimum maintained luminous intensity value for the appropriate signal size and color:

$$I_{(\theta vert,\, \theta horiz,\, size,\, color)} = [f(I_{Vert}) * f(I_{Horiz})] * I_{(-2.5,\, 0)}$$

The resultant value of the luminous intensity shall be rounded to the nearest whole number.

Example: What is the minimum maintained luminous intensity value for a green, 300 mm LED signal light at 5 degrees down and 10 degrees left?

$$I_{(-5,\ 10,\ 300,\ Green)} = [f(I_{vert\ =\ -5})^{*}\ f(I_{horiz\ =\ 10})]^{*}475\ cd$$
$$I_{(-5,\ 10,\ 300,\ Green)} = [0.953^{*}0.678]^{*}475\ cd$$
$$I_{(-5,\ 10,\ 300,\ Green)} = 0.65^{*}475 = 309\ cd$$

6. Table 1 located at end of spec., provides the minimum maintained luminous intensity values, over the required angular range, at 5-degree increments. Note that the horizontal limitations vary for various vertical angles (e.g.: at θ_{Vert} = +12.5 degrees, requirements are only specified from 7.5 degrees right to 7.5 degrees left, while at θ_{Vert} = -12.5 degrees, the horizontal limitations are from 27.5 degrees right to 27.5 degrees left). Table 2 located at end of spec, provides the minimum maintained luminous intensity values, over the required angular range, at 2.5-degree increments. Tables 1 and 2 are provided to illustrate the minimum required values at certain specific angles within the required angular range of performance (i.e. while testing for light output compliance of a module in a laboratory, an agency may use Table 1, and/or other specific pairs of vertical and horizontal angles of its choosing within the required angular range.) One must use the procedure outlined above for determining the minimum maintained luminous intensity values at any specific pairs of vertical and horizontal angles within the required angular range.

7. Maximum permissible luminous intensity: When operated within the temperature range specified in Section 1.03-B, the actual luminous intensity for a module shall not exceed three times the required peak value of the minimum maintained luminous intensity for the selected signal size, and color.

8. Luminance uniformity: The uniformity of the signal output across the entire module lens shall not exceed a ratio of 10 to 1 between the maximum and minimum luminance values (cd/m^2).

B. CHROMATICITY

1. Color regions: The measured chromaticity coordinates of modules shall conform to the following color regions, based on the 1931 CIE chromaticity diagram (see Figure 1):

Red: $y = 0.308$; $y = 0.953 - 0.947x$; $y = 0.290$:

Point	Red	
	X	*y*
1	0.692	0.308
2	0.681	0.308
3	0.700	0.290
4	0.710	0.290

Yellow: $y = 0.151 + 0.556x$; $y = 0.972 - 0.976x$; $y = 0.235 + 0.300x$:

Point	Yellow	
	X	*Y*
1	0.545	0.454
2	0.536	0.449
3	0.578	0.408
4	0.588	0.411

Green: $y = 0.655 - 0.831x$ $x = 0.150$; $y = 0.422 - 0.278x$:

Point	Green	
	X	*Y*
1	0.005	0.651
2	0.150	0.531
3	0.150	0.380
4	0.022	0.416

2. Color uniformity: The dominant wavelength for any individual color measurement of a portion of the emitting surface of a module shall be within ±3nm of the dominant wavelength for the average color measurement of the emitting surface as a whole.

2.04 ELECTRIC

All wiring and terminal blocks shall meet the requirements. Two secured, color coded, 600V, jacketed wires, a minimum of 20 AWG and at least 1 meter (39 in) in length, conforming to the NFPA 70, National Electrical Code, and rated for service at +105°C, shall be provided.

A. VOLTAGE RANGE

1. LED signal modules shall operate from a 60±3 Hz AC line power over a voltage range from 80 to 135 VAC RMS.

2. Fluctuations in line voltage over the range of 80 to 135 VAC shall not affect luminous intensity by more than ±10 percent.

3. The module circuitry shall prevent flicker of the LED output at frequencies less than 100 Hz over the voltage range specified in Section 2.04-A-1.

4. Low Voltage Turn OFF: There shall be no visible illumination from the LED signal module when the applied voltage is less than 35 VAC.

5. Turn-ON and Turn-OFF Time: A module shall reach 90% of full illumination (turn-ON) within 75 msec of the application of the nominal operating voltage. The signal shall cease emitting visible illumination (turn-OFF) within 75 msec of the removal of the nominal operating voltage.

B. TRANSIENT VOLTAGE PROTECTION

1. The on-board circuitry of a module shall include voltage surge protection, to withstand high-repetition noise transients and low-repetition high-energy transients.

C. INPUT PROTECTION (optional)

1. At the point of entry to the module for each input provide two 0.5-Ohm, 10-watt wire-wound power resistors with 0.2 micro Henries inductance (one on the AC+ Line & on the AC- Line). Provide one 20 Joule surge arrestor between AC+ to AC-. A 0.68 microfarad capacitor must be placed between AC+ & AC – (between the resistor & arrestor).

D. ELECTRONIC NOISE

1. The LED signal and associated on-board circuitry shall meet the requirements of the Federal Communication Commission (FCC) Title 47, Subpart B, Section 15 regulations concerning the emission of electronic noise by Class A digital devices.

E. POWER FACTOR AND AC HARMONIES

1. Modules shall provide a power factor of 0.90 or greater when operated at nominal operating voltage, and 25°C (77°F).

2. Total harmonic distortion induced into an AC power line by a module at nominal operating voltage, and at 25°C (77°F), shall not exceed 20%.

F. CONTROLLER ASSEMBLY COMPATIBILITY

1. The current draw shall be sufficient to ensure compatibility and proper triggering and operation of load current switches and conflict monitors in signal controller units.

2. Off State Voltage Decay: When the module is switched from the On state to the Off state the terminal voltage shall decay to a value less than 10 VAC RMS in less than 100 milliseconds when driven by a maximum allowed load switch leakage current of 10 milliamps peak (7.1 milliamps AC).

G. FAILED STATE IMPEDANCE

1. The module shall be designed to detect catastrophic loss of the LED load. Upon sensing the loss of the LED load, the module shall present a resistance of at least 250 kΩ across the input power leads within 300 msec. The LED light source will be said to have failed catastrophically if it fails to show any visible illumination when energized according to Section 2.04-A-1 after 75 msec.

PART 3 EXECUTION

3.01 PHYSICAL & MECHANICAL REQUIREMENTS

A. GENERAL

1. Modules shall fit into existing traffic signal housings built to the VTCSH Standard without modification to the housing, or shall be stand-alone units that incorporate a housing meeting the performance and design requirements of the VTCSH Standard.

2. Installation of a module into an existing signal housing shall not require the use of special tools. The module shall connect directly to existing electrical wiring system.

3.02 CONSTRUCTION

A. A module shall be a self-contained device, not requiring on-site assembly for installation into an existing traffic signal housing. The power supply for the module may be either integral or packaged as a separate component. The power supply may be designed to fit and mount inside the traffic signal housing adjacent to the LED signal module.

B. Assembly and manufacturing processes for a module shall be designed to assure all internal LED and electronic components are adequately supported to withstand mechanical shock and vibration due to high winds and other sources.

END OF SECTION

Table 1

Table 1 provides the minimum maintained luminous intensity values for the Section 16718 COH SPEC. LED Circular Signal, for the range from 12.5 degrees above to 22.5 degrees below the horizontal plane, and from 27.5 degrees left to 27.5 degrees right of the vertical plane, at 5 degree increments.
Minimum Maintained Luminous Intensity Values—Section 16718 COH SPEC LED Circular Signal

Vertical Angle	Horizontal Angle	Luminous Intensity (candela)					
		200m (8-inch)			300 mm (12-inch)		
		Red	Yellow	Green	Red	Yellow	Green
+12.5	2.5	17	41	22	37	91	48
	7.5	13	33	17	29	73	38
+7.5	2.5	31	78	41	69	173	90
	7.5	25	62	32	55	137	71
	12.5	18	45	24	40	100	52
+2.5	2.5	68	168	88	150	373	195
	7.5	56	139	73	124	309	162
	12.5	38	94	49	84	209	109
	17.5	21	53	28	47	118	62
	22.5	12	29	15	26	64	33
-2.5	2.5	162	402	211	358	892	466
	7.5	132	328	172	292	728	380
	12.5	91	226	118	201	501	261
	17.5	53	131	69	117	291	152
	22.5	28	70	37	62	155	81
	27.5	15	37	19	33	82	43
-7.5	2.5	127	316	166	281	701	366
	7.5	106	262	138	234	582	304
	12.5	71	176	92	157	391	204
	17.5	41	103	54	91	228	119
	22.5	21	53	28	47	118	62
	27.5	12	29	15	26	64	33
-12.5	2.5	50	123	65	110	273	143
	7.5	40	98	52	88	218	114
	12.5	28	70	37	62	155	81
	17.5	17	41	22	37	91	48
	22.5	8	21	11	18	46	24
	27.5	5	12	6	11	27	14
-17.5	2.5	23	57	30	51	127	67
	7.5	18	45	24	40	100	52
	12.5	13	33	17	29	73	38
	17.5	7	16	9	15	36	19

	22.5	3	8	4	7	18	10
-22.5	2.5	17	41	22	37	91	48
	7.5	13	33	17	29	73	38
	12.5	10	25	13	22	55	29
	17.5	5	12	6	11	27	14
-27.5	2.5	12	29	15	26	64	33
	7.5	8	21	11	18	46	24

Note 1: Luminous intensity values for equivalent left and right horizontal angles are the same.
Note 2: Tabulated values of luminous intensity are rounded to the nearest whole value.

Table 2

Table 2 provides the minimum maintained luminous intensity values for the Section 16718 COH SPEC LED Circular Signal, for the range from 12.5 degrees above to 22.5 degrees below the horizontal plane, and from 27.5 degrees left to 27.5 degrees right of the vertical plane, at 2.5 degree increments.
Minimum Maintained Luminous Intensity Values—Section 16718 COH SPEC LED Circular Signal

Vertical Angle	Horizontal Angle	Luminous Intensity (candela)					
		200m (8-inch)			300 mm (12-inch)		
		Red	Yellow	Green	Red	Yellow	Green
+12.5	0	18	45	24	40	100	52
	2.5	17	41	22	37	91	48
	5	17	41	22	37	91	48
	7.5	13	33	17	29	73	38
+10.0	0	23	57	30	51	127	67
	2.5	23	57	30	51	127	67
	5	21	53	28	47	118	62
	7.5	18	45	24	40	100	52
+7.5	0	31	78	41	69	173	90
	2.5	31	78	41	69	173	90
	5	28	70	37	62	155	81
	7.5	25	62	32	55	137	71
	10	21	53	28	47	118	62
	12.5	18	45	24	40	100	52
+5.0	0	46	115	60	102	255	133
	2.5	45	111	58	99	246	128
	5	41	103	54	91	228	119
	7.5	36	90	47	80	200	105
	10	31	78	41	69	173	90
	12.5	25	62	32	55	137	71
+2.5	0	69	172	90	153	382	200
	2.5	68	168	88	150	373	195
	5	63	156	82	139	346	181
	7.5	56	139	73	124	309	162
	10	46	115	60	102	255	133
	12.5	38	94	49	84	209	109
	15	30	74	39	66	164	86
	17.5	21	53	28	47	118	62
	20	17	41	22	37	91	48
	22.5	12	29	15	26	64	33

0.0	0	106	262	138	234	582	304
	2.5	102	254	133	226	564	295
	5	96	238	125	212	528	276
	7.5	84	209	110	186	464	242
	10	71	176	92	157	391	204
	12.5	58	144	75	128	319	166
	15	45	111	58	99	246	128
	17.5	33	82	43	73	182	95
	20	25	62	32	55	137	71
	22.5	18	45	24	40	100	52

Table 2 (cont'd)

Vertical Angle	Horizontal Angle	Luminous Intensity (candela)					
		200m (8-inch)			300 mm (12-inch)		
		Red	Yellow	Green	Red	Yellow	Green
-2.5	0	165	410	215	365	910	475
	2.5	162	402	211	358	892	466
	5	150	373	196	332	828	432
	7.5	132	328	172	292	728	380
	10	112	279	146	248	619	323
	12.5	91	226	118	201	501	261
	15	71	176	92	157	391	204
	17.5	53	131	69	117	291	152
	20	38	94	49	84	209	109
	22.5	28	70	37	62	155	81
	25	20	49	26	44	109	57
	27.5	15	37	19	33	82	43
-5.0	0	157	390	204	347	865	451
	2.5	153	381	200	339	846	442
	5	142	353	185	314	783	409
	7.5	125	312	163	277	692	361
	10	107	267	140	237	592	309
	12.5	86	213	112	190	473	247
	15	66	164	86	146	364	190
	17.5	50	123	65	110	273	143
	20	36	90	47	80	200	105
	22.5	26	66	34	58	146	76
	25	20	49	26	44	109	57
	27.5	15	37	19	33	82	43
-7.5	0	130	324	170	288	719	375
	2.5	127	316	166	281	701	366
	5	119	295	155	263	655	342
	7.5	106	262	138	234	582	304
	10	89	221	116	197	491	257
	12.5	71	176	92	157	391	204
	15	56	139	73	124	309	162
	17.5	41	103	54	91	228	119
	20	30	74	39	66	164	86
	22.5	21	53	28	47	118	62
	25	17	41	22	37	91	48

	27.5	12	29	15	26	64	33
-10.0	0	89	221	116	197	491	257
	2.5	86	213	112	190	473	247
	5	81	201	105	179	446	233
	7.5	71	176	92	157	391	204
	10	59	148	77	131	328	171
	12.5	48	119	62	106	264	138
	15	38	94	49	84	209	109
	17.5	28	70	37	62	155	81
	20	20	49	26	44	109	57
	22.5	15	37	19	33	82	43
	25	12	29	15	26	64	33
	27.5	8	21	11	18	46	24

Table 2 (cont'd)

Vertical Angle	Horizontal Angle	Luminous Intensity (candela)					
		200m (8-inch)			300 mm (12-inch)		
		Red	Yellow	Green	Red	Yellow	Green
-12.5	0	50	123	65	110	273	143
	2.5	50	123	65	110	273	143
	5	46	115	60	102	255	133
	7.5	40	98	52	88	218	114
	10	35	86	45	77	191	100
	12.5	28	70	37	62	155	81
	15	21	53	28	47	118	62
	17.5	17	41	22	37	91	48
	20	12	29	15	26	64	33
	22.5	8	21	11	18	46	24
	25	7	16	9	15	36	19
	27.5	5	12	6	11	27	14
-15.0	0	30	74	39	66	164	86
	2.5	30	74	39	66	164	86
	5	28	70	37	62	155	81
	7.5	25	62	32	55	137	71
	10	20	49	26	44	109	57
	12.5	17	41	22	37	91	48
	15	13	33	17	29	73	38
	17.5	10	25	13	22	55	29
	20	7	16	9	15	36	19
	22.5	5	12	6	11	27	14
-17.5	0	23	57	30	51	127	67
	2.5	23	57	30	51	127	67
	5	21	53	28	47	118	62
	7.5	18	45	24	40	100	52
	10	17	41	22	37	91	48
	12.5	13	33	17	29	73	38
	15	10	25	13	22	55	29
	17.5	7	16	9	15	36	19
	20	5	12	6	11	27	14
	22.5	3	8	4	7	18	10
-20.0	0	20	49	26	44	109	57
	2.5	20	49	26	44	109	57
	5	18	45	24	40	100	52

	7.5	17	41	22	37	91	48
	10	13	33	17	29	73	38
	12.5	12	29	15	26	64	33
	15	8	21	11	18	46	24
	17.5	7	16	9	15	36	19
-22.5	0	17	41	22	37	91	48
	2.5	17	41	22	37	91	48
	5	15	37	19	33	82	43
	7.5	13	33	17	29	73	38
	10	12	29	15	26	64	33
	12.5	10	25	13	22	55	29
	15	7	16	9	15	36	19
	17.5	5	12	6	11	27	14

Table 2 (cont'd)

Vertical Angle	Horizontal Angle	Luminous Intensity (candela)					
		200m (8-inch)			300 mm (12-inch)		
		Red	Yellow	Green	Red	Yellow	Green
-25.0	0	15	37	19	33	82	43
	2.5	13	33	17	29	73	38
	5	13	33	17	29	73	38
	7.5	12	29	15	26	64	33
-27.5	0	12	29	15	26	64	33
	2.5	12	29	15	26	64	33
	5	10	25	13	22	55	29
	7.5	8	21	11	18	46	24

Note 1: Luminous intensity values for equivalent left and right horizontal angles are the same.
Note 2: Tabulated values of luminous intensity are rounded to the nearest whole value.

Figure 1

Color Regions for LED Traffic Control Signal Lights:

Figure 1 illustrates the acceptable color regions for traffic control signal lights using LED emitters as the light source.

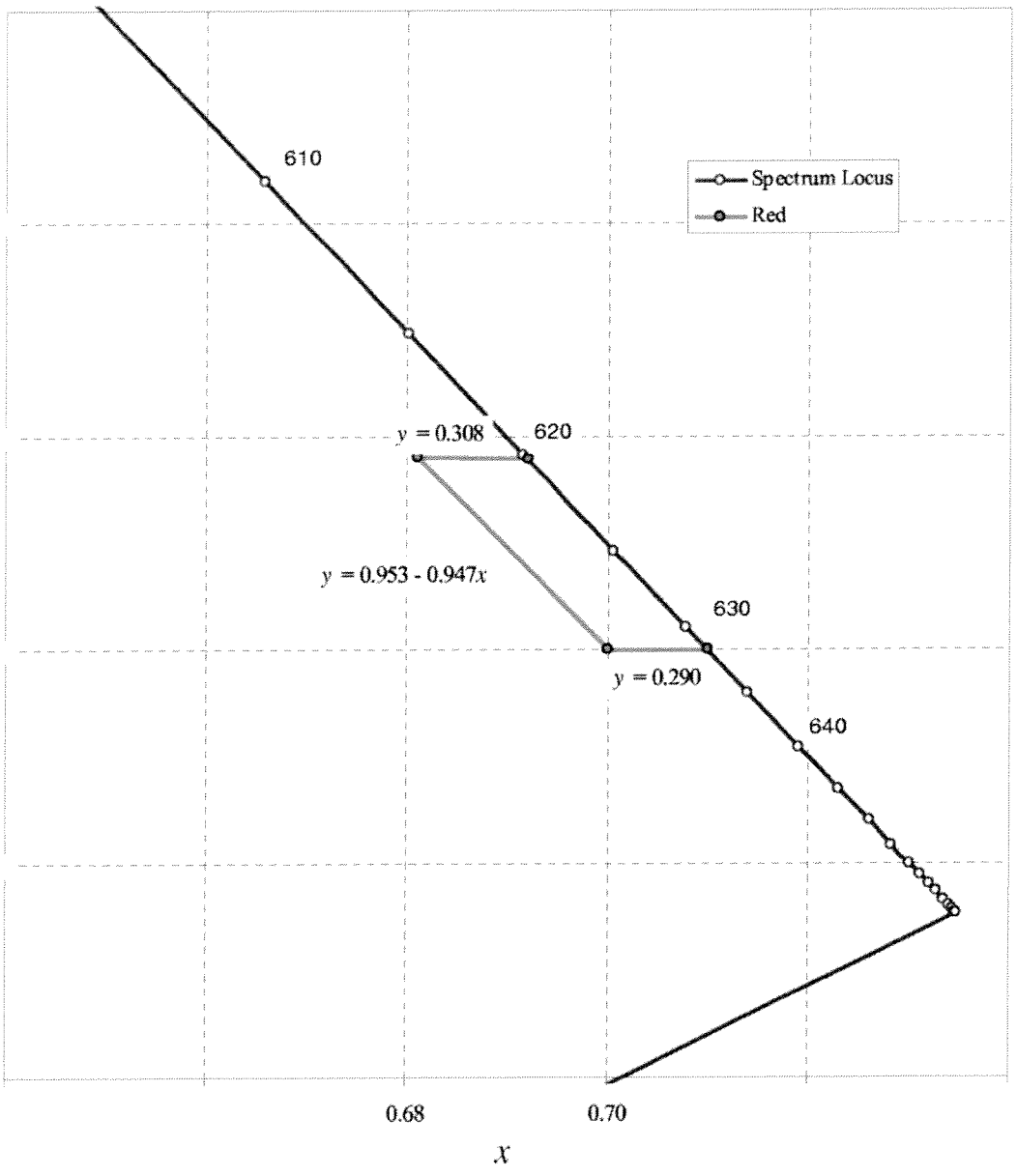

Figure 1a: Color Region for Red Traffic Control Signal Lights

Figure 1 (cont'd)

Color Regions for LED Traffic Control Signal Lights:

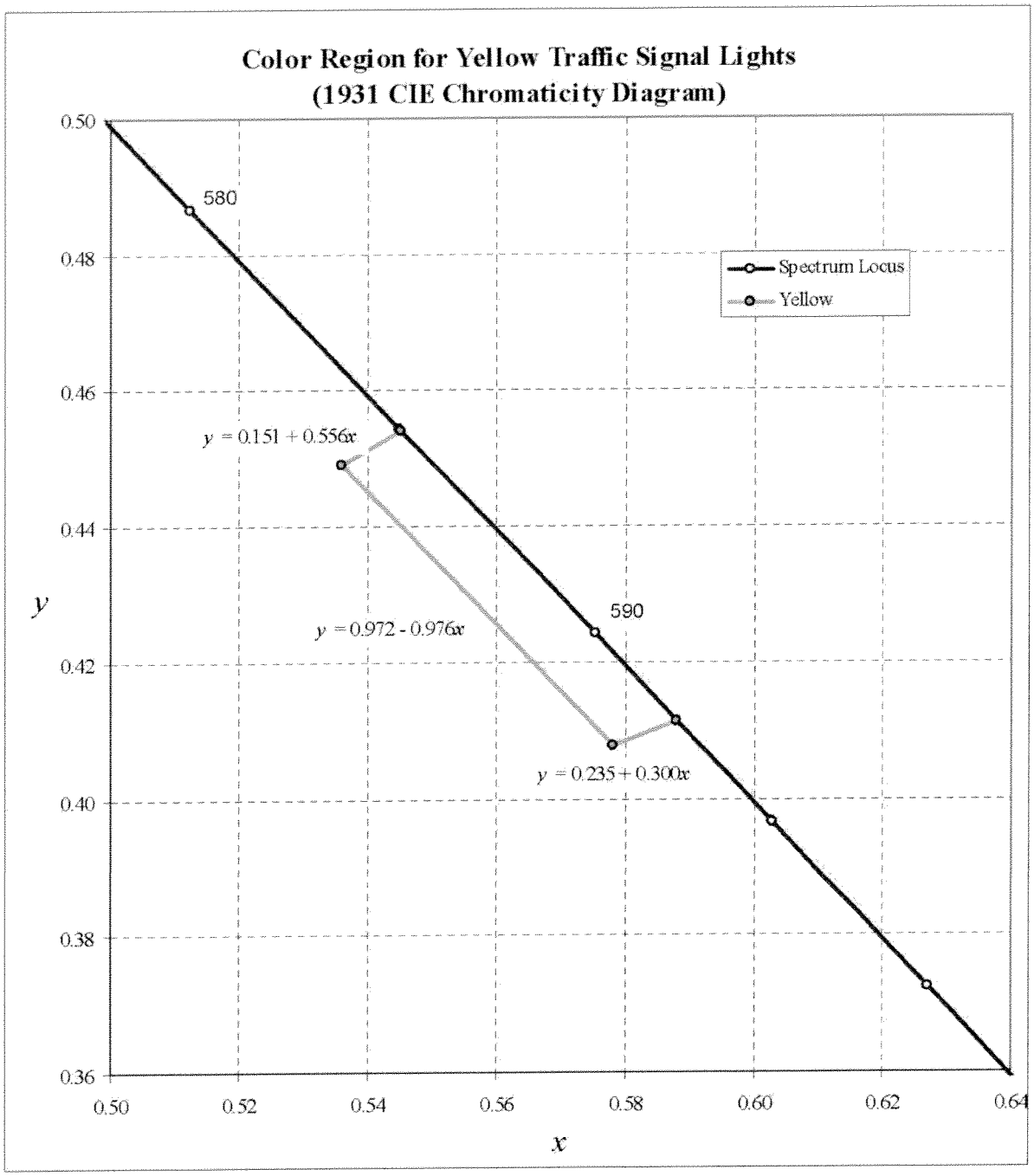

Figure 1b: Color Region for Yellow Traffic Control Signal Lights

Figure 1 (cont'd)

Color Regions for LED Traffic Control Signal Lights:

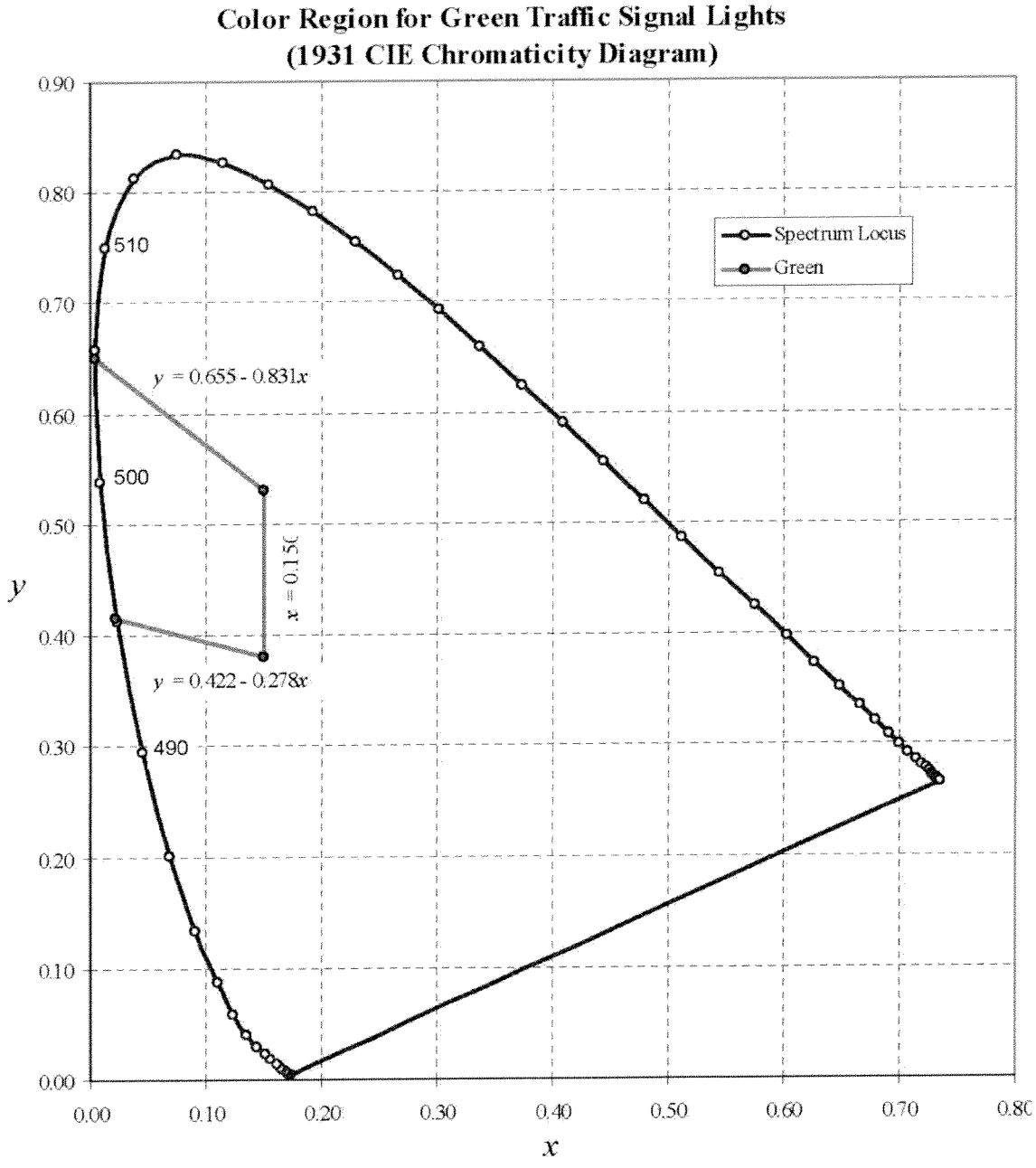

Table 1 a. – Minimum Maintained Luminous Intensity

Vertical Angle	Horizontal Angle	Red 8"		Yellow 8"		Green 8"		RED 12"		Yellow 12"		Green 12"	
		Min.	160%	Min.	110%	Min.	135%	Min.	160%	Min.	110%	Min.	135%
12.5	2.5	17	27	41	45	22	30	37	59	91	100	48	65
	7.5	13	21	33	36	17	23	29	46	73	80	38	51
7.5	2.5	31	50	78	86	41	55	69	110	173	190	90	122
	7.5	25	40	62	68	32	43	55	88	137	151	71	96
	12.5	18	29	45	50	24	32	40	64	100	110	52	70
2.5	2.5	68	109	168	185	88	119	150	240	373	410	195	263
	7.5	56	90	139	153	73	99	124	198	309	340	162	219
	12.5	38	61	94	103	49	66	84	134	209	230	109	147
	17.5	21	34	53	58	28	38	47	75	118	130	62	84
	22.5	12	19	29	32	15	20	26	42	64	70	33	45
-2.5	2.5	162	259	402	442	211	285	358	573	892	981	466	629
	7.5	132	211	328	361	172	232	292	467	728	801	380	513
	12.5	91	146	226	249	118	159	201	322	501	551	261	352
	17.5	53	85	131	144	69	93	117	187	291	320	152	205
	22.5	28	45	70	77	37	50	62	99	155	171	81	109
	27.5	15	24	37	41	19	26	33	53	82	90	43	58
-7.5	2.5	127	203	316	348	166	224	281	450	701	771	366	494
	7.5	106	170	262	288	138	186	234	374	582	640	304	410
	12.5	71	114	176	194	92	124	157	251	391	430	204	275
	17.5	41	66	103	113	54	73	91	146	228	251	119	161
	22.5	21	34	53	58	28	38	47	75	118	130	62	84
	27.5	12	19	29	32	15	20	26	42	64	70	33	45
-12.5	2.5	50	80	123	135	65	88	110	176	273	300	143	193
	7.5	40	64	98	108	52	70	88	141	218	240	114	154
	12.5	28	45	70	77	37	50	62	99	155	171	81	109
	17.5	17	27	41	45	22	30	37	59	91	100	48	65
	22.5	8	13	21	23	11	15	18	29	46	51	24	32
	27.5	5	8	12	13	6	8	11	18	27	30	14	19
-17.5	2.5	23	37	57	63	30	41	51	82	127	140	67	90
	7.5	18	29	45	50	24	32	40	64	100	110	52	70
	12.5	13	21	33	36	17	23	29	46	73	80	38	51
	17.5	7	11	16	18	9	12	15	24	36	40	19	26
	22.5	3	5	8	9	4	5	7	11	18	20	10	14
-22.5	2.5	17	27	41	45	22	30	37	59	91	100	48	65
	7.5	13	21	33	36	17	23	29	46	73	80	38	51
	12.5	10	16	25	28	13	18	22	35	55	61	29	39
	17.5	5	8	12	13	6	8	11	18	27	30	14	19
-27.5	2.5	12	19	29	32	15	20	26	42	64	70	33	45
	7.5	8	13	21	23	11	15	18	29	46	51	24	32

SECTION 16719

COUNTDOWN PEDESTRIAN SIGNAL MODULE

PART 1 GENERAL

Furnish LED countdown pedestrian signal modules that conform to the following:

A. Manual on Uniform Traffic Control Devices (MUTCD)
Control Signal Indications (PTCSI).

B. Federal Communications Commission (FCC) Title 47, Subpart B, Section 15 on the Emission of Electronic Noise.

1.01 MATERIALS

The items furnished and installed under this contract shall be new, unused of the latest product in production to commercial trade, and shall be of the highest quality as to materials used and workmanship. Manufacturers furnishing these items shall be experienced in design and construction of such items and shall furnish evidence of having supplied similar items which have been in successful operation. The bidder shall be an established supplier of the items bid.

1.02 UNIT IDENTIFICATION

Units shall be clearly marked on the back surface of the unit in a permanent manner showing information required for warranty and long term performance. Information to be shown shall include manufacturer name, date of manufacture, electric power requirements, model type, and serial number

1.03 SILENCE OF SPECIFICATIONS

The apparent silence of these specifications as to any detail, or the apparent omission from them of a detailed description concerning any point, shall be regarded as meaning that only the best commercial practice is to prevail and that only material and workmanship of the finest quality are to be used. All interpretations of these specifications shall be made on the basis of this statement. The bidder shall be an established supplier of the items bid.

1.04 TEST EQUIPMENT

Suppliers/manufacturers shall furnish with their bid a complete description and cost of any special test equipment that is necessary to install, operate, or maintain its equipment.

1.05 UNIT PRICES

A. Measurement
This item will be measured as by each countdown pedestrian signal module complete in place.

B. Payment
The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid at the unit price bid for "Countdown Pedestrian Signal Module". This price shall be full compensation for furnishing, assembling, and installing the countdown signal, and for all mounting attachments, labor, tools, equipment, and incidentals necessary to complete the work.

PART 2 PRODUCTS

Upon request, one schematic wiring diagram and installation manual shall be provided with each LED module.

2.01 MATERIALS

A. Countdown Pedestrian Signal Module

1. The message-bearing surface of the module shall be supplied with a fully populated "HAND" and "MAN" symbol, overlapping, that comply with PTCSI Standard for these symbols for a message-bearing surface of the size specified.

2. The LED module shall display a solid Portland orange hand and lunar white man and two Portland orange countdown numbers.

3. The numbers 00 to 99 on the numerical display shall have 2 rows of LEDs, that are side by side, not offset, and a minimum height of 9 inches.

4. The LED countdown pedestrian signal module shall be a single, self-contained device.

5. Portland Orange (amber hand and countdown numbers) LEDs shall be "AlInGaP" (Aluminum Indium Gallium Phosphorus) technology or equal, and rated for 100,000 hours or more of continuous usage at 25°C and 20 mA. White LEDs shall be InGaN (Indium Gallium Nitide) technology.

6. The assembly and manufacturing process for all internal LED and electronic components shall be adequately supported to withstand mechanical shock and vibration from high winds and other sources.

7. The signal module shall be made of UL94VO flame-retardant materials. The lens is excluded from this requirement.

8. The lens of the LED pedestrian and countdown signal modules shall be polycarbonate UV stabilized.

9. The exterior of the lens of the LED countdown pedestrian signal module shall be uniform and frosted to reduce sun phantom effect.

10. Each individual LED traffic module shall be identified for warranty purposes with the manufacturer's trade name, serial number and operating characteristics, i.e., rated voltage, power consumption, and volt-ampere.

11. LED countdown pedestrian signal modules shall fit into traffic housings built to the VTCSH Standard without any modification to the housing.

12. Lens must diffuse the LED array over the entire surface of the lens.

B. ENVIRONMENTAL REQUIREMENTS

1. The LED pedestrian and countdown signal modules shall be rated for use in the ambient operating temperature range of -40°C to +60°C (-40°F to +140°F).

2. The LED pedestrian and countdown signal modules, when properly installed with gasket, shall be protected against dust and moisture intrusion per requirements of NEMA Standard 250-1991, sections 4.7.2.1 and 4.7.3.2, for type 4 enclosures to protect all internal LED, electronic, and electrical components.

C. ELECTRICAL REQUIREMENTS

1. The secured, color coded, 914 mm (36 in) long, 600V, 20 AWG minimum, jacketed wires, conforming to the National Electrical Code, rated for service at +105°C, are to be provided for electrical connection.

2. The LED pedestrian and countdown signal module shall operate from a 60 ±3 Hz AC line over a voltage range of 80 to 135 volts rms. Variations in the voltage range shall have a minimal impact, less than 10%, on the luminous output of the module. Rated voltage for all measurements shall be 120 ±3 volts rms.

3. The LED circuitry shall prevent perceptible flicker over the voltage range specified above.

4. Transient Voltage Immunity: The modules shall be tested for transient immunity, at minimum amplitude of 2000 volts, using the procedure described in Section 2.1.8, NEMA Standard TS 2-2003.

5. Catastrophic failure of one LED light source in Man & Hand Symbol shall not result in the loss of more than the light from the one display segment.

6. The LED pedestrian and countdown module shall be operationally compatible with the currently used controller assemblies. The LED pedestrian and countdown module shall be operationally compatible with conflict monitors.

7. The LED pedestrian and countdown module including its circuitry must meet Federal Communications Commission (FCC) Title 47, Subpart B, Section 15 regulations concerning the emission of electronic noise.

8. The LED pedestrian and countdown module shall provide a power factor of .90 or greater when operated at the nominal operating voltages, and 25 degrees C (77 degrees F).

9. Total harmonic distortion (current and voltage) induced into an AC power line by an LED pedestrian and countdown module operated at the nominal operating voltages, and 25 degrees C (77 degrees F), shall not exceed 20 percent.

D. INPUT PROTECTION (optional)

At the point of entry to the module for each input provide two 0.5-Ohm, 10-watt wire-wound power resistors with 0.2 micro Henries inductance (one on the AC+ Line & on the AC- Line). Provide one 20 Joule surge arrestor between AC+ to AC-. A 0.68 microfarad capacitor must be placed between AC+ & AC – (between the resistor & arrestor).

E. PHOTOMETRIC REQUIREMENTS

1. Luminance

For a minimum period of 60 months, the maintained minimum luminance values for the modules under the operating conditions defined in Sections 3.3.1 and 5.2.1, when measured normal to the plane of the icon surface, shall not be less than:

Walking person: 2,200 cd/m^2
Hand: 1,400 cd/m^2

The luminance of the emitting surface, measured at angles from the normal of the surface, may decrease linearly to a value of 50% of the values listed above at an angle of 15 degrees.

The light output requirements in this specification apply to pedestrian signal heads without any visors, hooded or louvered (egg-crate). Addition of such visors may affect the light output of the signal head, and the purchasing agency may wish to consult the issue with the manufacturer.

2. Uniformity and Distribution

The uniformity of the walking person and hand icons' luminance shall meet a ratio of not more than 1 to 5 between the minimum and maximum luminance values, as measured in 12mm (0.5 in) diameter spots.

When operating within the temperature range specified in Section B1, the average luminance of the module shall not exceed three times the maintained minimum luminance of the modules, as defined in Section D1.

3. Chromaticity

The standard colors for the LED Pedestrian Signal Module shall be White for the walking person and Portland Orange for the hand icon. The colors for these icons shall conform to the following color regions, based on the 1931 CIE chromaticity diagram:

Walking Person—
White: Blue boundary: $x = 0.280$.
1st Green boundary: $0.280 \leq x < 0.400$
$y = 0.7917 \cdot x + 0.0983$.
2nd Green boundary: $0.400 \leq x < 0.450$
$y = 0.4600 \cdot x + 0.2310$.
Yellow boundary: $x = 0.450$
1st Purple boundary: $0.450 \leq x < 0.400$
$y = 0.4600 \cdot x + 0.1810$.
2nd Purple boundary: $0.400 \leq x < 0.280$
$y = 0.7917 \cdot x + 0.0483$.

White Point	*x*	*y*
1	0.280	0.320
2	0.400	0.415
3	0.450	0.438
4	0.450	0.388
5	0.400	0.365
6	0.280	0.270

Hand—Portland Orange:
Yellow boundary: y = 0.390
White boundary: $0.600 \leq x \leq 0.659$ y = 0.990 – x Red boundary: y = 0.331.

Portland Orange Point	x	y
1	0.6095	0.390
2	0.600	0.390
3	0.659	0.331
4	0.669	0.331

4. Color Uniformity

The uniformity of the emitted colors shall be such that any color measurement within a 12mm (0.5 in) spot on the emitting surface shall fall within the following regions around the average measured color of the entire emitting surface:

• Walking Person—White:

where Δx and Δy are the differences in the chromaticity coordinates of the measured colors to the coordinates of the average color, using the CIE 1931 Chromaticity Diagram and a 2 degree Standard Observer.

• Hand—Portland Orange:

The dominant wavelength for all individual color measurements shall be within ±3 nm of the dominant wavelength for the average of all the individual color measurements.

F. FUNCTIONAL REQUIREMENTS

1. Basic Operation

The control and regulation module shall allow for the countdown displays to be automatically adjusted with the programmed intervals of the traffic controller.

2. Operating Modes
The module shall operate in one mode:
   a. Clearance Cycle Countdown Mode – The module will start counting when the flashing clearance signal turns on and will countdown to "0" and turn off when the steady "Don't Walk" signal turns on.

3. Power Failures
The equipment must maintain a consistent countdown during short power failures (<1 second). A longer failure or an absence of signal superior to one (1) second must turn off display and trigger a restart system remembering the last sequence, as it is done for the NEMA traffic controller.

PART 3 EXECUTION

3.01 PRODUCT TEST AND INSPECTION

Upon final delivery The City of Houston shall randomly select two modules of each type and deliver City of Houston approved testing laboratory. Said modules shall be subjected to testing according to Part 2.C.4 with all associated costs including shipping to be born by supplier. Any quality issues resulting from these tests will result in rejection of whole shipment.

3.02 WARRANTY

A minimum guarantee for both materials and workmanship shall be provided by the Contractor for the products bid as specified. The guarantee (warranty) period shall begin the day the City officially accepts the item. Any guarantee work is to be completed within 15 days after receipt of notice of material deficiencies.

A. Warranties and Guarantees

1. All material, workmanship and labor furnished shall be covered by Supplier(s)/Manufacturer(s) guarantee and/or warranty for a minimum period of sixty (60) months. Warranty period shall begin the day the LED signal module is received by the City of Houston, either as new order or warranty repair. Bidder shall also be required to have resources to complete any required warranty work within fifteen (15) days after receipt of found defective LED signal module. The City of Houston's preference is for all non-warranty service to be charged a singular flat-rate. Successful bidder will include flat rate repair cost, if available in bid document for all non-warranty covered repairs. If flat rate repair charge is not available, then

Supplier(s)/Manufacturer(s) will provide current hourly labor rate, along with any associated minimum charges that may apply.

2. Successful bidder shall bear all expenses connected with return of any material which the City deems necessary to return for adjustments during guarantee period. Any work done by the City will be at a rate of $40 per labor unit.

3. Modules which exhibit luminous intensities less than the minimum values specified within the first 36 months, of the date of delivery, shall be replaced or repaired.

4. The City of Houston may perform random sample testing on all shipments. Random sample testing will be completed within 45 days after delivery. Optical testing shall be performed with the LED module mounted in a standard pedestrian signal unit. The number of modules tested shall be determined by the quantity of each shipment. The Traffic Operations Division shall determine the sampling parameters to be used for the random testing. Acceptance or rejection of the shipment shall conform to ANSI/ASQC Z1.4 for random sampled shipments.

5. The City of Houston reserves the right to withhold payments which may be due, should it be discovered that material does not meet specifications and/or claims of bidder.

6. Supplier(s)/Manufacturer(s) shall make all engineering data, diagrams, software changes or improvements, which increases performance of equipment purchased under this bid, available to the City of Houston at no additional cost.

7. Supplier(s)/Manufacturer(s) shall have field engineers or technicians available on request to assure satisfactory initial operation, and to consult with City's Traffic Engineer, or his representative, on any special circuitry that may be required in certain applications.

END OF SECTION

SECTION 16750

ACCESSIBLE PEDESTRIAN PUSH BUTTON STATION

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Accessible Pedestrian Push Button Station Assembly with control unit and mounting hardware. The assembly shall be the 2-Wire Navigator Push Button Station and 2-Wire Navigator Central Control Unit (CCU) as manufactured by Polara Engineering, Inc.

1.02 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Accessible Pedestrian Push Button Stations will be measured by each push button assembly and necessary central control unit.

2. Payment for the work performed and materials furnished in accordance with this item will be paid for at the unit price bid for "Accessible Pedestrian Push Button Station." The price shall be full compensation for furnishing, assembling, installing, made fully operational and testing the unit, as well as all mounting attachments, labor, tools, equipment, and incidentals necessary to complete the work.

PART 2 PRODUCTS

2.01 MATERIALS

Provide new materials that comply with the details shown on the plans and the requirements of this specification.

2.02 ACCESSIBLE PEDESTRIAN PUSH BUTTON STATION

A. The assembly and manufacturing process for all internal electronic components shall be adequately supported to withstand mechanical shock and vibration from high winds and other sources.

B. Weather-proof speaker protected by vandal proof screen.

C. Central Control Unit (CCU) for the pushbutton detector unit that resides in the Traffic Signal Controller Cabinet capable of controlling a minimum of 12 units using no more

than one pair of wires for each phase. The CCU must be capable of controlling up to 4 phases and all inputs and outputs shall have Transient Voltage Protection.

1. Pedestrian Walk / Don't Walk inputs: optically isolated 80-150 Volts AC/DC 5 mA maximum.

2. General purpose outputs and pedestrian outputs: optically isolated 36 Volts AC/DC peak 0.3A solid state fused contact closure.

3. Fault Output: normally open and closed relay contacts 125 Volts AC/DC 1A maximum.

4. A, B, C, D PBS power outputs: nominal 22 Volts DC, short circuit protected – auto recovering.

5. General Purpose Inputs: 10-36 Volts AC/DC peak 10 mA maximum, optically isolated.

6. Environmental: operating and storage -30°F (-34°C) to 165°F (74°C) 0-100% humidity non-condensing.

D. Each unit will contain a vibrating tactile arrow to provide a tactile representation of the status of the WALK indication. The arrow shall contrast with the background.

E. Confirmation of button push via latching LED, sound, and vibrotactile bounce.

F. Vibrating tactile arrow shall be able to be adjusted for directional indication.

G. Pedestrian push buttons shall be at least 2 inches in diameter or width, contrast visually with the housing, and require 5 lbf (poundforce) maximum force.

H. The pushbutton assembly shall be die-cast aluminum, powder coated from aluminum alloy 319 or equivalent.

I. The unit shall be fabricated free of voids, pits, dents, molding sand and excessive foundry grinding marks. All design radii shall be smooth and intact. Exterior surface finish shall be smooth and cosmetically acceptable by being free of molding fins, cracks and other exterior blemishes.

J. Assembly color shall be yellow.

K. Mounting bolts shall be brass or stainless steel.

L. Push button unit shall have an actuation indication which will activate upon depression of the push button. If actuation indication is a light then it shall remain on until the next walk cycle.

M. All push button assemblies shall be mounted to the poles by drilling and tapping. Stainless Steel ¼ - 20 bolts shall be used to mount the push button assemblies to poles. Self-tapping screws shall not be used. Stainless steel strapping shall not be allowed.

N. Attached crossing signs shall be 9" x 15" R10-3e, as per the Texas Manual on Uniform Traffic Control Devices (TMUTCD).

O. The back panel portion of the push button assembly shall be designed to accommodate pole diameters from 4" to 14".

2.03 AUDIBLE INDICATIONS

A. A push button locator tone shall sound at each push button.

B. Locator tones should be audible 6 to 12 feet from the push button or to the building line, whichever is less.

C. Locator tones shall have a duration of 0.15 seconds or less, and shall repeat at 1-second intervals.

D. Automatic volume adjustments in response to ambient traffic sound level shall be provided up to a maximum of 89 dB. Locator tone and verbal messages shall be no more than 5 dB louder than ambient sound.

E. All sounds must automatically adjust to ambient noise levels over a 60 dB range.

F. Standard locating tone during Don't Walk (and clearance if desired) and cuckoo, chirp, or standard voice message during walk.

G. Standard locating tone, custom sound, or verbal countdown during PED clearance.

H. Most sounds can have minimum and maximum volume independently set.

I. Extended button push can turn on, boost, volumes, and/or mute all sounds except those on activated crosswalk.

J. The tone or voice volume, measured at 36 inches from the APS, should be 2dB minimum and 5 dB maximum above the ambient noise.

K. Cuckoo - 1250 Hz and 1000 Hz.

L. Chirp - 2700 Hz and 1700 Hz.

M. Substituting Cuckoo and Chirp sounds with "walk" and "don't walk" audible sounds is optional.

N. Push button locator tone different from cuckoo or chirp.

O. Extended button press which can be used to request a louder WALK signal and locator tone for subsequent clearance interval.

P. System shall allow for independent volume control for locate tones, clearance, and walk tones.

Q. All sounds shall be synchronized to reduce sound clutter.

R. Custom message and sound options definable by customer include:

1. Custom locating tone
2. Informational Message
3. Custom walk sounds/message
4. Custom clearance sound
5. Multiple languages (up to three, selectable by user)
6. Street name in Braille on the sign

2.04 ENVIRONMENTAL REQUIREMENTS

A. The Accessible Pedestrian Push Button Station Assembly (pole unit and central control unit) shall be rated for use in the ambient operating temperature range of -40°C to +65°C (-40°F to +150°F).

B. Push button shall be rated for minimum of 20 million operations with >2 lb. actuation force.

2.05 ELECTRICAL REQUIREMENTS

The Accessible Pedestrian Push Button Station Assembly shall operate over a

voltage range of 95 to 130 VAC, 60 Hz. E. TRANSIENT

2.06 VOLTAGE PROTECTION

The on-board circuitry of a module shall include voltage surge protection, to withstand high-repetition noise transients and low-repetition high-energy transients.

2.07 INPUT PROTECTION

At the point of entry to the module for each input, provide two 0.5-Ohm, 10-watt wire-wound power resistors with 0.2 micro Henries inductance (one on the AC+ Line & one on the AC- Line). Provide one 20 Joule surge arrestor between AC+ to AC-. A 0.68 microfarad capacitor must be placed between AC+ & AC- (between the resistor & arrestor).

2.01 POWER FAILURES

Whenever there is a loss of power to the "Walk" or "Don't Walk" for a period greater than 2.0 seconds, the sound shall be deactivated.

PART 3 WARRANTY

3.01 A minimum guarantee for both materials and workmanship shall be provided for the products bid as specified. The guarantee (warranty) period shall begin the day the City officially accepts the item. Any guarantee work is to be completed within 15 days after receipt of notice of material deficiencies.

A. WARRANTY AND GUARANTEES

1. All material, workmanship and labor furnished shall be covered by Supplier(s)/Manufacturer(s) guarantee and/or warranty for a minimum period of thirty-six (36) months. Warranty period shall begin the day the item is received by the City of Houston, either as new order or warranty repair. Bidder shall also be required to have resources to complete any required warranty work within fifteen (15) days after receipt of found defective item. The City of Houston's preference is for all non-warranty service to be charged a singular flat-rate. Successful bidder will include flat rate repair cost, if available in bid document for all non-warranty covered repairs. If flat rate repair charge is not available, then Supplier(s)/Manufacturer(s) will provide current hourly labor rate, along with any associated minimum charges that may apply.

2. Successful bidder shall bear all expenses connected with return of any material which the City deems necessary to return for adjustments during guarantee

period. Said work shall be done by manufacturer's representative at no cost to the City.

3. The City of Houston may perform random sample testing on all shipments. Random sample testing will be completed within 45 days after delivery. The number of modules tested shall be determined by the quantity of each shipment. The Traffic Operations Division shall determine the sampling parameters to be used for the random testing. Acceptance or rejection of the shipment shall conform to ANSI/ASQC Z1.4 for random sampled shipments.

4. The City of Houston reserves the right to withhold payments which may be due, should it be discovered that material does not meet specifications and/or claims of bidder.

5. Supplier(s)/Manufacturer(s) shall make all engineering data, diagrams, software changes or improvements, which increases performance of equipment purchased under this bid, available to the City of Houston at no additional cost during guarantee period.

6. Supplier(s)/Manufacturer(s) shall have field engineers or technicians available on request to assure satisfactory initial operation, and to consult with City's Traffic Engineer, or his representative, on any special circuitry that may be required in certain applications.

END OF SECTION