

**TEXAS DEPARTMENT OF TRANSPORTATION
DEPARTMENTAL SPECIFICATION
TO-7045
VEHICLE SIGNAL HEADS**

1. Description

This specification governs for the materials, composition, quality, sampling, and testing of traffic control signal heads.

2. Bidders' and/or Suppliers' Requirements

Only materials with approved product codes and/or designations from the TO-7045 prequalified products list (QPL) will be accepted for bid, if required and stated in the procurement or contract documents. The Traffic Operations Division (TRF), Signal Operations Section of the Texas Department of Transportation (TxDOT) maintains the QPL. The TO-7045 QPL may be viewed at the following website: <http://www.dot.state.tx.us/gsd/purchasing/supps.htm>.

3. Payment

Procurement by the State

Payment for materials under this specification shall be in accordance with the conditions prescribed in the contract awarded by the State.

Contracts

Payment for materials governed by this specification used in contract projects will not be measured or paid for directly, but will be subsidiary to bid items of the Contract.

4. Prequalification

All prospective suppliers shall submit a sample 3-section signal head including optical units for evaluation to the TxDOT Traffic Operations Division; Traffic Management Section; 118 East Riverside Drive; Austin, Texas 78704. This is to ensure that the manufacturer has the technical and production capabilities to produce a material conforming to the requirements of this specification.

TRF tests samples for specification compliance and updates the QPL to include materials that meet specification requirements. If materials fail to meet any of the specification requirements, the producer may not resubmit for prequalification until one year from original evaluation date. TRF may waive this time limit if provided with documentation from an independent testing facility stating that materials meet all requirements. TRF will enforce the one-year time limit if, after retesting, the material again fails any of the specification requirements.

All materials submitted for prequalification tests will be at no cost to TxDOT. All materials which pass the prequalification testing shall become the property of TxDOT. If requested within 6 months of testing, materials that fail the prequalification testing will be returned to the submitter at their expense. After 6 months, failed materials shall become TxDOT property to be disposed at TxDOT's discretion.

5. Sampling and Testing

Specific tests are normally indicated in conjunction with specific specification requirements. However, TxDOT reserves the right to conduct whatever tests are deemed necessary to identify component materials and verify results of specific tests indicated in conjunction with specification requirements.

Cost of sampling and testing are normally borne by TxDOT. However, the costs of sampling and testing materials failing to conform to the requirements of this specification shall be borne by the contractor or supplier. Cost of sampling and testing of failing material shall be assessed at the rate established by the Director of TRF in effect at the time of testing. Amounts due TxDOT for conducting such tests shall be deducted from monthly or final estimates on contracts or from partial or final payments on direct purchases by the State.

6. Material Requirements

A. General

1. Traffic control signal heads shall be in accordance with the latest “Chapter 2: Vehicle Traffic Control Signal Heads” of *Equipment and Material Standards of the Institute of Transportation Engineers* except as noted herein.
2. Signal indications shall be in accordance with the latest revision to the Texas Manual on Uniform Traffic Control Devices.
3. The procurement or contract will specify the material type, either aluminum or polycarbonate, of the traffic signal heads to be provided.
4. The procurement or contract will specify if optical units, LED modules, or neither are to be provided.

B. Definitions

1. Optical Unit – lens, reflector, lamp, lamp receptacle, and associated supporting parts.
2. LED Module – an array of LEDs sealed in its own lens and housing that is capable of providing a traffic signal indication.
3. Signal Section – the assembly of a signal housing case, housing door, visor, and an optical unit or LED module.
4. Signal Face – the front part of a signal head.
5. Signal Head – one or more signal faces that when illuminated in a definite sequence indicate to traffic approaching the signal face the right of way at the intersection or give warning of existence of a hazardous condition. When designated as Two-Way, Three-Way, Four-Way, or Five-Way Signal Head, that number of faces are attached to pipe arm supports (e.g., a Three-Way Signal Head requires three signal faces). Unless otherwise specified, the pipe support arms radiate from their point of support at equal angles (i.e., 180°, 120°, 90°, and 72° angles of separation) for two-way, three-way, four-way, and five-way signal heads, respectively.

C. Physical and Mechanical Requirements

1. All material shall be accurately formed and free of defects affecting strength and appearance.
2. All materials furnished shall be new.

3. The complete unit, including optical unit and LED module, shall be designed to operate reliably throughout an ambient temperature range of -40 degrees F to 165 degrees F. This range corresponds to the environmental tests required by the National Electrical Manufacturers Association Standards Publication TS-2-1998 – *Traffic Controller Assemblies with NTCIP Requirements*. TxDOT may use the environmental testing required by TS-2-1998 while qualifying signal heads and their components.
4. Signal head housing components shall be either aluminum or polycarbonate as specified in the procurement or contract documents.
5. Individual signal sections shall be rigidly joined to form a single "Signal Face." Hardware used to join signal sections shall be stainless steel.
6. A three-section signal head rigidly supported at one end and extending horizontally shall:
 - a. Deflect no more than 2-1/2 inches in any direction when subjected to a 10 pound load at the opposite end, and
 - b. Deflect no more than 4 inches in any direction when subjected to a 25 pound load at the opposite end.
7. The applied loads above are in addition to the dead weight of the assembled head without the visors or backplate installed. The deflections above are measured at the point of loading.
8. All components and mounting attachments shall be of adequate strength for the purpose intended.
9. All signal head components and related mounting hardware shall be of corrosion/rust resistant materials capable of withstanding constant exposure to sunlight and corrosive atmospheres, including salt air.

10. Aluminum

- a. Cast aluminum parts shall have a minimum tensile strength of 17,000 psi.
- b. Cast aluminum components shall be accurately formed and free from pouring faults, sponginess, cracks, blow holes, or other defects affecting their strength and appearance.
- c. Sheet aluminum parts shall have a minimum tensile strength of 27,000 psi.
- d. Aluminum materials shall conform to the following:

TYPE	ASTM	ALLOY
Die Castings	B85	SG100B, SG100A, SC84B, SC84A, S12B, or SC12A
Permanent Mold Castings	B108	CS72A or S5A
Sheet	B209	M1A

11. Polycarbonate

- a. Polycarbonate material shall be ultraviolet-stabilized.
- b. Polycarbonate components shall be of one-piece construction molded construction. Bonding (chemical, thermal, ultrasonic, etc.) of multiple pieces is not allowed.

- c. Polycarbonate housings shall be at least 0.090 inches thick and shall be ribbed so as to produce the strongest possible assembly consistent with light weight.
- d. Polycarbonate material shall meet the following physical property requirements:

TEST	REQUIRED	ASTM
Specific Gravity	≥ 1.17	D792
Vicat Softening Point	305 - 325 degrees F	D1525
Brittleness Point	< 200 degrees F	D746
Flammability	Self-Extinguishing	D635
Tensile Strength (Yield)	≥ 8500 psi	D638
Elongation at Yield	5.5 to 8.5 %	D638
Shear Strength (Yield)	≥ 5500 psi	D732
Izod Impact Strength (notched, 1/8 inch thick)	≥ 15 ft-lb/in	D256
Fatigue strength, (2.5 mm cycles)	≥ 900 psi	D671

12. Hardware

- a. Except were noted, all bolts, nuts, washers, lock washers, screws, and other assembly hardware shall be galvanized steel, stainless steel, or dichromate sealed aluminum.

MATERIAL	APPLICABLE SPECIFICATION
Stainless Steel	ASTM A 320, Grade B8F Annealed
Galvanized Steel	ASTM A 307, Galvanized to ASTM A 153, Class C or D, or ASTM B 695, Class 50
Aluminum	Alloy 2024-T4, Dichromate sealed finished according to Mil-A-8625A Type II
Brass	UNS C36000

- b. When used, dissimilar metals shall be so selected or insulated to prevent corrosion.
- c. All non-metallic hardware shall be fiberglass reinforced polycarbonate.

13. Gaskets

- a. Gaskets used in the optical unit shall be closed-cell silicone or peroxide-cured EPDM and shall withstand temperatures up to 250 degrees F without permanent deformation or becoming brittle
- b. Other gaskets shall be closed-cell neoprene.

D. HOUSINGS, DOORS, AND VISORS

- 1. Design of door, housing, and visor shall be such that there is no light leakage (i.e. light is emitted only through the lens).
- 2. Housings when assembled, together with doors, lenses, and mounting attachments, shall comprise a dust and moisture proof housing for the optical units or LED modules, connecting wiring, and terminal block.

3. Housings

- a.** The housing shall be one piece and shall be either die cast aluminum alloy, permanent mold cast aluminum alloy, or molded polycarbonate.
- b.** Housings shall be of the sectional adjustable expandable type.
- c.** Portions of cases providing for attachment to supporting arms shall be molded with large bosses for the supporting arms.
- d.** Both the top and the bottom of each traffic signal housing case shall be provided with an opening of 2 inches in diameter to accommodate 1-1/2 inch pipe brackets.
- e.** Both the top and the bottom of each traffic signal housing case shall be provided with four openings of 0.2 inches in diameter to accommodate connection by No. 10 machine screws.
- f.** Unused holes at the ends of assembled signal heads shall be sealed with removable nylon plugs to prevent the entry of foreign material (e.g. dust, insects, and moisture) into the housing.
- g.** A minimum of four holes shall be provided on the rear of each signal section for mounting a back plate. They shall accommodate No. 8 x 1/2 inch self-threading screws. The holes shall not open to the inside of the housing.
- h.** Each signal section shall be capable of being rotated 360 degrees about its mounting axis and shall be capable of being locked at 5 degree intervals. Locking shall be accomplished by the engagement of serrations in adjacent signal sections and in the mounting bracket assembly.
- i.** Serrations shall be integral with the signal section and designed to insure flush alignment of the perimeters of the section.
- j.** Polycarbonate sections shall have additional strengthening ribs integral with the mating sides.
- k.** Individual units shall be so manufactured that all units are interchangeable except for terminal blocks.

4. Doors

- a.** Door shall be of the same material as the housing.
- b.** Aluminum door shall be provided with hinges and lugs for attachment to the main body casting, so spaced as to hold the door in perfect alignment when closed. The door shall be securely gasketed to the traffic signal housing with a weatherproof gasket.
- c.** Polycarbonate door shall be attached to the housing by means of two stainless steel hinge pins, or by polycarbonate hinge pins which are an integrally molded part of the housing door.
- d.** Two thumb screws shall be installed on the side of the door to provide for opening and closing the door without the use of special tools.

- e. Thumb screws shall have a flat-bearing surface or flat washer to prevent gouging of the housing door by the screws.
- f. Thumb screws shall remain captive in housing door when the door is open.

5. Visors

- a. Each signal section shall be provided with an easily detachable visor.
- b. The visor shall be rigidly attached to the door in a manner that will prevent the leakage of light and moisture throughout the periphery of attachment.
- c. Visor shall be standard tunnel type.
- d. Visor shall be of the same material as the housing and door.
- e. Aluminum alloy visors may be of cast or sheet material with a minimum thickness of 0.050 inches.
- f. Polycarbonate visors shall have a minimum thickness of 0.100 inches.
- g. Heads may be shipped with visors detached. If heads are shipped with the visors attached, visors shall be easily removed and replaced without damage to visor or signal head.
- h. The visor on the front of each door shall:
 - (1) be circular in section,
 - (2) have a downward tilt of 2 to 8 degrees relative to the perpendicular plane of the housing door,
 - (3) encompass approximately 300 degrees of the lens,
 - (4) extend outward from the face of the lens a minimum of 9-½ inches,
 - (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, and
 - (6) be open at the bottom so as to prevent the accumulation of snow and dirt.

E. EXTERIOR FINISH

- 1. Unless stated otherwise in the procurement or contract documents, the color of the completed traffic signals shall be Federal Yellow No. 13538 of Federal Standard 595 with the exception of the insides of the visors which shall be painted flat black.
- 2. **Aluminum**
 - a. All exposed metal surfaces except for the inside of the visors of the assembled traffic signal head shall be electrostatically applied powder-coat paint or given two separately baked-on coats of high-grade enamel.
 - b. The inside of the visors shall be provided with two coats of high grade flat black finish paint.

3. Polycarbonate

- a. The federal yellow colorant shall be completely impregnated in the polycarbonate material.
- b. The inside of the visors shall be provided with two coats of high grade flat black finish paint.

F. OPTICAL UNIT

1. Optical units shall be provided only when required in the procurement or contract documents.
2. Each optical unit consists of a lens, a reflector, and a lamp receptacle with leads to the terminal block (which is to be furnished in each complete traffic signal face assembly) together with all bolts, nuts, screws, clips, hinges, lugs and incidentals necessary for mounting and sealing the various parts of the optical assembly.
3. When assembled, a minimum clearance of 4.25 inches shall be provided between the lens and the lamp filament (assuming an A21 bulb with a 3 inch light center length is used).

4. Lens

- a. The optical system shall consist of a red, red arrow, yellow, yellow arrow, green, or green arrow lens with a nominal size of 12 inches.
- b. Lenses shall be permanently marked, in an inconspicuous manner, indicating the top of the lens and the trademark of the manufacturer.
- c. Lenses in polycarbonate housing shall be injection molded of a polycarbonate material; lenses in an aluminum housing shall be either polycarbonate or glass.
- d. Glass lenses shall have a high transmission value, have a specific gravity of not less than 2.50, and conform to all ITE specifications.
- e. Lenses and optical systems shall be capable of withstanding continuous illumination of a 150 watt lamp in a 12 inch head without distortion of the lenses.

5. Reflector

- a. The reflector shall be approximately parabolic in section.
- b. The reflector may be made of silvered glass, aluminum with anodic coating, or metalized plastic.
- c. The reflecting surface shall be totally free of flaws, scratches, defacements or mechanical distortion.
- d. The reflector shall be provided with hinges and/or lugs so spaced as to give clearance to the hinges or lugs for the door and rigidly hold the reflector in place. The reflector holder and receptacle shall be rigidly fastened in place by hinges and/or lugs for easy removal of the assembly. It shall not be necessary to remove the assembly from its supports for re-lamping or cleaning the reflector.

- e. The following two additional requirements apply to glass reflectors (in addition to ITE requirements):
 - (1) The silver application method shall prevent the inclusion of foreign substances between the silver and glass.
 - (2) A heat-resisting backing of high-grade enamel shall be placed over the copper coating.

6. Lamp Receptacle

- a. The receptacle shall be of weather-proof molded construction capable of withstanding without deterioration the high temperatures within the optical unit during operation.
- b. The lamp receptacle contact and threads shall be brass. The threads shall provide a uniform and sufficient contact with the lamp base.
- c. A lamp grip shall be provided to prevent the lamp from loosening due to vibration.
- d. The receptacle shall be rotatable for proper lamp orientation.
- e. The receptacle shall be set so as to place the filament of a standard 150 watt traffic signal lamp (A21 bulb with a medium base and a 3 inch light center length) in the proper focal position with respect to the reflector.

7. Lamps

Lamps are not furnished unless indicated in the procurement or contract documents.

G. LED TRAFFIC SIGNAL MODULE

- 1. LED traffic signal modules shall be provided only when required in the procurement or contract documents.
- 2. The LED traffic signal module shall be interchangeable with standard optical units and shall require no modifications to the signal housing or door.
- 3. If proper orientation of the LED unit is required for optimum performance, prominent and permanent directional marking(s), that is an "UP arrow", for correct indexing and orientation shall exist on the unit.
- 4. The manufacturer's name, serial number, manufactured date (month and date) and other necessary identification shall be permanently marked on the backside of the LED traffic signal lamp unit. A label shall be placed on the unit certifying compliance to ITE standards.

5. Physical and Mechanical Requirements

- a. The LED traffic signal module shall be a single, self-contained device.
- b. The LED traffic signal module shall withstand without adverse effects mechanical shock and vibration due to high winds, transportation/shipping, and other foreseeable sources.
- c. Each LED traffic signal lamp unit shall comprise of a UV stabilized polymeric outer shell, multiple LED light sources, and a regulated power supply. LEDs are to be mounted on a polycarbonate positioning plate or conformally coated PC board.

6. Optical and Light Output Requirements

- a. The LEDs shall be manufactured using AlInGaP (Aluminum-Indium-Gallium-Phosphide) technology or other LEDs with lower susceptibility to temperature degradation than AlGaS (Aluminum-Gallium-Arsenic). AlGaS LEDs will not be allowed.
- b. Each LED traffic signal lamp shall meet minimum laboratory light intensity values, color (chromaticity), and light output distribution as described in "Chapter 2: Vehicle Traffic Control Signal Heads" (VTCSH) of *Equipment and Material Standards of the Institute of Transportation Engineers* as a minimum excepted as noted herein.
- c. **Minimum Luminous Intensity Values for Circular Indications**

The table below replaces the values in Table 1 of Section 4.1.1 of the I.T.E. VTCSH. The 6.4.2.1 test shall include an expanded view for the Red and Green Ball indications with the following minimums for a period of 60 months, based on normal use in traffic signal operation over an operating temperature range of -40 degrees C to +74 degrees C. In addition, yellow LED signal modules shall meet or exceed the following minimum illumination values for a minimum period of 60 months, based on normal use in traffic signal operation at 25 degrees C:

Vertical Angle	Horizontal Angle (°Left/°Right)	RED (candelas)	YELLOW (candelas)	GREEN (candelas)
+/-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°	20	40	40
	17.5°	20	40	40
-27.5°	2.5°	20	40	40
	17.5°	20	40	40
-32.5°	2.5°	20	40	40
	17.5°	20	40	40

d. Minimum Luminous Intensity Values for Arrow Indications

The table below replaces the values in Table 1 of Section 4.1.1 of the I.T.E. VTCSH. The 6.4.2.1 test shall have the following minimums for a period of 60 months, based on normal use in traffic signal operation over an operating temperature range of -40 degrees C to +74 degrees C. In addition, yellow LED signal modules shall meet or exceed the following minimum illumination values for a minimum period of 60 months, based on normal use in traffic signal operation at 25 degrees C:

Vertical Angle	Horizontal Angle (°Left/°Right)	RED (candelas)	YELLOW (candelas)	GREEN (candelas)
+/-2.5°	2.5°	54	135	70
	7.5°	40	99	51
	12.5°	29	72	38
	17.5°	21	53	27
+/-7.5°	2.5°	44	109	57
	7.5°	32	80	42
	12.5°	23	59	30
	17.5°	17	43	22
	22.5°	12	31	16
	27.5°	9	23	12
+/-12.5°	2.5°	17	43	22
	7.5°	12	31	16
	12.5°	9	23	12
	17.5°	7	17	9
	22.5°	5	12	6
	27.5°	4	9	5
+/-17.5°	2.5°	6	16	8
	7.5°	5	12	6
	12.5°	3	9	4
	17.5°	2	6	3
	22.5°	2	5	2
	27.5°	1	3	2

e. The “stroke width” on arrow indications shall be at least three LEDs wide (i.e., the arrow shall be filled rather than outlined).

f. Arrow LED signal modules shall be tested in conformance with California Test 3001.

g. Chromaticity Standards

Measured chromaticity coordinates of LED signal modules shall conform to the chromaticity requirements of the following table, for a minimum period of 60 months, over an operating temperature range of -40 degrees F to +165 degrees F. Each LED traffic signal lamp unit shall meet the minimum requirements for light output for the entire range from 80 to 135 volts.

RED	$(0.998 - x) \leq y \leq 0.308$
YELLOW	$\left. \begin{array}{l} 0.411 \\ \text{and} \\ (0.995 - x) \end{array} \right\} \leq y \leq 0.452$
GREEN	$\left. \begin{array}{l} (0.506 - 0.519x) \\ \text{and} \\ (0.150 + 1.068x) \end{array} \right\} \leq y \leq (0.730 - x)$

- h. LED signal modules tested or submitted for testing shall be representative of typical production units. Optical testing shall be performed with LED signal modules mounted in standard traffic signal sections without visors or hoods attached to the signal sections.
- i. After burn-in, red and green LED signal modules shall be tested for rated initial luminous intensity in conformance with the provisions in "Optical and Light Output Requirements." Before measurement, the red and green LED signal modules shall be energized at rated voltage, with 100 percent on-time duty cycle, for a time period of 30 minutes. Test results for this testing shall record the current, voltage, total harmonic distortion (THD) and power factor (PF) associated with each measurement.
- j. Photometrics, luminous intensity and color measurements for yellow LED signal modules shall be taken immediately after the modules are energized. The ambient temperature for these measurements shall be 25 degrees C. Test results for this testing shall record the current, voltage, total harmonic distortion (THD) and power factor (PF) associated with each measurement.

7. Electrical

- a. Each unit shall incorporate a regulated power supply engineered to electrically protect the LEDs and maintain a safe and reliable operation. The power supply shall provide capacitor filtered DC regulated current to the LEDs per the LED manufacturer specification. Design of the power supply shall be 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. Any deviation without prior testing and approval from TxDOT shall be grounds for automatic removal from the QPL for an undetermined time.
- b. The LED traffic signal lamp unit shall operate on a 60 Hz AC line voltage ranging from 80 volts RMS to 135 volts RMS. The circuitry shall prevent flickering over this voltage range. Nominal rated voltage for all measurements shall be 117 volts RMS.
- c. The LED traffic signal lamp unit shall be operationally compatible with TS1, TS2, 170 and 2070 controllers, conflict monitors with plus features, and malfunction management units currently used by TxDOT and any other Texas governmental entities. In the case of conflicts between specifications, the latest TxDOT specifications will control.
- d. The LED lamp shall be designed to sense a loss of light output due to catastrophic LED failures of between 25 and 40 percent. Loss of light output due to LED failure will not be detected for losses of less than 25 percent, but will be detected for any loss of light greater than 40 percent. The unit, upon sensing a valid loss of light, shall present impedance of at least 500K Ohms to the AC line.

- e. Any deviation to product design after testing and approval from TxDOT shall consist of a new model and must be resubmitted for acceptance. Failure to adhere to this requirement shall be grounds for automatic removal from the QPL for an undetermined time. Random testing of average production modules will be tested to ensure compliance with specification.
- f. Two, captive, color coded, 600 V, 18 AWG minimum jacketed wires, 3 feet long, conforming to the National Electric Code, rated for service at 105 degrees C, are to be provided for an electrical connection.
- g. LEDs shall be arranged in no less than 5 equally loaded circuits.
- h. The LED signal shall operate with a minimum 0.90 power factor.
- i. Total harmonic distortion (current and voltage) induced into an AC power line by a signal module shall not exceed 20 percent.
- j. LED signal modules and associated on-board circuitry shall conform to the requirements in Federal Communications Commission (FCC) Title 47, SubPart B, Section 15 regulations concerning the emission of electronic noise.

8. Environmental Requirements

- a. The LED traffic signal lamp unit shall be rated for use in the ambient operating temperature range of -40 degrees C to +74 degrees C.
- b. The unit shall be dust and moisture tight to protect all internal LED and electrical components.
- c. The unit shall consist of a housing that is a sealed watertight enclosure that eliminates dirt contamination and allows for safe handling in all weather conditions. Moisture resistance testing shall be performed on LED signal modules in conformance with the requirements in NEMA Standard 250-1991 for Type 4 enclosures. Evidence of internal moisture after testing shall be cause for rejection.

9. Production Testing Requirements

- a. Each new LED traffic signal lamp unit shall be energized for a minimum of 24 hours at operating voltage and at a temperature of +60 degrees C in order to cause any electronic infant mortality to occur, and to ensure electronic component reliability prior to shipment.
- b. After the burn-in procedure is completed, each LED traffic signal lamp unit shall be tested by the manufacturer for rated initial intensity at rated operating voltage.
- c. Destructive testing will be conducted to determine that the units are in conformance with the catastrophic LED failure clause in G.7.d. (above).

10. Documentation Requirements

- a. Each LED traffic signal lamp unit shall be provided with the following documentation:
 - (1) Complete and accurate installation wiring guide.
 - (2) Contact name, address, telephone number, and fax number for the representative, manufacturer, or distributor for warranty repair.

- (3) Schematics for all electronics, if required in the procurement or contract documents.
- (4) Copy of a test report certified by an independent laboratory that the LED traffic signal lamp model submitted meets I.T.E. Standards for light distribution, chromaticity, and power (consumption, power factor and harmonic distortion). The table in Item G.6.c. of this specification replaces the values in Table 1 of Section 4.1.1 of the I.T.E. VTCSH. In addition, the independent lab report shall specify the drive current being supplied to individual LEDs within the unit. Designs which require LEDs to be operated at currents greater than the LED manufacturer's recommended drive current will not be allowed.
- (5) One schematic diagram shall be provided for each LED lamp unit, along with any necessary installation instructions.
- (6) For each unit submitted, the manufacturer name, brand and model number of LEDs used shall be provided, along with the LED manufacturer's recommended drive current and degradation curves.

11. Warranty

- a. The LED traffic signal lamp unit shall be warranted against any failure due to workmanship, material defects or intensity within the first 60 months of field operation. The LED signal shall meet or exceed minimum luminous intensity values during the 60 months of field operation.
- b. The LED signal modules shall meet or exceed 85 percent of the standard light output values specified in the I.T.E. VTCSH, after 60 months of continuous use over the temperature range of -40 degrees C to +74 degrees C in a traffic signal operation.
- c. The measured chromaticity coordinates of the LED signal modules shall conform to the requirements for chromaticity in Section 8.04 and Figure 1 of the I.T.E. VTCSH over the temperature range of -40 degrees C to +74 degrees C.
- d. The manufacturer shall provide a written warranty against defects in materials and workmanship for LED signal modules for a period of 60 months after installation of LED signal modules. Replacement LED signal modules shall be provided within 5 days after receipt of failed LED signal modules at no cost to the State, except the cost of shipping the failed modules.

12. Quality Assurance Testing (Random Sample Testing)

- a. The State will perform random sample testing on shipments. Random sample testing will be completed within 30 days after delivery.
- b. Optical testing shall be performed with the module mounted in a standard traffic signal section, but without a visor or hood attached to the section or housing. The number of modules tested shall be determined by the quantity of each model in the shipment. The sample size shall conform to ANSI/ASQC Z1.4. The TRF shall determine the sampling parameters to be used for the random sample testing. All parameters of the specification may be tested on the modules. Acceptance or rejection of the shipment shall conform to ANSI/ASQC Z1.4 for random sampled shipments

H. ELECTRICAL

1. The signal head shall be designed to operate from a 120 volt, single-phase, 60 Hz alternate current power supply.
2. **Receptacle**
 - a. Each lamp receptacle assembly shall be provided with two flexible insulated color coded leads a minimum of 3 feet in length and no smaller than No. 18 American Wire Gauge.
 - b. Receptacle leads are to be securely fastened to the lamp socket and connected to the terminal block mounted in the signal section housing at the receptacle/optical unit by means of solderless wire connector or binding screws and spade lugs.
3. **Terminal Blocks**
 - a. Terminal blocks shall be double-row and contain a minimum of six sections.
 - b. All terminal blocks shall be securely mounted in an accessible position and shall be of weatherproof molded construction.
 - c. The terminal block body shall be of one-piece molded construction using phenolic materials.
 - d. The block shall consist of permanently identified electrical sections, each section consisting of two 8/32 inch by 5/16 inch binding screws and a conducting metal strip between the screws.
 - e. The block shall be rated for a minimum of 20 ampere, 250 volt service and section to section breakdown voltage shall be a minimum of 1600 volts AC RMS.
 - f. All metal parts with the exception of screws shall be nickel plated brass.
 - g. Binding screws shall be nickel-plated brass or stainless steel.
 - h. **Section Terminal Block**

The terminal block shall either be securely mounted on or integrally molded into the interior of the housing.
 - i. **Signal Face Assembly Terminal Block**
 - (1) Each multiple section signal face assembly shall be provided with a double- row, six-section terminal strip in the top section of the assembly. The section terminals shall be wired to the top-mounted common terminal, ready for field installation. Binding screws for solderless connectors shall be provided for the interior wires.
 - (2) The terminal block shall be securely mounted to the housing case in an internally accessible position in the signal section.
4. **Wiring**
 - a. Each lead shall be brought to a separate terminal in the terminal compartment, except the commons from one housing can all be brought to the same terminal in the terminal compartment.

- b. The color coding on leads from the individual optical units or LED modules shall be maintained from the lamp holder or back of LED module to the individual terminals in the signal head terminal compartment, except that the commons from each housing shall be grouped and carried to one terminal. The color coding shall be as follows:

INDICATION	COLOR CODE
Red Ball and Red Arrow	RED
Yellow Ball	YELLOW
Green Ball	BROWN
Yellow Arrow	YELLOW with BLUE or WHITE tracer
Green Arrow	BROWN with BLUE or WHITE tracer
Neutral	WHITE

- c. The wiring shall be so arranged that any one optical unit can be individually illuminated through connections to terminals in the terminal compartment.
- d. Separate terminals shall be provided for the interior wires and the field wires. In addition to the interior wires required in Section H.3.i.(1), the contractor or supplier is also required to furnish and install all other leads necessary to connect the terminal block of the multiple section face to the terminal block in the terminal compartment.
- e. Any variations from the above requirements shall be covered in the procurement or contract documents.

I. MOUNTING REQUIREMENTS

1. Complete signal faces shall provide positive locked positioning when used with serrated brackets, mast arm, or span wire fittings.
2. 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 of a dust-and-moisture-proof enclosure for optical units and lead wiring.
3. 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.
4. Provision shall be made for carrying the traffic signal leads enclosed in the mounting attachment.
5. Any opening in an assembled signal head shall be plugged with an aesthetically pleasing plug.
6. Mounting attachments shall be one of the following types as specified in the procurement or contract documents: None, Span-Wire, Mast-Arm, Side-of-Pole, or Top-of-Post
7. **Span-Wire Mounting**
 - a. The span-wire mounting attachment shall consist of a cable clamp to receive a suspension cable of 3/8 inch diameter together with a suitable connection to the head.
 - b. The mounting shall provide a balance adjuster between the signal head and the span wire capable of permitting freedom of movement with reference to the point of suspension.

- c. 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.
- d. 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 the signal wiring.
- e. Mounting 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.

8. Mast-Arm Mounting

The mast-arm and signal-head mounting shall be as shown in the procurement or contract documents.

9. Side-of-Pole Mounting

- a. Supports for side-of-pole mounting of the signal head in a vertical position shall be 1-1/2 inch (nominal diameter) standard pipe bracket arms, attached to the top and bottom of the signal head.
- b. 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 throughout the range of adjustment.
- c. The mounting assembly shall consist of two standard pipe sections extending 12-3/4 inches from and at right angles to the axis of rotational adjustment of the signal head.
- d. Both supports shall have running threads at least 1-1/4 inches long at the pole connection end.
- e. Provision shall be made for carrying the wire from the signal head enclosed in the bottom support and an outlet tilted downward for the wiring shall be provided, adjacent to the pole connection end, tapped and plugged for 1-1/4 inch conduit.
- f. Any variation to this design is shown in the procurement or contract documents.

10. Top-of-Post Mounting

- a. Supports for top-of-post mounting of the signal head in a vertical position shall be 1-1/2 inch (nominal diameter) standard pipe bracket arms attached to the top and the bottom of the signal head.
- b. The mounting assembly shall consist of a slipfitter connection, as either the hub or as part of the hub of the bottom pipe-arm assembly, for attachment around the top of a 4-1/2 inch outside diameter pipe.
- c. Six each 3/8 inch nominal major diameter stainless steel set screws with 20 threads per inch in pairs with a 120 degree spacing shall be provided for attaching the slipfitter to the pole.

- d. The signal head assembly shall be adjustable, by rotation about its vertical axis in a horizontal plane, throughout a radial angle of 360 degrees and the mounting attachment shall be so constructed that the head may be firmly clamped in any position throughout the range of adjustment.
- e. The slipfitter connection shall be of pleasing appearance and of adequate strength, capable of holding the signal head rigidly in place and effectively sealing the interior of the pipe from moisture.