Purchase Specification of the
Institute of Transportation Engineers

Vehicle Traffic Control Signal Heads - Part 3: Light Emitting Diode (LED) Vehicle Arrow Traffic Signal Modules

Prepared by Joint Industry and Traffic Engineering Council Committee

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STANDARD ITE METRIC CONVERSION INSERT

During the service life of this document, use of the metric system in the United States is expected to expand. The following common factors represent the appropriate magnitude of conversion. This is because the quantities given in U.S. Customary units in the text, tables or figures, represent a precision level that in practice typically does not exceed two significant figures. In making conversions, it is important to not falsely imply a greater accuracy in the product than existed in the original dimension or quantity. However, certain applications such as surveying, structures, curve offset calculations, and so forth, may require great precision. Conversions for such purposes are given in parentheses.

Length
1 inch = 25 mm (millimeters—25.4)
1 inch = 2.5 cm (centimeters—2.54)
1 foot = 0.3 m (meters—0.3048)
1 yard = 0.91 m (0.914)
1 mile = 1.6 km (kilometers—1.61)

Volume
1 cubic inch = 16 cm^3 (16.39)
1 cubic foot = 0.028 m^3 (0.02831)
1 cubic yard = 0.77 m^3 (0.7645)
1 quart = 0.95 L (liter—0.9463)
1 gallon = 3.8 L (3.785)

Speed
foot/sec. = 0.3 m/s (0.3048)
miles/hour = 1.6 km/h (1.609)

Temperature
To convert °F (Fahrenheit) to °C (Celsius), subtract 32 and divide by 1.8.

Area
1 square inch = 6.5 cm^2 (6.452)
1 square foot = 0.09 m^2 (0.0929)
1 square yard = 0.84 m^2 (0.836)
1 acre = 0.4 ha (hectares—0.405)

Mass
1 ounce = 28 gm (gram—28.34)
1 pound = 0.45 kg (kilograms—0.454)
1 ton = 900 kg (907)

Light
1 footcandle = 11 lux (lumens per m^2—10.8)
1 footlambert = 3.4 cd/m^2 (candelas per m^2—3.426)

Vehicle Traffic Control Signal Heads - Part 3: Light Emitting Diode (LED) Vehicle Arrow Signal Modules - A Purchase Specification of the Institute of Transportation Engineers, prepared by the ITE Joint Industry and Traffic Engineering Council Committee.

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Table of Contents

1. PURPOSE……Page 3
2. DEFINITIONS……..3
3. PHYSICAL AND MECHANICAL REQUIREMENTS……...4
    3.1. General……4
    3.2. The Module……4
    3.3. Environment Requirements……4
    3.4. Construction……4
    3.5. Materials……..5
    3.6. Module Identification……..5
4. PHOTOMETRIC REQUIREMENTS……...5
    4.1. Luminous Intensity, Uniformity & Distribution……..5
    4.2. Chromaticity……...6
5. ELECTRICAL……...6
    5.1. General……6
    5.2. Voltage Range……6
    5.3. Transient Voltage Protection……...6
    5.4. Nighttime Dimming (Optional)……...6
    5.5. Electronic Noise……..6
    5.6. Power Factor (PF) and AC Harmonics……6
    5.7. Controller Assembly Compatibility……7
6. QUALITY ASSURANCE……7
    6.1. General……7
        6.1.1. Quality Assurance Program……...7
        6.1.2. Record Keeping……7
        6.1.3. Conformance……7
    6.2. Manufacturers Serial Numbers……7
    6.3. Production Tests & Inspections……7
        6.3.1. Introduction ……7
        6.3.2 Production Tests……..7
        6.3.3 Current Consumption Measurement……7
        6.3.4. Visual Inspection……8
    6.4. Design Qualification Testing……..8
        6.4.1. Introduction……..8
        6.4.2 Conditioning……8
        6.4.3. Environmental Tests..……...8
        6.4.4. Photometric & Colorimetric Test……8
        6.4.5 Lens Tests……10
        6.4.6. Electrical Tests……10
        6.4.7 Controller Assembly Compatibility Test……..11

1. Purpose

The purpose of this specification is to provide the minimum performance requirements for 300 mm (12 in) LED arrow traffic signal modules (hereafter called module or modules). 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 refers to definitions and practices described in "Vehicle Traffic Control Signal Heads" published in the *Equipment and Materials Standards of the Institute of Transportation Engineers*, referred to in this document as "VTCSH." This specification applies to modules purchased after the effective date of this specification. This specification is not restricted to any specific LED technology.

2. Definitions

The following definitions are in addition to the definitions in the VTCSH.

1. Burn-In Procedure. The procedure by which a module is energized at an ambient temperature for a specified time duration

2. Chromaticity. The color of the light emitted by the module, specified as x-y chromaticity coordinates on the chromaticity diagram according to the 1931 Commission Internationale d'Eclairage (CIE) standard observer and coordinate system.

3. Duty Cycle. The fraction of time during a specified time period that the module is energized, expressed as a percent of the specified time period.

4. Hard coat. A surface coating or a film used to provide front surface abrasion resistance.

5. LED Arrow Signal Module (the module)**.** An array of LEDs and lens that are capable of providing a signal indication. The module shall be capable of replacing the optical unit of an existing vehicle arrow signal section.

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

7. Light Stabilization Procedure. The procedure by which the module is energized at a given temperature for a specified time duration to cause stabilization in light output.

8. Long Term Luminous Intensity Degradation. The reduction in luminous intensity that normally occurs when an LED is illuminated over an extended period of time.

9. Luminous Intensity. The luminous flux per unit solid angle in a given direction, expressed in Candelas (cd).

10. Nominal Operating Voltage. The Voltage**,** 120 VAC RMS, at which photometric and electrical performance requirements are specified.

11. **Power Consumption.** The electrical power in Watts consumed by the module when operated at nominal operating voltage and ambient operating temperature range.

12. **Power Factor (PF).** PF equals Watts divided by Volt-Ampere (VA) or the ratio of power consumption in Watts to Volt-Amperes.

13. **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.

14. Turn Off Time. The amount of time required after removal of the nominal operating voltage for the module to show no visible illumination.

15. Turn Off Voltage. The voltage below which there is no visible illumination**.**

16. Turn On Time. The amount of time required for the module to reach 90% of its full illumination**.**

17. **Volt-Amperes.** The product of root-mean-square (RMS) line voltage and RMS line current measured with true RMS meter.

3. Physical and Mechanical Requirements

3.1 General

Modules designed as retrofit replacements for existing signal lamps shall not require special tools for installation. Retrofit replacement modules shall fit into existing traffic signal housings built to the VTCSH Standard without modification to the housing.

Installation of a retrofit replacement module into an existing signal housing shall only require the removal of the existing optical unit components, i.e., lens, lamp module, gaskets, and reflector; shall be weather tight and fit securely in the housing; and shall connect directly to existing electrical wiring.

3.2 The Module

3.2.1 The retrofit module shall be capable of replacing the optical unit.

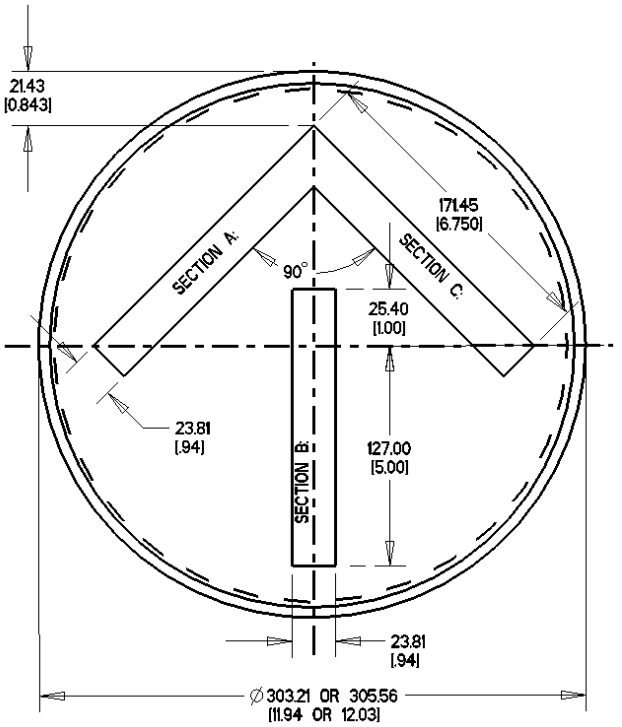
3.2.2 Tinting (Optional) - The lens shall be tinted or shall use transparent film or materials with similar characteristics.

3.2.3 The module lens may be a replaceable part without the need to replace the complete module.

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

3.2.5 The general configuration of the arrow icon is illustrated in Figure 1. The arrow should be oriented in the direction of its intended use.

Figure 1



3.3 Environmental Requirements

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

3.3.2 The LED signal module shall be protected against dust and moisture intrusion per the requirements of MIL-STD-810F procedure I Rain and Blowing Rain. The test is to be conducted on a stand alone unit. No protective housing shall be used.

3.3.3 The module lens shall be UV stabilized.

3.4 Construction

3.4.1 The module shall be a single, 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 module. The power supply may be designed to fit and mount inside the traffic signal housing adjacent to the module.

3.4.2 The assembly and manufacturing process for the module shall be designed to assure all internal

LED and electronic components are adequately supported to withstand mechanical shock and vibration from high winds and other sources.

3.5 Materials

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

3.5.2 Enclosures containing either the power supply or electronic components of the module shall be made of UL94VO flame retardant materials. The lens of the module is excluded from this requirement.

3.6 Module Identification

3.6.1 Each module shall be identified on the backside with the manufacturer's name, model number and serial number.

3.6.2 The following operating characteristics shall be identified: nominal operating voltage, power consumption, and Volt-Ampere.

3.6.3 If the modules must be correctly positioned inside the signal housing to conform to the requirements in table 1, they shall have a prominent and permanent vertical indexing indicator, i.e., UP ARROW or the word UP or TOP.

3.6.4 Modules conforming to this specification, may have the following statement: "Manufactured in Conformance with the ITE VTCSH Part 3: LED Vehicle Arrow Traffic Signal Module." on an attached label

4. Photometric Requirements

4.1 Luminous Intensity, Uniformity & Distribution

4.1.1 For a minimum period of 60 months, the maintained minimum luminous intensity values for the modules under the operating conditions defined in Sections 3.3.1 and 5.2.1, shall not be less than the values shown Table 1 when oriented in the direction of its intended use.

4.1.2 When operating within the temperature range specified in Section 3.3.1 the maximum luminous intensity shall not exceed 3 times the peak intensity (at 2.5° down and +/- 2.5° horizontal) shown in table 1.

4.1.3 The uniformity of the icon illumination shall meet a ratio of not more than 1 to 5 between the minimum and maximum illuminance measurements (in Cd/m2).

Table 1. Maintained Minimum Luminous Intensity for the module when oriented in the direction of its intended use

Candlepower Values (candelas (cd))

Vert.	Horiz.	300mm (12") Arrow Signal		
Down	+/-	Red	Yellow	Green
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

4.2 Chromaticity

The measured chromaticity coordinates of the modules shall be between conforming to the chromaticity requirements of Section 8.04 and Figure 1 of the VTCSH standard.

5. Electrical

5.1 General

All wiring and terminal blocks shall meet the requirements of Section 13.02 of the VTCSH standard. Two secured, color coded, 914 mm (36 in) long 600 V, 20 AWG minimum, jacketed wires, conforming to the National Electrical Code, rated for service at +105°C, are to be provided for electrical connection.

The wires should be color coded to identify the color of the module to in accordance to the following convention. White shall identify the neutral lead. Green shall only be used for earth ground, if provided. Red color signals shall be identified with a red lead, yellow with a yellow lead and green with a brown lead.

5.2 Voltage Range

5.2.1 The modules shall operate from a 60±3 Hertz ac line power over a voltage range from 80 VAC RMS to 135VAC RMS. 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 the procuring traffic authority customer has in use.

5.2.2 Nominal operating voltage for all measurements shall be 120±3 VAC RMS.

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

5.2.4 The LED circuitry shall prevent flicker at less than 100 Hz over the voltage range specified in Section 5.2.1.

5.2.5 Low Voltage Turn Off: There should be no illumination from the module when the applied voltage is less than 35 VAC RMS.

5.2.6 Turn-On and Turn-Off Time:
The modules shall reach 90% of their full illumination (turn-on) within 75 msec. of the application of the nominal operating voltage. The modules shall not be illuminated (turn-off) after 75 msec of the removal of the nominal operating voltage.

5.3 Transient Voltage Protection

5.3.1 The module's on-board circuitry shall include voltage surge protection to withstand high-repetition noise transients and low-repetition high-energy transients as stated in Section 2.1.6, NEMA Standard TS-2, 1998.

5.4 Nighttime Dimming (Optional)

5.4.1 When requested the module circuitry shall allow a reduction of the intensity of the light output in response to an input from the traffic signal controller.

5.4.2 Dimming, if provided, shall diminish light output to levels established to match threshold ambient light conditions. The dimming may be in stepped increments or may be continuously variable. The minimum light output when dimmed shall not be less than thirty (30) percent of the maintained minimum luminous intensity shown in table 1.

5.5 Electronic Noise

The modules and associated on-board circuitry must meet Federal Communications Commission (FCC) Title 47, SubPart B, Section 15 regulations concerning the emission of electronic noise.

5.6 Power Factor (PF) and AC Harmonics

5.6.1 The modules shall provide a power factor of 0.90 or greater when operated at nominal operating voltage, and 25ºC (77ºF).

5.6.2 Total harmonic distortion induced into an AC power line by the module, operated at nominal operating voltage, at 25ºC (77ºF) shall not exceed 20 percent.

5.7 Controller Assembly Compatibility

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

6. Quality Assurance

6.1 General

6.1.1 Quality Assurance Program: LED signal modules shall be manufactured in accordance with a vendor quality assurance (QA) program. The QA program shall include two types of quality assurance: (1) design quality assurance and (2) production quality assurance. The production quality assurance shall include statistically controlled routine tests to ensure minimum performance levels of LED signal modules built to meet this specification.

6.1.2 Record Keeping: QA process and test results documentation shall be kept on file for a minimum period of seven years.

6.1.3 Conformance: LED signal module designs not satisfying design qualification testing and the production quality assurance testing performance requirements in Sections 6.3 and 6.4 shall not be labeled, advertised, or sold as conforming to this specification.

6.2 Manufacturers Serial Numbers

Each LED signal module shall be identified by a manufacturer's serial number. Identification of the component and sub-assembly level may be required if reliability and performance of the module must be traceable to original item manufacturers of the module components and subassemblies.

6.3 Production Tests & Inspections

6.3.1 All new LED signal modules shall undergo the following Production Testing & Inspection prior to shipment. Failure of any LED signal module to meet requirements of Production Testing & Inspection shall be cause for rejection. Test results shall be maintained per the requirement of Section 6.1.2.

6.3.2 Production Tests: Unless otherwise specified, all Production Tests shall be performed at an ambient temperature of 25ºC (77ºF) and at the nominal operating voltage of 120 VAC.

6.3.2.1 Luminous Intensity: All LED signal modules shall be tested for luminous intensity. A single point measurement, with a correlation to the intensity requirements of Sections 4.1.1 and 4.1.2 may be used. The LED signal module shall be operated at nominal operating voltage and at an ambient temperature of 25°C (77°F). The purchaser may specify additional measurements.

6.3.2.3 Power Factor: All LED signal modules shall be tested for power factor per the requirements of Section 5.6.1. A commercially available power factor meter may be used to perform this measurement.

6.3.2.4 Acceptance/Rejection Criteria: Failure of a LED signal module to meet the requirements for minimum maintained luminous intensity (4.1.1), maximum permissible luminous intensity (4.1.2), luminance uniformity (4.1.3), and/or power factor (5.6.1) shall be cause for rejection of the module. A measured current consumption in excess of 120% of the design qualification current values shall be cause for rejection.

6.3.3 Current Consumption Measurement: All LED signal modules shall be measured for current flow in Amperes. The measured current values shall be compared against the design current values from design qualification measurements in Section 6.4.4.1.

6.3.3.1 Acceptance/rejection criteria: Measured current values in excess of 120% of the design

qualification current values shall be cause for rejection.

6.3.4 Visual Inspection: All LED signal modules shall be visually inspected for any exterior physical damage or assembly anomalies. Careful attention shall be paid to the surface of the lens to ensure there are no scratches (abrasions), cracks, chips, discoloration, or other defects.

6.3.4.1 Acceptance/rejection criteria. The presence of any such defects shall be cause for rejection.

6.4 Design Qualification Testing

6.4.1 Design Qualification testing shall be performed on new LED signal module designs, and when a major design change has been implemented on an existing design. LED signal modules used in design qualification testing shall be representative of the manufacturer's proposed normal production.

6.4.1.1 Testing shall be performed once every 5 years or when the module design or LED technology has been changed. Test data shall be retained by the LED signal module manufacturer in accordance with Section 6.1.2 or for 60 months following final production of a specific design, whichever is longer.

6.4.1.2 Six modules shall be used in Design Qualification Testing. All six modules shall be subjected to conditioning (6.4.2), followed by the Environmental Tests (6.4.3). Following the Environmental Tests, three modules shall undergo Photometric & Colorimetric Tests (6.4.4), followed by the Lens Abrasion Test (6.4.5). The remaining three modules shall undergo the Electrical Tests (6.4.6). Tests shall be conducted in the order described herein, unless otherwise specified.

6.4.1.3 In order for a module design to be considered acceptable for marking with the label described in 3.6.4, all tested modules must comply with the acceptance/rejection criteria for the Environmental Tests (6.4.3), Photometric & Colorimetric Tests (6.4.4), Lens Tests (6.4.5), Electrical Tests (6.4.6), and Controller Assembly Compatibility Tests (6.4.7)..

6.4.2 Conditioning: LED signal modules shall be energized for a minimum of 24 hours, at 100% duty cycle, in an ambient temperature of +60°C (+140°F).

6.4.3 Environmental Tests:

6.4.3.1 Mechanical Vibration: Mechanical vibration testing shall be performed per MIL-STD-883, Test Method 2007, using three 4 minute cycles along each x, y, and z axis, at a force of 2.5 Gs, with a frequency sweep from 2 Hz to 120 Hz.

6.4.3.2 Temperature Cycling: Temperature cycling shall be performed per MIL-STD-883, Test method 1010. The temperature range shall include the full ambient operating temperature range specified in 3.3.1. A minimum of 20 cycles shall be performed with a 30-minute transfer time between temperature extremes and a 30-minute dwell time at each extreme temperature. Signals under test shall be non-operating.

6.4.3.3 Moisture Resistance: Moisture resistance testing shall be performed per NEMA Standard 250-1991 for Type 4 enclosures.

6.4.3.4 Environmental Tests Evaluation: At the conclusion of the Environmental Tests, all the LED signal modules will be visual inspected for damage.

6.4.3.5 Acceptance/Rejection Criteria: The loosening of the lens, or any internal components, or evidence of other physical damage, such as cracking of the module lens or housing or presence of internal moisture after testing shall be considered a failure for the proposed design.

6.4.4 Photometric & Colorimetric Tests: Three of the modules that were subjected to the Environmental Tests shall undergo Photometric & Colorimetric Tests. Unless otherwise specified, these tests shall be performed with the LED signal modules energized at nominal operating voltage (120 VAC).

6.4.4.1 Luminous intensity at standard temperature: The LED signal modules shall be tested for compliance with the requirements for minimum maintained luminous intensity at a temperature of 25°C (77°F). Measurements shall be made for all of the 44 points as given in Table 1.

6.4.4.1.1 Luminous intensity measurements for red and green signal modules shall be made after the signal module has been operated under the test conditions for a minimum of 60 minutes at a 100% duty cycle.

6.4.4.1.2 Luminous intensity measurements for amber signal modules shall be made after the signal module has been operated under the test conditions for a minimum of 60 minutes at a 12.5% duty cycle (5 seconds on and 35 seconds off). Readings shall be taken at the end of the 5-second on interval.

6.4.4.2 Luminous intensity at high temperature: The LED signal modules shall be tested for compliance with the requirements for minimum maintained luminous intensity at a temperature of 74ºC (165ºF). The modules shall be mounted in a temperature chamber so that the signal module lens is outside the chamber and all portions behind the lens are within the chamber at a temperature of 74ºC (165ºF). The air temperature in front of the lens of the signal shall be maintained at a minimum of 49°C (120°F) during all tests. A single-point correlation measurement of the luminous intensity, in the region from 5 degrees left to 5 degrees right, and from 0 degrees to 5 degrees down shall be recorded. The single-point measurement at shall be factored to the 25°C (77°F) measurement made in the same direction under Section 6.4.4.1 to generate a full range of luminous intensity values at high temperature.

6.4.4.2.1 Luminous intensity measurements for red and green signal modules shall be made after the signal module has been operated under the test conditions for a minimum of 60 minutes at a 100% duty cycle.

6.4.4.2.2 Luminous intensity measurements for amber signal modules shall be made after the signal module has been operated under the test conditions for a minimum of 60 minutes at a 12.5% duty cycle (5 seconds on and 35 seconds off). Readings shall be taken at the end of the 5-second on interval.

6.4.4.3 Luminance uniformity: The LED signal modules shall be tested for compliance with the requirements for luminance uniformity at a temperature of 25°C (77°F). Measurements shall be made using a luminance meter located on the physical axis of the module lens at a distance such that the selected aperture samples a spot size of 12mm (.5 inch) at the lens surface. The position of the luminance meter shall be translated from side to side and up and down, so as to sample the entire emitting surface of the module. The highest and lowest values of luminance shall be recorded. Luminance measurements may be made immediately following measurements for luminous intensity at standard temperature (6.4.4.1).

6.4.4.3.1 Luminance measurements for red and green signal modules shall be made after the signal module has been operated under the test conditions for a minimum of 60 minutes at a 100% duty cycle.

6.4.4.3.2 Luminance measurements for amber signal modules shall be made after the signal module has been operated under the test conditions for a minimum of 60 minutes at a 12.5% duty cycle (5 seconds on and 35 seconds off). Readings shall be taken at the end of the 5-second on interval.

6.4.4.4 Chromaticity: The chromaticity of the light output of the LED signal modules shall be measured at a temperature of 25°C (77°F). A spectroradiometer with a minimum interval of 4nm shall be used for this measurement. The measurement area shall include at least 80% of the emitting surface of the module. Chromaticity measurements may be made immediately following measurements for luminance uniformity (6.4.4.3).

6.4.4.4.1 Chromaticity measurements for red and

green signal modules shall be made after the signal module has been operated under the test conditions for a minimum of 60 minutes at a 100% duty cycle.

6.4.4.4.2 Luminous intensity measurements for amber signal modules shall be made after the signal module has been operated under the test conditions for a minimum of 60 minutes at a 12.5% duty cycle (5 seconds on and 35 seconds off). Readings must be taken with the module operating at a 100% duty cycle.

6.4.4.5 Photometric & Colorimetric Tests Evaluation: At the conclusion of the Photometric & Colorimetric Tests, the measurement data shall be compared to the requirements of Section 4.1, and applicable requirements of Section 4.2.

6.4.4.6 Acceptance/Rejection Criteria: The failure of any LED signal module to meet the requirements for minimum maintained luminous intensity (4.1.1) or maximum permissible luminous intensity (4.1.2) under standard and high temperatures, the requirement for luminance uniformity (4.1.3) and/or the appropriate requirement for chromaticity (4.2) shall be considered a failure of the proposed design.

6.4.5 Lens Tests: Following the Photometric & Colorimetric Tests, the three LED signal modules shall be subjected to the following tests of the acceptability of the lens construction.

6.4.5.1 UV Stabilization: Documentation shall be provided that clearly demonstrates that installation in accordance with 3.3.3 shall not result in a loss of direct transmission through the lens material of greater than 10% after 60 months service.

6.4.5.2 Lens Abrasion Test: Abrasion resistance testing of the LED signal module lens shall be performed in accordance with ASTM D1044. A mass of 500 grams shall be applied on a CS10F wheel for 150 cycles.

6.4.6 Electrical Tests: Three of the modules that were subjected to the Environmental Tests shall undergo Electrical Tests. These tests shall be performed with the LED signal modules energized at nominal operating voltage and at a standard temperature of 25°C (77°F), unless specified otherwise.

6.4.6.1 Current Consumption: The current flow, in Amperes, of the LED signal modules shall be measured at various ambient temperatures across the span of the operating temperature range specified in 3.3.1. The measured current values shall be used to establish the standards for the proposed design to be used as a comparison during Production Quality Assurance current measurements on production modules. The manufacturer shall provide information (charts, tables and/or graphs) on the variation in current over time within the operating temperature range of 3.3.1.

6.4.6.2 Transient Voltage Immunity: The LED signal modules shall be tested for transient immunity using the procedure described in Section 2.1.8, NEMA Standard TS 2-1998.

6.4.6.3 Electronic Noise: The LED signal modules shall be tested for conformance with the requirements of a Class A digital device, as required by the Federal Communications Commission (FCC) in CFR Title 47, SubPart B, Section 15.

6.4.6.4 Power Factor: The power factor for the LED signal modules shall be measured and recorded. A commercially available power factor meter may be used to perform this measurement.

6.4.6.5 Total Harmonic Distortion (THD): The total harmonic distortion induced into an AC power line by the LED signal modules shall be measured and recorded. A commercially available total harmonic distortion meter may be used to perform this measurement.

6.4.6.6 Electrical Tests Evaluation: At the conclusion of the Electrical Tests, the measurement data shall be compared to the requirements of Sections 5.3 through 5.6.

6.4.6.7 Acceptance/Rejection Criteria: The failure of any LED signal module to meet the requirements for transient voltage immunity

(5.3), emission of electronic noise (5.5), minimum power factor (5.6.1), and/or maximum total harmonic distortion (5.6.2) shall be considered a failure of the proposed design.

6.4.7 Controller Assembly Compatibility Tests: Following the Electrical Tests, three LED signal modules shall be tested for compatibility with load current switches and conflict monitors presently in service. The LED signal module manufacturer shall test the design for the specific type signal control unit that the design is to be qualified for.

6.4.7.1 Load Switch Compatibility: The LED signal modules shall be tested for compatibility and proper operation with load current switches. Each LED signal module shall be connected to a variable AC voltage supply. The AC line current into the LED signal module shall be monitored for sufficient current draw to ensure proper load switch operation while the voltage is varied from 80 to 135 VAC.

6.4.7.2 Signal Conflict Monitor Compatibility: The LED signal modules shall be tested for compatibility and proper operation with signal conflict monitors. Each LED signal module shall be operated from a 135 VAC voltage supply. A 19.5 kΩ resistor shall be wired in series in the hot line between the LED signal monitor and the AC power supply. A single-pole-single-throw switch shall be wired in parallel with the 19.5 kΩ resistor. A 220 kΩ shunt resistor shall be wired between the hot line connection and the neutral line connection on the LED signal module. Conflict monitor compatibility shall be tested by measuring the voltage decay across the 220 kΩ shunt resistor as follows: The single-pole-single-throw switch shall be closed, bypassing the 19.5 kΩ resistor and allowing the AC power supply to energize the LED signal module. Next, the switch shall be opened and the voltage across the 220 kΩ shunt resistor shall be measured for decay to a value equal to or less than 10 VAC RMS. The test shall be repeated 10 times, with the longest decay time recorded as the final test value.

6.4.7.3 Controller Assembly Compatibility Evaluation: At the conclusion of the Controller Assembly Compatibility Tests, the measurement data shall be compared to the requirements of the specific make and model Controller Assembly with which the LED signal module design is intended to operate.

6.4.7.4 Acceptance/Rejection Criteria: Failure of the LED signal module to draw sufficient current to ensure compatibility with the load current switches in the appropriate Controller Assembly (5.7) and/or failure of the circuit voltage to decay to a value equal to or less than 10 VAC RMS within a time period equal to or less than 100 milliseconds (5.7) shall be considered a failure of the proposed design