Performance Specification of the
Institute of Transportation Engineers

Pedestrian Traffic Control Signal Indicators: Light Emitting Diode (LED) Signal Modules

Prepared by the LED Committee
of the Traffic Engineering Council

August 4, 2010

Performance Specification of the
Institute of Transportation Engineers

Pedestrian Traffic Control Signal Indicators -
Light Emitting Diode (LED) Signal Modules

Prepared by the LED Committee of the Traffic Engineering Council

August 4, 2010

Institute of Transportation Engineers
1627 Eye Street, NW, Suite 600
Washington, DC 20006
www.ite.org

STANDARD ITE METRIC CONVERSIONS

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 not to 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)

Pedestrian Traffic Control Signal Indications—Light Emitting Diode Signal Module Supplement: *A Performance Specification of the Institute of Transportation Engineers* was prepared by the ITE LED Committee of the Traffic Engineering Council.

Members of the LED Committee of the Traffic Engineering Council are Nathaniel S. Behura, Transportation & Energy Solutions, Inc., Yorba Linda, CA (Chair); Seth Chalmers, Chalmers Engineering Consultant, Tempe, AZ; Andrew Lipman, Next Generation Lighting, Chicago, IL; Henri R. Arcand, Consultant (GE Lighting Solutions), Pierrefonds, Quebec, Canada; Gary R. Durgin, Dialight Corp., Farmingdale, NJ; Carl K. Andersen, FHWA, McLean, VA; and Siva Narla, Staff Liaison, ITE, Washington, DC.

Certain individual volunteer members of the Institute committees are employed by federal agencies, other governmental offices, private enterprise, or other organizations. Their participation in the Institute committee activities does not constitute endorsement by these government agencies or other organization endorsement of any of the Institute committees or any purchase specification that is developed by such committees.

The Institute of Transportation Engineers (ITE) is an international educational and scientific association of transportation professionals who are responsible for meeting mobility and safety needs. ITE facilitates the application of technology and scientific principles to research, planning, functional design, implementation, operation, policy development and management for any mode of ground transportation. Through its products and services, ITE promotes professional development of its members, supports and encourages education, stimulates research, develops public awareness programs and serves as a conduit for the exchange of professional information.

Founded in 1930, ITE is a community of transportation professionals including, but not limited to transportation engineers, transportation planners, consultants, educators and researchers. Through meetings, seminars, publications and a network of nearly 17,000 members, working in more than 90 countries, ITE is your source for expertise, knowledge and ideas.

Institute of Transportation Engineers
1627 Eye Street, NW, Suite 600
Washington, DC 20006
www.ite.org

ISBN-10: 1-933452-59-5
ISBN-13: 978-1-933452-59-3
Publication No. ST-055-E

Table of Contents

1 Purpose

The purpose of this specification is to provide the minimum performance requirements for the LED "walking person" and "upraised hand" icons and numeric countdown pedestrian signal modules (hereafter called module or modules). This specification includes the following three sizes (nominal message bearing surface): 406 mm x 457 mm (16 in x 18 in), 305 mm x 305 mm (12 in x 12 in), and 229 mm x 229 mm (9 in x 9 in). 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 *Pedestrian Traffic Control Signal Indications* published in the Equipment and Materials Standards of the Institute of Transportation Engineers, referred to in this document as "PTCSI." This specification is not restricted to any specific LED technology.

The *Manual on Uniform Traffic Control Devices* (MUTCD), FHWA, 2009 Edition, in **Section 4E.07 Countdown Pedestrian Signals** requires the following:

> **Standard:**
> **All pedestrian signal heads used at crosswalks where the pedestrian change interval is more than 7 seconds shall include a pedestrian change interval countdown display in order to inform pedestrians of the number of seconds remaining in the pedestrian change interval.**
>
> Option:
> Pedestrian signal heads used at crosswalks where the pedestrian change interval is 7 seconds or less may include a pedestrian change interval countdown display in order to inform pedestrians of the number of seconds remaining in the pedestrian change interval.
>
> **Standard:**
> **Where countdown pedestrian signals are used, the countdown shall always be displayed simultaneously with the flashing UPRAISED HAND (symbolizing DONT WALK) signal indication displayed for that crosswalk.**

Additional operational and application requirements and guidelines are provided in the MUTCD.

The requirements of this specification are based on the best information available at the time it was developed. It is the responsibility of the user and the module manufacturer to evaluate specific applications to insure that the requirements of a traffic control signal are met. Deviation from the performance standards provided in this specification should be documented in an engineering study.

This is a minimum specification. If local operating or environmental conditions are more severe than those described herein, the user should consider additional testing and manufacturing requirements to suit their specific needs.

2 Definitions

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

2.2 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) coordinate system.

2.3 Conditioning. Energizing an 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.

2.4 Countdown Pedestrian Signal. A two digit numeric interval countdown display used to inform the pedestrians of the number of seconds remaining in the pedestrian change interval.

2.5 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.

2.6 Hard Coat. A surface coating or a film used to provide front surface abrasion resistance.

2.7 Illuminance. The density of the luminous flux incident on a surface. Its value is determined by luminous intensity, angle of incidence and distance from the source to the surface, expressed as lux.

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

2.9 LED Pedestrian Signal Module. A "walking person" and/or "upraised hand" signal module comprised of an array of LEDs and related power supply and any required lenses, which, when connected to appropriate power, provides a single pedestrian signal indication, and a countdown signal when appropriate for modules with a countdown display.

2.10 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.

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

2.12 Message Bearing Surface. The exposed front surface area of the pedestrian signal displaying any or all of the "walking person", "upraised hand" and "countdown" icons.

2.13 Minimum Maintained Luminance. The minimum luminance a module is required to provide throughout service as a pedestrian indication or countdown display.

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

2.15 Pedestrian Change Interval. Period of time when "upraised hand" icon is flashing to advise the pedestrians that they should leave and /or not enter the crosswalk. The stored countdown timing value that represents duration of the Pedestrian Change Interval shall be determined by measuring the time in seconds between the end of the WALK indication and the start of the solid DONT WALK indication.

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

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

2.18 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.

2.19 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.

2.20 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.

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

2.22 Turn ON Time. The amount of time required for the LED signal module to reach 90 percent of full illumination.

2.23 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

3.1.1 Module Installation: 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.

3.1.2 Minimum Message Bearing Surface Size: The minimum size of the message bearing surface of a module shall be determined by the length of the intended crosswalk, but in no case shall it be less than 229 mm x 229 mm (9 in x 9 in). The sizes of the message bearing surfaces shall be in accordance with the dimensions given in Table 1.

Table 1—Dimensions of Signal Sizes

Class	Message Bearing Surface Height X Width	Crosswalk Length[1]	Minimum Message Size Height X Width	
			Walking Person and Upraised Hand Icons	Countdown Display
1	229 mm x 229 mm (9" x 9")	≤18.2 m (≤60')	152 mm x 89 mm (6" x 3.5")	229 mm x 178 mm (9" x 7")
2	305 mm x 305 mm (12" x 12")	>18.2 m (>60')	229 mm x 134 mm (9" x 5.25")	229 mm x 178 mm (9" x 7")
3	406 mm x 457 mm (16" x 18")	>18.2 m (>60')	297 mm x 178 mm (11" x 7")	229 mm x 178 mm (9" x 7")

[1]Class 2 & 3 signal indications may also be used when the crosswalk length is equal to or less than 18.2 m (60').

3.2 LED Signal Module

3.2.1 Module Installation: 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.

3.2.2 Hard Coat (Optional): The module lens may be hard coated or otherwise made to comply with the UV material exposure and weathering effects requirements of the Society of Automotive Engineers (SAE) J576.

3.2.3 Unlit Illumination: When not energized, the “walking person” (symbolizing WALK) and “upraised hand” (symbolizing DON’T WALK) icons shall not be readily visible to pedestrians at the far end of the crosswalk that the pedestrian signal head indications control.

3.2.4 Replaceable Lens: The module lens may be a replaceable part, without the need to replace the complete LED signal module.

3.2.5 Countdown Signal Module (For modules with countdown): The countdown pedestrian signal module shall be made up of two digits and shall be located immediately adjacent to the associated "upraised hand" icon.

3.2.5.1 Pedestrian Change Interval: The countdown pedestrian signal shall display the time remaining, in seconds, beginning at the start of the pedestrian change interval and ending at the termination of the pedestrian change interval. Countdown displays shall not be used during the walk interval. After the countdown displays zero, the display shall remain dark until the beginning of the next pedestrian change interval.

3.2.5.2 Countdown Range: The countdown display shall be capable of counting down from 99 to 0. Leading zeros on numbers less than 10 shall be blanked (i.e. Displaying 09, 08, 07 … 01, 00 is unacceptable). Numbers less than 10 shall be displayed in the right hand digit of the countdown display.

3.2.5.3 Display of the "1" Digit: The display of the digit "1" must be displayed in the right hand portion of the digit segment.

3.2.5.4 Learning Cycle: The countdown learning cycle, when applicable, may only be initiated after the initial installation, a return from a power failure greater than 2 seconds, a repeated demand to change programming, or after preemption. During the learning cycle, the countdown display shall remain blank. The learning cycle shall not last more than two complete cycles.

3.2.5.5 Countdown Timer: During the pedestrian change interval, the display of each number in the countdown sequence, the interval from the display of one number to the display of the subsequent number in the sequence, and the display of the "0" at the end of the countdown cycle (before going blank) shall be 1 second ± 0.04 seconds. At no point in time during the countdown interval shall the digit display go entirely blank, except in the case of preemption (see 3.2.5.6).

3.2.5.6 Preemption: If the pedestrian change interval is interrupted or shortened as a part of a transition into a preemption sequence (re: Section 4E.07, paragraph 10, MUTCD 2009), the countdown pedestrian signal display should be discontinued and go dark upon activation of the preemption transition.

Icon Configurations: The configurations of the "walking person" icon, the "upraised hand" icon and the countdown display digits are illustrated in Figure 1, Figure 2 and Figures 3A and 3B respectively.

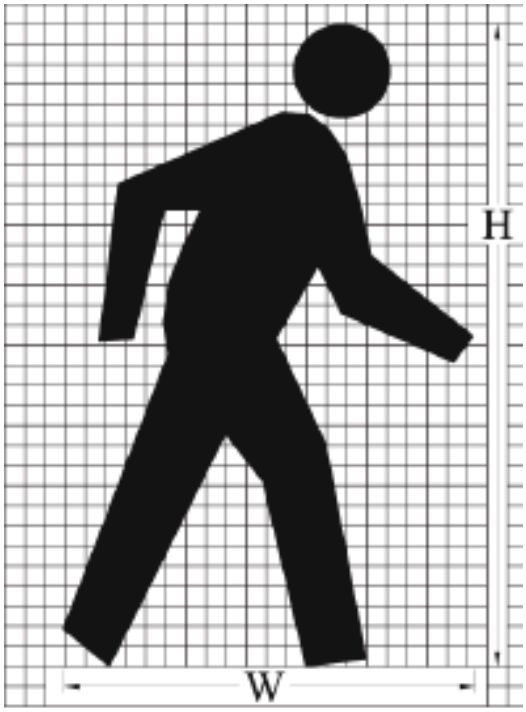

Figure 1—Walking Person Icon

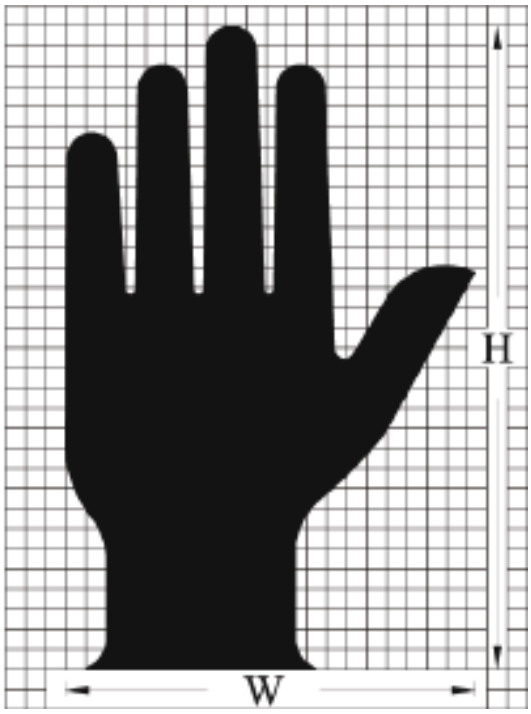

Figure 2—Upraised Hand Icon

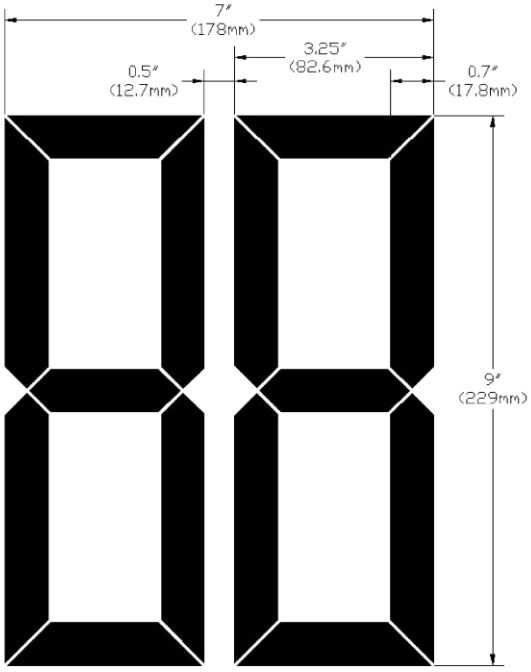

Figure 3A – Countdown Display Digits[1]

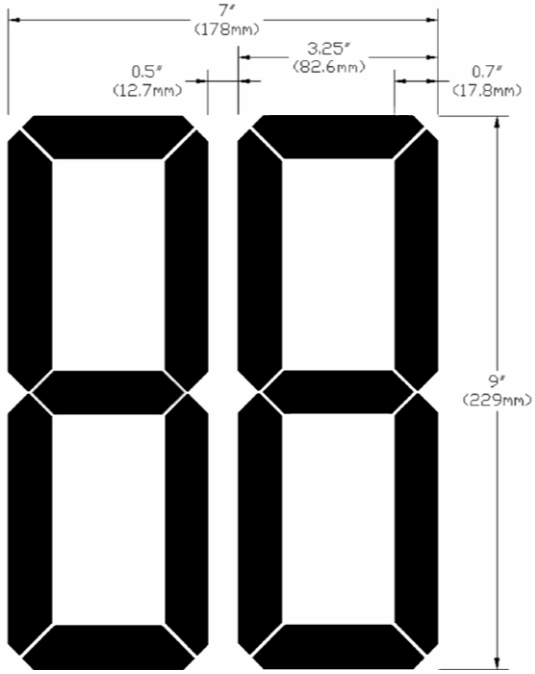

Figure 3B –Countdown Display Digits[1]

[1] *The acceptable pedestrian countdown display digits are shown in Figures 3A and 3B. With these shapes, every digit shall have the same height except in Figure 3B where every digit shall be at least 95% of the height and width of the comparable digits in Figure 3A.*

3.3 Environmental Requirements

3.3.1 Environmental Resistance: 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 60 months in a south-facing Arizona desert installation.

3.3.2 Operating Temperature Range: 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).

3.3.3 Moisture Intrusion: A module shall be protected against dust and moisture intrusion, including rain and blowing rain.

3.3.4 UV Resistance: 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 60 months in service.

3.4 Construction

3.4.1 Configuration: A module shall be a self-contained device, not requiring on-site assembly for installation into an existing signal housing. The power supply for the module may be either integral or packaged as a separate component.

3.4.2 Shock and Vibration Resistance: Assembly and manufacturing processes for the 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.

3.5 Materials

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

3.5.2 Flammability Resistance: Enclosures containing either the power supply or electronic components of the module shall be made of UL94 flame-retardant materials. The module lens is excluded from this requirement.

3.6 Module Identification

3.6.1 Identification Label: Each module shall be identified on the backside with the manufacturer's name, model, operating characteristics and serial number. The operating characteristics of each icon shall be identified and shall include the nominal operating voltage and stabilized power consumption as defined in Section 6.3.5 in watts and volt-amperes. The operating characteristics of the countdown shall be for the countdown displaying the "88" digits. The identification labels shall be permanent in nature and must last and be legible through the operating life of the module(s) through its normal operating conditions and environment.

3.6.2 PTCSI Conformance Label: Modules conforming to all non-optional requirements of this specification, may have the following statement on an attached label: "Manufactured in Conformance with the ITE Pedestrian Traffic Control Signal Indicators - Light Emitting Diode (LED) Signal Modules ***Date of Latest Publication.***"

4 Photometric Requirements

4.1 Luminance, Uniformity & Distribution

4.1.1 Minimum Maintained Luminance: For a minimum period of 60 months, the minimum luminance values for the modules under the operating conditions defined in Sections 3.3.2 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;
- Upraised hand: 1,400 cd/m^2;
- Countdown display (while displaying "88"): 1,400 cd/m^2.

4.1.2 Minimum Maintained Luminous Intensity (Off-Axis): For a minimum period of 60 months the luminous intensity values at +/- 15 degrees on each side of the vertical plane and 15 degrees below the horizontal plane shall not be less than the values in Table 3.

The light output requirements in this specification apply to pedestrian signal heads without any visors or louvers (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.

4.1.3 Maximum Permissible Luminance: When operated within the temperature range specified in Section 3.3.2, the actual luminance for a module shall not exceed three times the minimum maintained luminance of the modules as defined in 4.1.1.

4.1.4 Luminance Uniformity: The uniformity of the signal output across the emitting section of the module lens for the "upraised hand" and "walking person" icons and the countdown display shall not exceed a ratio of 5 to 1 between the maximum and minimum luminance values (cd/m^2).

4.2 Chromaticity

4.2.1 Chromaticity: The standard colors for the LED pedestrian signal module shall be white for the "walking person" and Portland Orange for the "upraised hand" icon and the countdown digits. The colors for these icons shall conform to the following color regions, based on the 1931 CIE chromaticity diagram (Figure 5):

4.2.1.1 Walking Person —White:

Blue boundary: $x = 0.280$

Green boundary: $0.280 \leq x < 0.400$
$y = 0.0983 + 0.7917 \cdot x$

Yellow boundary: $x = 0.400$

Purple boundary: $0.280 \leq x < 0.400$
$y = 0.0483 + 0.7917 \cdot x$

White		
Point	x	y
1	0.280	0.320
2	0.400	0.415
3	0.400	0.365
4	0.280	0.270

4.2.1.2 Upraised Hand and Countdown Digits—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	0.609	0.390
2	0.600	0.390
3	0.659	0.331
4	0.669	0.331

4.2.2 Color Uniformity:

4.2.2.1 Walking Person—White:

$$\sqrt{(\Delta x^2) + (\Delta y^2)} \leq 0.04$$

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.

4.2.2.2 Upraised Hand and Countdown

Digits—Portland Orange:

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.

5 Electrical

5.1 General

5.1.1 Wiring and Terminal Blocks: All wiring and terminal blocks shall meet the requirements of Section 13.02 of the current VTCSH standard. Conductors shall have a 600V insulation rating, 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. The conductors shall be color coded with orange for the hand, blue for the walking person, orange with blue stripes for countdown if required and white as the common lead.

5.2 Voltage Range

5.2.1 Operating Voltage Range: The modules shall operate from a 60±3 hertz (Hz) AC power line over a voltage range from 80 to 135 VAC RMS.

5.2.2 Voltage Fluctuations: Fluctuations in line voltage over the range of 80 to 135 VAC RMS shall not affect luminance by more than ±10 percent.

5.2.3 Flicker Prevention: To prevent the appearance of flicker, the module circuitry shall drive the LEDs at frequencies greater than 100 Hz when modulated, or at DC, over the voltage range specified in Section 5.2.1.

5.2.4 Low Voltage Turn-Off: There shall be no visible illumination from the module when the applied voltage is less than 35 VAC RMS.

5.2.5 Turn-ON and Turn-OFF Time: A module (excluding the pedestrian countdown display) shall reach 90% of full illumination (turn-ON) within 75 milliseconds (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.

5.2.6 Default Condition: Applies to modules that have both the "walking person" and the "upraised hand" as one module: For abnormal conditions when nominal voltage is applied to the unit across the two-phase wires or simultaneously to both "upraised hand" and "walking person" icons, the pedestrian signal unit shall default to the "upraised hand" icon.

5.3 Transient Voltage Protection

5.3.1 Transient Voltage Immunity: The onboard circuitry of a module shall include voltage surge protection to withstand high-repetition noise transients and low-repetition high-energy transients as stated in Section 2.1.8, NEMA Standard TS 2-2003.

5.3.2 Ring Wave Immunity: The module shall be capable of withstanding ring wave immunity specified in Section 8 of IEC 61000-4-12 (2006).

5.4 Electronic Noise

5.4.1 Electromagnetic Emissions: The LED signal and associated onboard circuitry shall meet the conducted and radiated emissions requirements of the Federal Communications Commission (FCC) Title 47, Subpart B, Section 15 regulations concerning the emission of electronic noise by Class A digital devices.

5.5 Power Factor (PF) and AC Harmonics

5.5.1 Power Factor: Modules shall provide a power factor of 0.90 or greater when

operated at nominal operating voltage and at 25ºC (77ºF).

5.5.2 Total Harmonic Distortion: Total harmonic distortion induced into an AC power line by a module at nominal operating voltage, and at 25ºC (77ºF), shall not exceed 20 percent.

5.6 Controller Assembly Compatibility

5.6.1 Current Draw: 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.

5.6.2 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).

5.7 Failed State Impedance (Optional)

5.7.1 Failed State Impedance: If requested, 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 5.2.1 after 75 msec.

5.8 Nighttime Dimming (Optional)

5.8.1 Dimming Functionality: When requested, the module circuitry shall allow a reduction of the luminance of the light output in response to an input from the traffic signal controller.

5.8.2 Dimming Level: Dimming, if provided, shall reduce light output to levels established to match ambient lighting conditions. Dimming may be in stepped increments or may be continuously variable. The minimum light output, when dimmed, shall not be less than 30 percent of the minimum maintained luminance, as defined in Section 4.1.1.

6 Quality Assurance

6.1 General

6.1.1 Quality Assurance Program: 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 modules built to meet this specification.

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

6.1.3 Conformance: 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

6.2.1 Module Identification: Each module shall be identified with the information specified in Section 3.6.

6.3 Production Tests & Inspections

6.3.1 Production Test Requirements: All modules tendered for sale shall undergo the following production testing and inspection prior to shipment. Failure of a module to meet the requirements of production testing and inspection shall be cause for rejection. Test results shall be maintained per the requirement of Section 6.1.2.

6.3.1.1 Production Test Conditions: All production tests shall be performed at an ambient temperature of 25ºC (77ºF) and at the nominal operating voltage of 120 VAC.

6.3.1.2 Countdown Display Test Condition: Unless otherwise specified, all production measurements of the countdown display shall be with the countdown displaying the "88".

6.3.2 Production Light Output Test: All modules shall be tested for light output. A single point measurement, with a correlation to the minimum luminous intensity values in Table 2, may be used. Failure of a module to meet the minimum luminous intensity values in Table 2 or the maximum permissible luminous intensity values in Table 4 shall be cause for rejection of the module.

6.3.3 Power Factor (PF): All modules shall be tested for power factor per the requirements of Section 5.5.1. A commercially available power factor meter may be used to perform this measurement. Failure of a module to meet the requirements for power factor (5.5.1) shall be cause for rejection of the module.

6.3.4 Current Consumption Measurement: All 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 6.4.6.2. A measured current consumption in excess of 120 percent of the design qualification current value for an ambient temperature of 25ºC (77ºF) shall be cause for rejection of the module.

6.3.5 Power Consumption Measurement: All modules shall be measured for power consumption in watts. The measured power values shall be compared against the design power values from design qualification measurements in Section 6.4.6.3. A measured power consumption in excess of 120 percent of the design qualification power value for an ambient temperature of 25ºC (77ºF) shall be cause for rejection of the module.

6.3.6 Visual Inspection: All 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. The presence of any such defects shall be cause for rejection of the module.

6.4 Design Qualification Testing

6.4.1 Design Qualification Test Requirements: Design qualification testing shall be performed on new module designs, when a major design change has been implemented on an existing design, or after every 5 years that a design is in service. Modules used in design qualification testing shall be representative of the manufacturer's proposed normal production. The certification of UV stabilization (6.4.5) shall be provided for all materials used in or on the emitting lenses.

6.4.1.1 Recordkeeping: Test data shall be retained by the 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 Testing Overview: 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 and colorimetric Tests (6.4.4). The remaining three modules shall undergo the electrical tests (6.4.6), the controller assembly compatibility tests (6.4.7), and the failed state impedance test (optional) (6.4.8). Tests shall be conducted in the order described herein, unless otherwise specified. Figure 4 provides a flow chart for the design qualification testing.

6.4.1.3 Testing Acceptance/Rejection: In order for a module design to be considered acceptable for marking with the label described

in 3.6.2, all tested modules must comply with the acceptance/rejection criteria for the environmental tests (6.4.3), photometric and colorimetric tests (6.4.4), electrical tests (6.4.6), controller assembly compatibility tests (6.4.7) and the failed state impedance test (optional) (6.4.8).

6.4.1.4 Countdown Display Test Condition: Unless otherwise specified, all design qualification testing of the countdown display shall be with the countdown displaying the "88".

6.4.2 Conditioning: Modules (each icon) shall be energized for a minimum of 24 hours, at 100 percent 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. Signals under test shall be non-operating.

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 3.3.2. 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 MIL-STD-810F, test method 506.4, Procedure I, Rain and Blowing Rain. The test shall be conducted on standalone modules, without a protective housing. The rainfall rate shall be 1.7 millimeters per minute (mm/min, or 4 inches per hour) and droplet size shall predominantly be between 0.5 mm and 4.5 mm (0.02 to 0.18 inches). The modules shall be vertically oriented, such that the lens is directed towards the wind source when at a zero-rotation angle. The module shall be rotated at a rate of 4 degrees per minute along the vertical axis, from an orientation of -60 to +60 degrees during the test. The duration of the test shall be 30 minutes. The modules shall be energized throughout the test. The water shall be at 25° ± 5°C (77° ± 9°F). The wind velocity shall be 80 kilometers per hour (km/hr); approximately 50 miles per hour (mph). If the module is equipped with a remote power supply unit, then the test shall be conducted with the remote power supply unit attached to the clamping device holding the module to the test apparatus.

6.4.3.4 Environmental Tests Evaluation: At the conclusion of the environmental tests, all the modules will be visually inspected for damage and energized to ensure proper operation.

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, or failure to operate correctly after testing shall be considered a failure for the proposed design.

6.4.4 Photometric & Colorimetric Tests:

6.4.4.1 Photometric & Colorimetric Test Conditions: Three of the modules that were subjected to the environmental tests shall undergo photometric and colorimetric tests. Unless otherwise specified, these tests shall be performed with the modules energized at nominal operating voltage. Unless otherwise specified, all photometric and colorimetric testing of the countdown display shall be with the countdown displaying the "88."

6.4.4.2 Luminance at Standard Temperature: The modules shall be tested for compliance with the requirements for minimum

maintained luminance at a temperature of 25°C (77°F).

6.4.4.2.1 Luminance Measurement: Luminance measurements shall be made after the module has been operated under the test conditions for a minimum of 60 minutes at a 100 percent duty cycle. 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 circular spot with a diameter of 12 mm (0.5 inch) at the lens surface. The position of the luminance meter shall be translated from side to side and up and down, to sample a minimum of nine equally distributed positions about the entire emitting surface of the "walking person" and/or "upraised hand" icons and/or a minimum of 14 positions (one per digit segment) of the "countdown" display. The luminance values for the measured points shall be recorded and the average value calculated.

6.4.4.3 Luminance at Low Voltage: The modules shall be tested for compliance with the requirements for minimum maintained luminance when operated at 80 VAC at a temperature of 25°C (77°F).

6.4.4.3.1 Luminance Measurement: Luminance measurements shall be made after the module has been operated under the test conditions for a minimum of 60 minutes at a 100 percent duty cycle. A single-point measurement of the luminance shall be recorded, and correlated to the measurement made in the same direction under Section 6.4.4.2 to generate a full range of luminance values at reduced voltage. The single point measurement shall be taken in the region described in Section 6.4.4.2.1. The luminance measurement at reduced voltage shall be made immediately following measurements for luminance at standard temperature (6.4.4.2).

6.4.4.4 Luminance at Elevated Voltage: The modules shall be tested for compliance with the requirements for minimum maintained luminance when operated at 135 VAC at a temperature of 25°C (77°F).

6.4.4.4.1 Luminance Measurement: Luminance measurements shall be made after the module has been operated under the test conditions for a minimum of 60 minutes at a 100 percent duty cycle. A single-point measurement of the luminance shall be recorded and correlated to the measurement made in the same direction under Section 6.4.4.2 to generate a full range of luminance values at elevated voltage. The single point measurement shall be taken in the region described in Section 6.4.4.2.1. The luminance measurement at elevated voltage shall be made immediately following measurements for luminance at reduced voltage (6.4.4.3).

6.4.4.5 Luminance at High Temperature: The modules shall be tested for compliance with the requirements for minimum maintained luminance at a temperature of 74ºC (165ºF).

6.4.4.5.1 Luminance Measurement: Luminance measurements shall be made after the module has been operated under the test conditions for a minimum of 60 minutes at a 100 percent duty cycle. 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) throughout the test. A single-point measurement of the luminance shall be recorded and correlated to the 25°C (77°F) measurement made in the same direction under Section 6.4.4.2 to generate a full range of luminance values at high temperature.

6.4.4.6 Luminance Uniformity: The 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 circular spot with a diameter of 12 mm (0.5 in) 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. Measured luminance values from the luminance at standard temperature (6.4.4.2) may be used.

6.4.4.6.1 Luminance Uniformity Measurement: Luminance uniformity measurements must be made with the signal module operating at a 100 percent duty cycle. Therefore, it is necessary for the signal module under test to reach thermal equilibrium and for the output to be stable prior to taking measurements.

6.4.4.7 Chromaticity: The chromaticity of the emitted light from modules shall be measured at a temperature of 25°C (77°F). A spectro-radiometer with a maximum bandwidth of 4 nanometers (nm), or a colorimeter that has a measurement uncertainty of less than 2.5 percent over the emission spectra of the module, shall be used for this measurement. The spectro-radiometer or colorimeter shall be located on the physical axis of the module lens at a distance such that the selected aperture samples a circular spot with a diameter of 12 mm (0.5 inch) at the lens surface. The meter shall be translated from side to side and up and down, so as to sample a minimum of nine equally distributed positions about the entire emitting surface of the "walking person" and/or "upraised hand" icons and/or a minimum of 14 positions (one per digit segment) of the "countdown" display. The colorimetric values of the emitted light at each of the measured positions shall be recorded, and an average value calculated, based on the CIE Standard 2° Observer. These measurements may be made immediately following measurements for luminance uniformity (6.4.4.5).

6.4.4.7.1 Chromaticity Measurement: Chromaticity measurements must be made with the signal module operating at a 100 percent duty cycle. Therefore, it is necessary for the signal module under test to reach thermal equilibrium and for the output to be stable prior to taking measurements.

6.4.4.8 Color Uniformity: The average and the nine individual sets of chromaticity values for the "walking person" and/or "upraised hand" icons and/or 14 individual sets of chromaticity values for the "countdown" display of each module under evaluation shall be plotted on the CIE 1931 Chromaticity Diagram (see Figure 1, VTCSH LED Circular Signal Supplement).

6.4.4.9 Luminous Intensity On-Axis:* The modules shall be measured and recorded for on-axis luminous intensity at a temperature of 25°C (77°F) and nominal operating voltage.

6.4.4.9.1 Luminous Intensity Measurement On-Axis: On-axis luminous intensity measurement shall be made after the module has been operated under the test conditions for a minimum of 60 minutes at a 100 percent duty cycle. The single point measurement shall be made using a photometer located on and normal to the physical axis of the module lens at a distance of at least 9 meters from the lens surface.

6.4.4.10 Luminous Intensity Off-Axis: The modules shall be tested for compliance with the off-axis minimum luminous intensity values in Table 3 at a temperature of 25°C (77°F) and nominal operating voltage.

---

* Note: On-axis luminous intensity is not a criterion for qualification but is used in production testing for quality assurance/control (see paragraph 6.3.2). Measurement of on-axis luminous intensity during qualification testing is solely conducted to establish a baseline value under standard conditions that can be used to develop a correlation function for measurements made during production or acceptance testing.

6.4.4.10.1 Luminous Intensity Measurements Off-Axis: Off-axis luminous intensity measurements shall be made after the module has been operated under the test conditions for a minimum of 60 minutes at a 100 percent duty cycle. Three separate measurements shall be made using a photometer located (1) 15 degrees left, (2) 15 degrees right and (3) 15 degrees below the physical axis of the module lens at a distance of at least 9 meters from the lens surface. The photometer shall be oriented so that it is directed at the center of the module lens.

6.4.4.11 Photometric and Colorimetric Tests Evaluation: At the conclusion of the photometric and colorimetric tests, the measurement data shall be compared to the applicable requirements of Sections 4.1 and 4.2.

6.4.4.12 Acceptance/Rejection Criteria: The failure of a module to meet any of the following: the requirements for minimum maintained luminance at standard and high temperatures and at low and elevated voltages (4.1.1) or off-axis luminous intensity (4.1.2) or maximum permissible luminance (4.1.3) under standard and high temperatures, the requirement for luminance uniformity (4.1.4), the appropriate requirement for chromaticity (4.2.1), and/or the color uniformity (4.2.2) shall be considered a failure of the proposed design.

6.4.5 UV Stabilization: Documentation shall be provided that certifies that the loss of direct transmission through the lens shall not cause the performance of the module to fall below the photometric requirements, or deviate from the colorimetric requirements of this specification after 60 months, or greater as specified by the manufacturer, of service in accordance with 3.3.1 and 3.3.4. Documentation shall be provided for hard-coat film (if used) and lens material.

6.4.6 Electrical Tests:

6.4.6.1 Electrical Test Conditions: Three of the modules that were subjected to the environmental tests shall undergo electrical tests. These tests shall be performed with the modules energized at nominal operating voltage and at a standard temperature of 25°C (77°F), unless specified otherwise. Unless otherwise specified, all electrical testing of the countdown display shall be with the countdown displaying the "88".

6.4.6.2 Current Consumption: The current flow, in amperes, shall be measured at various ambient temperatures across the span of the operating temperature range specified in 3.3.2. If requested, the manufacturer shall provide information (charts, tables and/or graphs) on the projected variation in current through 60 months of service, or greater as specified by the manufacturer, within the operating temperature range of 3.3.2. In addition, the current consumption at start up shall be measured at 25°C (77°F) to establish the reference value used for production quality assurance (6.3.4).

6.4.6.3 Power Consumption: The power consumption, in watts, shall be measured at 25°C (77°F) to establish the reference value used for production quality assurance (6.3.5). The countdown display shall be measured while displaying the "88".

6.4.6.4 Low-Voltage Turn-OFF: The modules shall be connected to a variable power supply and energized at nominal operating voltage. The applied voltage shall be reduced to a point where there is no visible illumination from the module when the background is at an average luminance of 0.1 candela per square meter ($cd/m^{2,}$ or 0.01 footcandle).

6.4.6.5 Turn-ON/Turn-OFF Times: Using a two-channel oscilloscope, the time delay between application of nominal operating voltage and the module reaching 90 percent of

full light output, and the time delay between de-energizing the module and the light output dropping to 0 percent of full output, shall be measured (the countdown display is excluded from this measurement).

6.4.6.6 Default Condition: This test is to be performed on modules that have both the "walking person" and the "upraised hand" as one unit. The module shall be connected such that the supply phase wire and neutral are connected to the phase wire of one indication and the phase wire of the other indication. Record illumination results. Repeat switching the supply phase and neutral wire as specified in 5.2.6.

6.4.6.7 Transient Voltage Immunity: The modules shall be tested for transient immunity using the procedure described in Section 2.1.8, NEMA Standard TS 2-2003.

6.4.6.7.1 Ring Wave Immunity: The modules shall be tested for ring wave immunity using the procedure described in Section 8, IEC Standard 61000-4-12. The ring wave shall have an open circuit voltage of 3KV with an output resistance of 30 ohms. The open circuit and short circuit wave form shall be as described in Figure 1 of IEC 61000-4-12. The ring wave shall be applied a minimum of 5 positive and 5 negative pulses at each of the following phase angles: 0 degrees (deg), 90 deg, 180 deg and 270 deg. They shall be applied at a maximum rate of 1 pulse per second for a total of 40 pulses.

6.4.6.8 Electronic Noise: The modules shall be tested for conformance with the conducted and radiated emissions requirements of a Class A digital device, as specified in FCC Title 47, Subpart B, Sections 15.107(b) and 15.109(b).

6.4.6.9 Power Factor (PF): The power factor for the modules shall be measured and recorded. A commercially available power factor meter may be used to perform this measurement.

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

6.4.6.11 Countdown Timing: The countdown display shall be connected to a countdown controller set to a flashing period of 1.2 seconds for 10 cycles and energized at nominal operating voltage. The countdown digit display shall be measured in seconds using a photomultiplier tube. The module shall be considered a failure if the digit display time and/or the interval from the light up of one number to the light up of the subsequent number is not 1.0 seconds ± 0.04 seconds and/or if the countdown module fails to countdown from 12 to 0 under these test conditions.

6.4.6.12 Electrical Tests Evaluation: At the conclusion of the electrical tests, the measurement data shall be compared to the requirements of Sections 3.2.5 and 5.2 through 5.5.

6.4.6.13 Acceptance/Rejection Criteria: The failure of any module to meet the requirements for low-voltage turn-OFF (5.2.4), turn-ON/turn-OFF times (5.2.5), default condition (5.2.6), transient voltage immunity (5.3), emission of electronic noise (5.4), minimum power factor (5.5.1), maximum total harmonic distortion (5.5.2) and/or countdown timing (3.2.5.5) shall be considered a failure of the proposed design.

6.4.7 Controller Assembly Compatibility Tests:

6.4.7.1 Overview: Following the electrical tests, three modules shall be tested for compatibility with load current switches and conflict monitors presently in service. The manufacturer shall test the design for the specific type signal control unit with which the design is intended to be compatible.

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

6.4.7.3 Off State Voltage Decay Test: Each 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 module 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 module. Conflict monitor off state impedance 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 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.

6.4.7.4 Controller Assembly Compatibility Tests Evaluation: At the conclusion of the controller assembly compatibility tests, the measurement data shall be compared to the requirements of Section 5.6.

6.4.7.5 Acceptance/Rejection Criteria: Failure of the module to draw sufficient current to ensure compatibility with the load current switches in the appropriate controller assembly (5.6.1) 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 (5.6.2) shall be considered a failure of the proposed design.

6.4.8 Failed State Impedance Test (Optional):

6.4.8.1 Failed State Impedance Measurement: The modules shall be tested for compliance with the requirement for provision of failed-state impedance (5.7). The test is conducted in two parts: First the module is energized with the LED load disconnected from the power supply to establish the failed-state impedance. Next, the requirement for the failed state impedance is tested. The module shall be operated from a 120 VAC voltage supply.

a) Wire a 50 kΩ resistor in series with the hot line between the module and the AC power supply. A 100 kΩ shunt resistor shall be wired between the hot line connection and the neutral line connection on the module. A single-pole-single-throw switch shall be wired in parallel with the 50 kΩ resistor. With the switch in the closed position and the LED load disconnected from the module power supply, energize the module for 300 milliseconds (ms) to establish the failed state impedance (5.7.2).

b) The second part of the failed state impedance test is conducted to ensure that the appropriate failed state impedance is established. The switch is opened and the circuit is energized by the 120VAC voltage supply. The voltage across the 100 kΩ shunt resistor shall be continuously monitored. The voltage shall decay to a value equal to or greater than 70 VAC RMS. For the continuous interval of 500 ms through 1,500 ms, after energizing the circuit with an open switch, the measured voltage shall be 70 VAC RMS or greater. The second part of the test shall be repeated 10 times, with the minimum voltage recorded during the continuous interval of 500 ms through 1,500 ms, after energizing the circuit with an open switch, recorded as the final test value.

6.4.8.2 Failed State Impedance Test Evaluation: At the conclusion of the failed state impedance test, the measurement data shall be compared to the requirement of Section 5.7.

6.4.8.3 Acceptance/Rejection Criteria: Failure of the voltage across the 100 kΩ shunt resistor to remain at a value equal to or greater than 70 VAC RMS for the continuous time interval of 500 ms through 1,500 ms, after energizing the circuit with an open switch, shall be considered a failure of the proposed design.

Table 2

Table 2 provides the on-axis minimum maintained luminous intensity values for the PTCSI LED pedestrian traffic signal for a single point measurement on and normal to the physical axis of the module lens at a distance of at least 9 meters from the lens surface.

On-Axis Minimum Luminous Intensity - PTCSI LED Pedestrian Traffic Signal

Class	Luminous Intensity (candela)		
	Walking Person	Hand	Countdown "88 digit"
1	12	11	--
2	28	26	27
3	42	38	27

Table 3

Table 3 provides the off-axis minimum maintained luminous intensity values for the PTCSI LED pedestrian traffic signal for single point measurements on the physical axis of the module at a distance of at least 9 meters from the lens surface when the module is rotated 15 degrees below the horizontal plane and rotated 15 degrees left and right of the vertical plane.

Off-Axis Minimum Luminous Intensity - PTCSI LED Pedestrian Traffic Signal

Class	Luminous Intensity (candela)		
	Walking Person	Hand	Countdown "88 digit"
1	6	5.5	--
2	14	13	13.5
3	23	19	13.5

Table 4

Table 4 provides the maximum permissible luminous intensity values for the PTCSI LED pedestrian traffic signal for a single point measurement on and normal to the physical axis of the module lens at a distance of at least 9 meters from the lens surface.

Maximum Permissible Luminous Intensity - PTCSI LED Pedestrian Traffic Signal

Class	Luminous Intensity (candela)		
	Walking Person	Hand	Countdown "88 digit"
1	36	33	--
2	126	114	81
3	126	114	81

Figure 4

Design Qualification Testing Flow Chart:

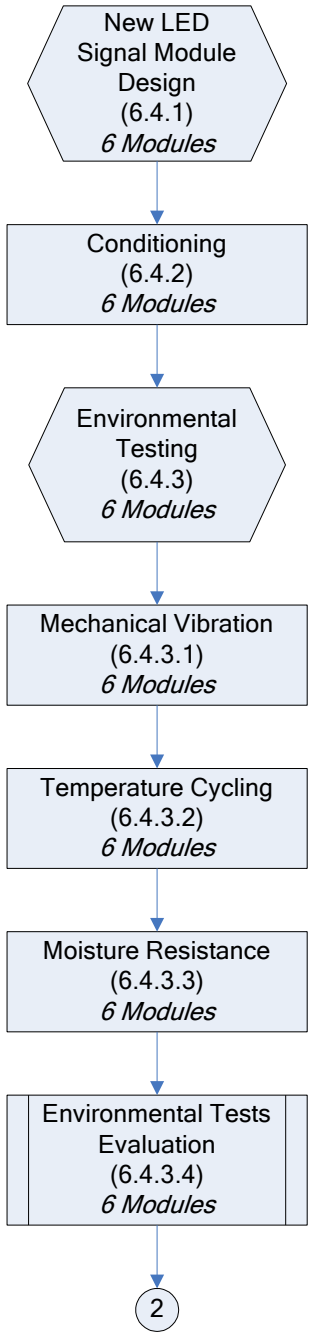

Figure 4 (cont'd)

Design Qualification Testing Flow Chart:

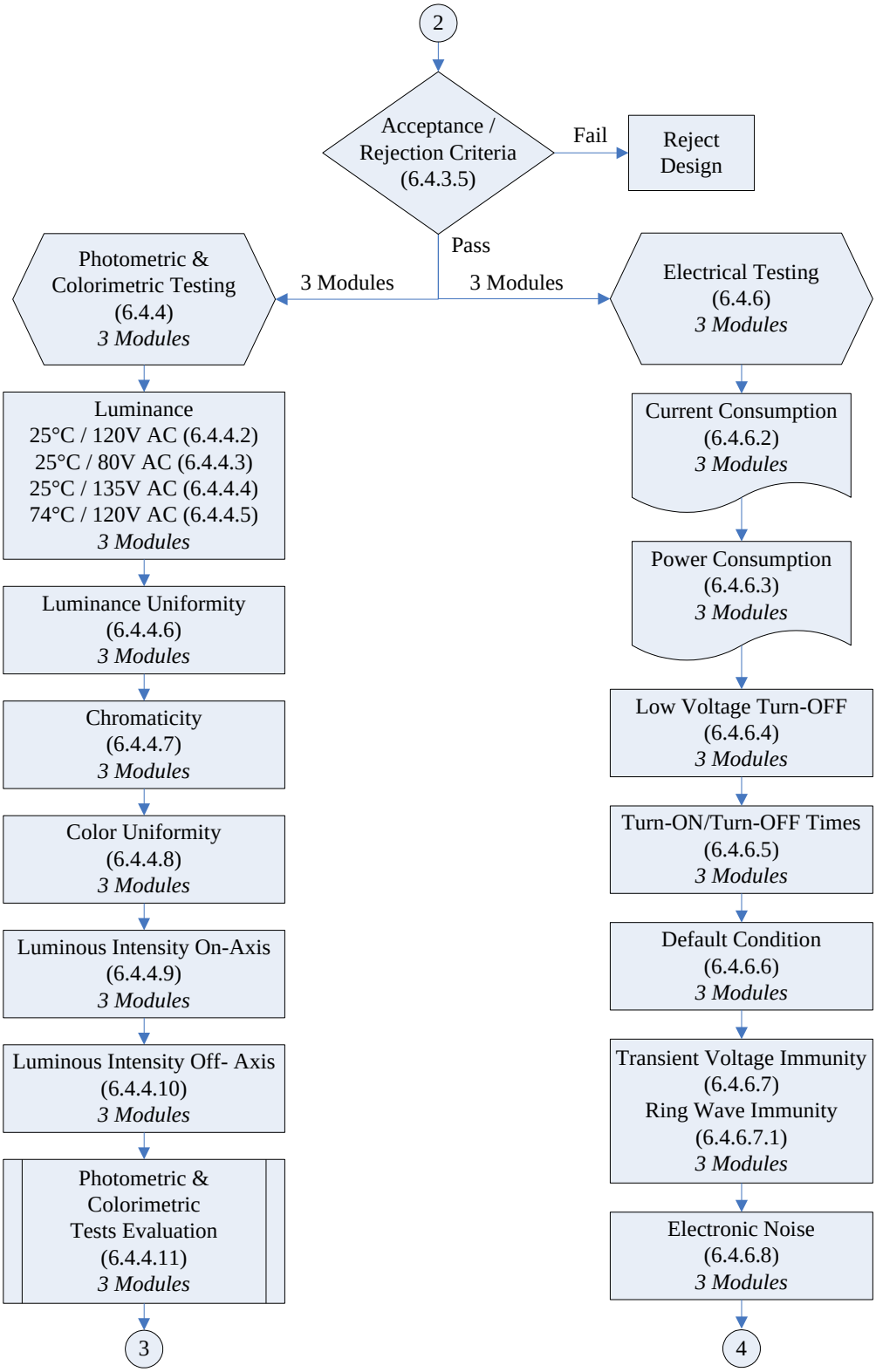

Figure 4 (cont'd)

Design Qualification Testing Flow Chart:

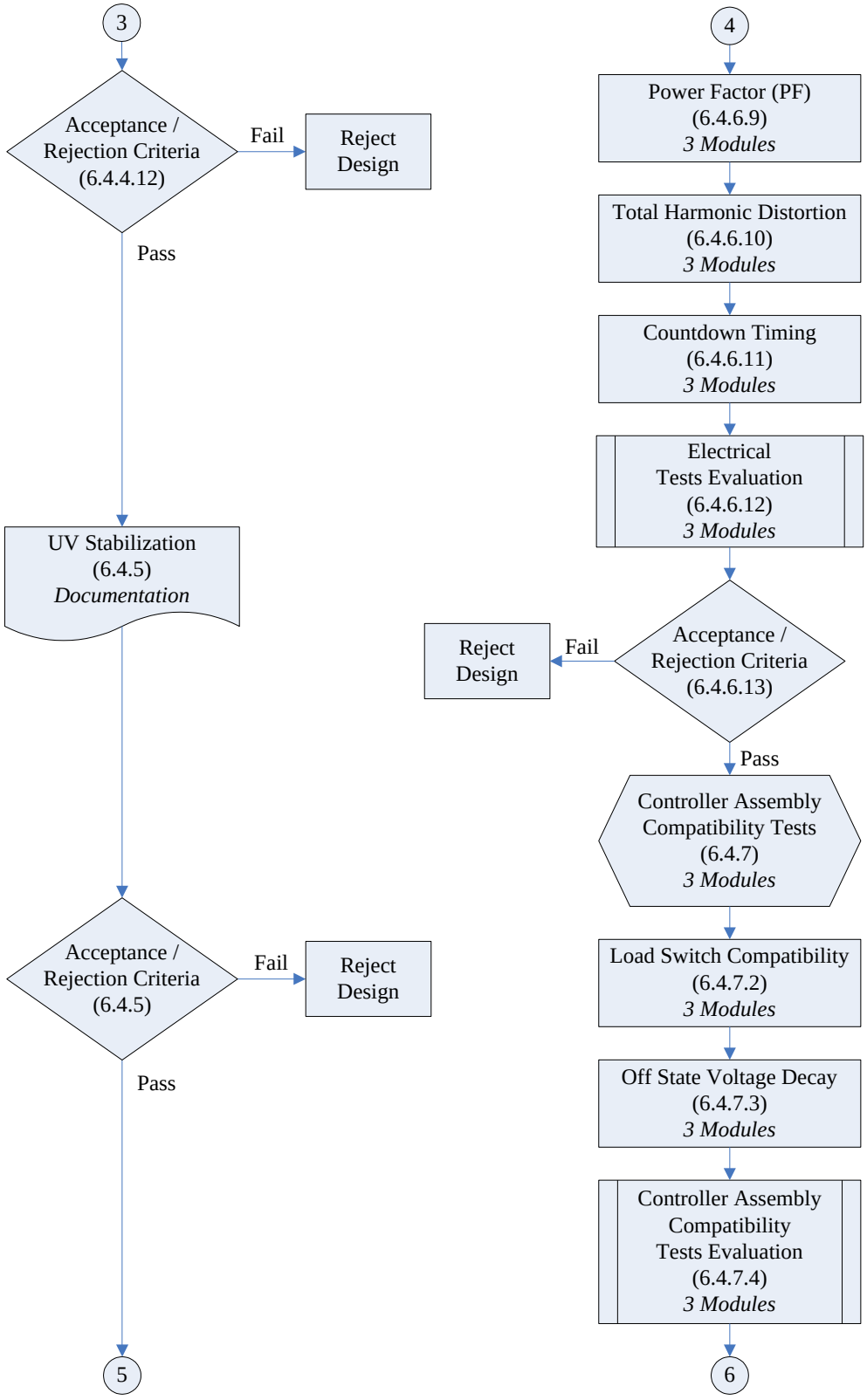

Figure 4 (cont'd)

Design Qualification Testing Flow Chart:

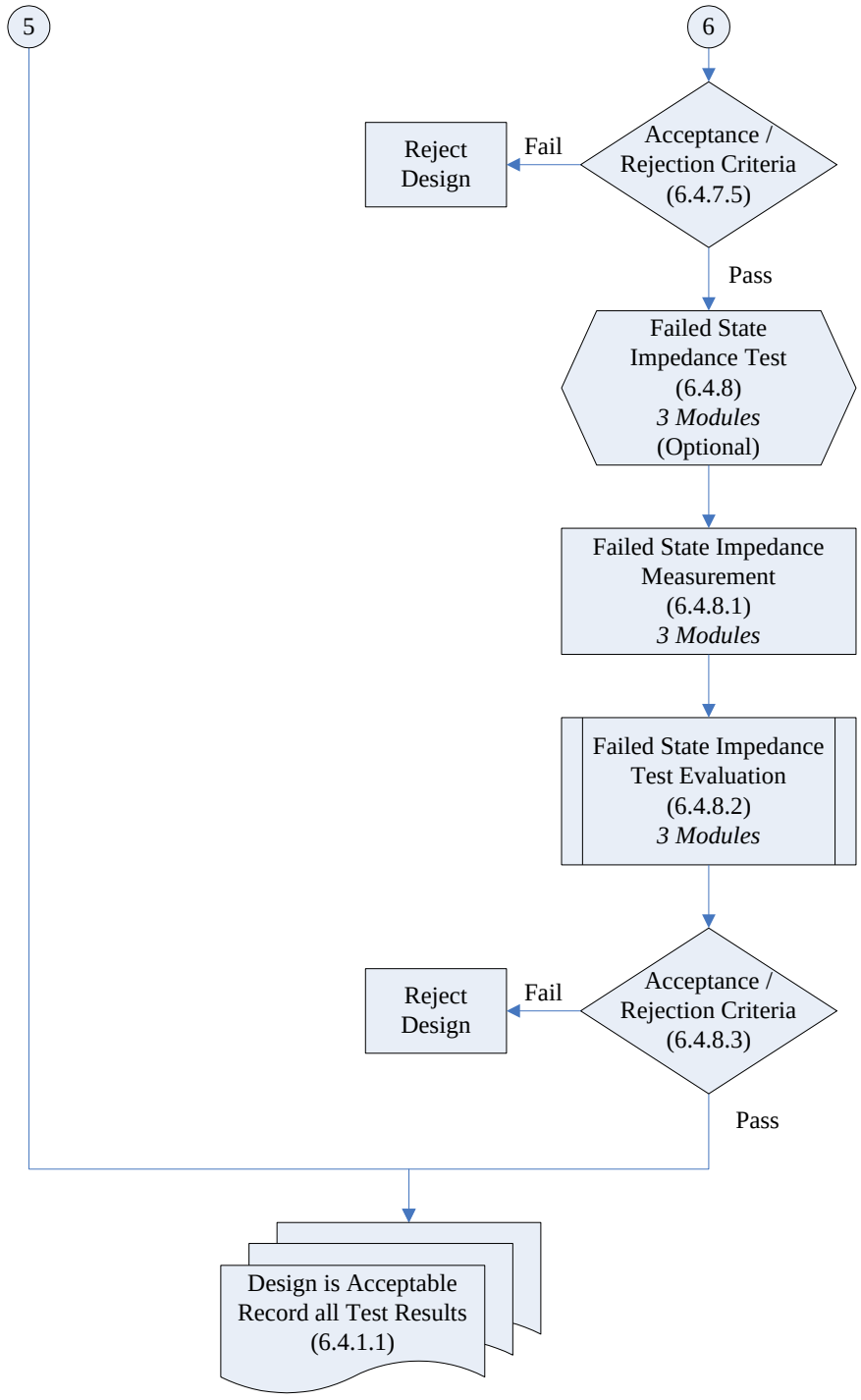

Figure 5

Color Regions for Pedestrian Traffic Control Signal Indications
(1931 CIE Chromaticity Diagram)