The New ITE Light-Emitting Diode Traffic Signal Specifications—A Guide for Purchasers

THE *VEHICLE TRAFFIC CONTROL SIGNAL HEADS—LIGHT EMITTING DIODE CIRCULAR SIGNAL SUPPLEMENT* IS A COMPREHENSIVE PERFORMANCE SPECIFICATION THAT HAS UPDATED MANY OF THE REQUIREMENTS FOR LED TRAFFIC SIGNAL MODULES TO INCORPORATE THE LATEST AVAILABLE RESEARCH AND TECHNOLOGY.

BY NATHANIEL S. BEHURA

THE INSTITUTE OF TRANSportation Engineers' (ITE) specification for light-emitting diode (LED) circular traffic signals recently was updated (June 27, 2005) and published under the name *Vehicle Traffic Control Signal Heads—Light Emitting Diode Circular Signal Supplement* (VTCSH-LED). This replaced the so-called *Interim LED Purchase Specifications*, or VTCSH-Part 2, that had been in place since July 1998.

VTCSH-LED has been adopted, by reference, into the Federal Highway Administration's (FHWA) *Manual on Uniform Traffic Control Devices* (MUTCD), which states that, with the exception of light intensity and distribution, traffic signal lights in the United States shall meet the requirements of VTCSH. Furthermore, MUTCD provides guidance that the light intensity and distribution of a traffic signal light should meet the requirements of VTCSH.

Accordingly, agencies in the United States purchasing or installing LED traffic signals should use VTCSH-LED as a minimum performance specification or must document alternative requirements based on an engineering study.

VTCSH-LED establishes new visual standards for LED vehicular traffic signals in terms of color, luminous intensity and distribution, as well as several physical and electrical requirements. These embody substantial improvements to the LED module over one based on the previous specification.

Therefore, it is imperative that users and purchasers of LED modules understand some of the stricter requirements that the product must meet and the tests that can distinguish ITE-compliant products.

Agencies also should be aware of factors that are not covered by the new VTCSH-LED specification. Because VTCSH-LED is a minimum purchase specification, it does not account for the totality of operational and maintenance issues related to the adequacy of a given traffic signal indication. The performance specification does not address signal placement, signal replacement schedules, lens cleaning, monitoring light output degradation and similar issues.

It is important for agencies using LED traffic signal modules to be cognizant of these factors and to implement appropriate systematic monitoring and maintenance activities.

It is not possible to discuss all the new requirements and corresponding tests in this feature. Some of the critical factors include:

- Luminous intensity over the full operating temperature range;
- Maximum intensity and luminance uniformity;
- Testing with duty cycle (yellow module);
- Resistance to dust and moisture intrusion;
- Hard coating of lens and abrasion tests;
- Low voltage turn-off;
- Turn-on and turn-off times;
- Failed state impedance; and
- Use of the "ITE Compliant" label on the product.

LUMINOUS INTENSITY

The new luminous intensity requirements arguably are the most critical standards in the new VTCSH-LED. It is the first time circa 1933 that wholly new intensity requirements for vehicle traffic signals have been established in the United States. The 1998 LED standards, in essence, had used the old incandescent

requirements. The new intensity requirements are different in a number of ways.

First, the intensity ratio of the red, yellow and green (R:Y:G) has changed. Near the center of the lens, at angle -2.5 degrees (down) on a vertical plane perpendicular to the center, the intensities of the 200-millimeter and 300-millimeter modules are as shown in Table 1. It shows a ratio of 1 : 2.5 : 1.3 for R:Y:G. This ratio was 1 : 4.6 : 2 in the older specification.

In other words, based on research data, the ITE committee found that intensity for yellow and green indications need not be as high as previously specified to elicit similar driver response times. In fact, numerous complaints were received by jurisdictions about green LED signals being "too bright" under the 1998 specification, and requests were made to manufacturers for dimming options.

In addition, because intensity or brightness is not the only factor that affects signal visibility, the new specification modified the CIE color coordinates allowed for signal indications to require more saturated colors.[1] This change was made to provide signal indications that may be more easily differentiated, even by drivers with a color-vision deficiency.

The 1998 specification required a module to meet intensity levels at specific measured angles in space, totaling 44 in number. This was referred to as the intensity distribution. The angles started at 2.5 degrees below a horizontal plane and went lower to 17.5 degrees and also to 27.5 degrees each side. If a module met this requirement at these discrete angles, as measured with a goniometer and photometer, it was considered to have met the intensity requirements.

Therefore, it was possible to design a module that could meet the intensity requirements at these discrete angles, but the intensity levels could dip lower between these angles. Also, in cases of signal heads on span wires or on steep curves, signal indications may need light output *above* the horizontal plane.

In the new specification, there are two main differences. First, the light output requirement is in a continuous curve in space and not discrete angles. Second, the light output requirement starts at 12.5 degrees above the horizon, giving the module a wider viewing angle.

Table 1. Intensities of the 200-millimeter and 300-millimeter modules.

	At -2.5 degrees and 0 degrees	
Color	200-millimeter	300-millimeter
Red	165 cd	365 cd
Yellow	410 cd	910 cd
Green	215 cd	475 cd

The light output requirements are to be met for a minimum period of 60 months for the entire operating range of temperature and voltage.

MAXIMUM INTENSITY AND LUMINANCE UNIFORMITY

Although it requires a minimum maintained intensity, the ITE specification also sets a limit on maximum intensity to reduce glare and driver discomfort. The maximum permissible luminous intensity (Section 4.1.2) requirement states that, when operated within the temperature range specified in Section 3.3.2, the actual luminous intensity for a module shall not exceed three times the required peak value of the minimum maintained luminous intensity for the selected signal size and color.

In addition, Section 4.1.3 requires that the luminance values (cd/m^2) across the signal face do not vary significantly. To retain uniformity of the signal output across the entire module lens, the ratio between the maximum and minimum luminance values across the face are not to exceed a ratio of 10 to 1. The test in Section 6.4.4.5 limits the measurements to 1-inch diameter spot sizes to avoid a mottled appearance of the module.

TESTING WITH DUTY CYCLE

When testing luminous intensity, the red and green modules must be on for one hour to reach thermal equilibrium and then must be measured at 25 degrees Celsius at 100-percent duty cycle. For yellow modules, luminous intensity measurements must be made after the module has been operated under the test conditions for a minimum of 60 minutes at a 12·5 percent duty cycle (5 seconds on and 35 seconds off), with readings taken at the end of the 5-second on interval or as close to the end of the on interval as possible.

This is a critical issue because the intensity of yellow Aluminum Indium Gallium Phosphide (AlInGaP) LEDs drops rapidly with the time they stay on. Therefore, testing the yellow modules after operating for 60 minutes at a 12.5-percent duty cycle provides a realistic evaluation of how a module might perform under actual service.

RESISTANCE TO DUST AND MOISTURE

Dust and moisture can affect modules during extreme weather conditions or in areas where these conditions are common. For example, arid areas in the vicinity of Las Vegas, NV, USA, may see high wind speeds with particulate matters in the wind. Coastal areas in Florida or similar regions face blowing rains.

The new specification requires the module to be resistant to dust, moisture, rain and blowing rain. In addition to using military specifications (MIL-STD-810F, Test Method 506.4), there is a detailed description of the test procedures in the specification. In these tests (Section 6.4.3.3) the modules are subjected to rain conditions and high wind when tested outside the housing (as stand alone units).

HARD COATING OF LENS AND ABRASION TESTS

LED modules generally have plastic lenses. Because the modules last for a long period, the lenses need periodic cleaning to ensure the accumulation of dust and grime does not reduce the light output from the modules over time. Unlike glass, plastic is more susceptible to scratching and damage during shipping, handling, installation and maintenance.

In Section 3.2.2, VTCSH-LED states that the module lens shall be "hard coated *or otherwise made to comply* with the material exposure and weathering effects requirements of the Society of Automotive Engineers (SAE) J576."

Because hard coating is not required (the manufacturer can use alternative means to comply with the requirement),

a front surface abrasion resistance test is the only way to determine the durability of the lens. The specification provides a description of the test (Section 6.4.5.2), which requires a specially constructed steel wool and rubber pad to impact the lens over several cycles. This is to ensure that an ITE-compliant module is not constructed of a low-quality lens material.

LOW VOLTAGE TURN-OFF

Although the LED traffic signal module is supposed to operate between 80 to 135 VAC, residual or induced voltage may create a condition for low voltage to exist on the line when the unit is meant to be off. This condition could become a safety hazard if this low voltage produces illumination from the traffic signal module, especially for the green color.

In accordance with National Electrical Manufacturers Association standards, VTCSH-LED requires that there shall be no visible illumination from the LED signal module when the applied voltage is less than 35 VAC.

TURN-ON AND TURN-OFF TIMES

An associated requirement for the module is that it must reach 90 percent of full illumination within 75 milliseconds (msec) of the application of the nominal operating voltage, and shall stop emitting visible illumination within 75 msec of the removal of the nominal operating voltage. These requirements (Sections 5.24 and 5.25) should be tested for any new module purchase.

FAILED STATE IMPEDANCE

One section in VTCSH-LED worth noting is the requirement for failed state impedance. As described earlier, an LED module is said to have failed catastrophically if there is no visible illumination when energized according to Section 5.2.1 after 75 msec. Section 5.7 requires the module, upon sensing the loss of the LED load, to present a resistance of 250 kilo-ohms across the input power leads within 300 msec. This is to ensure that the circuit carries no residual currents after the module has failed.

USE OF THE "ITE COMPLIANT" LABEL

VTCSH-LED states in Section 3.6.3 that "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 LED Circular Signal Supplement.*'" Two issues are significant:

- For a manufacturer to use the ITE label, the module must meet *all* the requirements of the specifications (that are non-optional), not just some or most of them. Hence, if a module fails to meet even one of the requirements of VTCSH-LED, it must not use the ITE label.
- ITE as an institution has set the standard of performance of the product but does not test or monitor the compliance of any manufacturer's modules. A number of independent laboratories in the United States conduct various tests for compliance.

When an agency is purchasing a product that complies with the ITE specification, it should demand the ITE compliance label and all the necessary paperwork/test data to back up the claim. These test data should come from an independent laboratory. Also, the agency itself should send a manufacturer's products to a laboratory and request its own testing. This may be done both to qualify a product and to ensure that a supplied product meets the agency's requirements (through random sample testing). Any such test data submitted must be recent and relevant to the actual models being purchased and not for other similar products tested by the manufacturer.

CONCLUSION

VTCSH-LED is a comprehensive performance specification that has updated many of the requirements for LED traffic signal modules to incorporate the latest available research and technology. It is important to note that modules are not allowed to carry an "ITE Compliant" label if they do not meet *all* the requirements of VTCSH-LED.

Agencies should be especially aware of some of the important requirements that can be challenges for manufacturers: luminous intensity over the full operating temperature range; maximum intensity and luminance uniformity; testing with duty cycle (yellow module); resistance to dust and moisture intrusion; hard coating of lens and abrasion tests; and low-voltage turn-off.

It will take time for the industry to become accustomed to designing and manufacturing an LED module that meets intensity (especially yellow), color, distribution and duty cycle requirements and is energy efficient and cost effective. Because most agencies acquire products through a low-bid process, when new products start entering the market, it is up to the purchasing agency to verify that a manufacturer has met the requirements of VTCSH-LED and that its claims are validated by laboratory tests. ■

Reference

1. Commission Internationale de l'Eclairage (CIE). Accessible via www.cie.co.at/.

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