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LED Traffic Signal Management System

INTRODUCTION

The light source of a signal module is comprised of an array of multiple individual light emitting diodes (LEDs). Fading of the array over its operational life is a serious concern of traffic engineers throughout the nation. The Institute of Transportation Engineers (ITE) developed minimum luminous intensity standards for LED signal modules that vary depending on the angle of the driver's view.

There are approximately 3,350 Louisiana intersections that utilize more than 100,000 LED traffic signal modules. The Louisiana Department of Transportation and Development (DOTD) is considering a replacement schedule based on signal module lifecycle curves. These curves can show the time duration it takes for the luminous intensity of the traffic signal modules to reduce from the initial value to the ITE minimum luminous intensity, below which it will be necessary to replace the traffic signal modules. As such, these curves represent the safe range of operation between the initial luminous intensity and ITE minimum luminous intensity.

OBJECTIVE

The research objectives were to develop lifecycle curves of DOTD-approved LED traffic signal modules and to evaluate the effectiveness of the two handheld devices used to measure luminous intensity by comparison to independent lab measurements. The effectiveness of the handheld devices needed to be assessed to determine if that device produced repeatable measurements (precision). Validating the handheld readings with lab measurements was needed to confirm accuracy.

SCOPE

This research project looked at the measurements of the luminous intensity of 63 new LED traffic signal modules that were installed outside at the Traffic Services yard. The research testing ran for 20,000 hours. Three individual samples of red, yellow, and green each were tested by an independent lab every 2,000 hours beginning at initial time (t_0) up to 10,000 hours and again at 20,000 hours. The modules were put back into operation after returning from lab tests. A traffic services signal foremen carried out in-house tests every 500 hours for the same 21 samples of red, yellow, and green each.

METHODOLOGY

An independent lab measured the luminous intensity of these modules using a goniophotometer system to collect multiple data points per module. Each data point measured by the lab represented a distinct angle

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coordinate in relation to the driver's view. LTRC conducted in-house tests on the modules using two types of handheld devices, Spectra Candela III and Traffic Light Intensity Meter (TIM). LTRC could only collect one angle at (0, 0) due to the design of the handheld devices, that is, perpendicular to the module lens. These values corresponded with the ITE minimum luminous intensity for 7.5 degrees down and 7.5 degrees right or left.

The handheld devices can only measure luminous intensity at (0, 0), while the lab can measure luminous intensity at all of the angles as specified by ITE. Figure 1 depicts how the handheld and lab measurements can be correlated. The upper plot shows the lab detecting a 157 cd failure at the 7.5 down and 12.5 left angle. At the same time, the luminous intensity as recorded by the handheld in the lower plot was 364 cd, which is above minimum standards of 234 cd at (0, 0). Thus, a handheld reading of 364 cd could be used to warn that a luminous intensity failure at 7.5 down and 12.5 left has occurred.

DISCUSSION OF RESULTS

Figure 2 depicts the 95% upper and lower confidence intervals of lab measurements at (-7.5, -7.5) (left) and (0, 0) as well as at (-7.5, 7.5) (right) and (0, 0). Each curve in Figure 2 will have to drop below 1 for the modules to be considered failed.

CONCLUSIONS

The 20,000-hour results presented failures for too few coordinates in order to establish the lifecycle curves. As of yet, it is unknown whether the failures will start to accumulate rapidly or whether there will be a long slow decline.

There was one Spectra Candela device and one TIM device measuring the same 21 samples per time interval for each LED color. Lab measurements were comprised of a subset of three different samples per time interval for each LED color. Given these facts, results show the following: Spectra Candela appears to be imprecise and inaccurate. TIM appears to be precise and inaccurate.

RECOMMENDATIONS

It is recommended that this study be continued for another 24,000 hours to determine the definitive recommended replacement time for LED Traffic Signal modules. It is recommended that any extension of this study includes considerably more handheld measurements using more units of Spectra Candela and TIM handheld devices in order to investigate precision and accuracy. In reference to on-off duty cycles, it is recommended that a parallel study with these cycles be conducted as well.

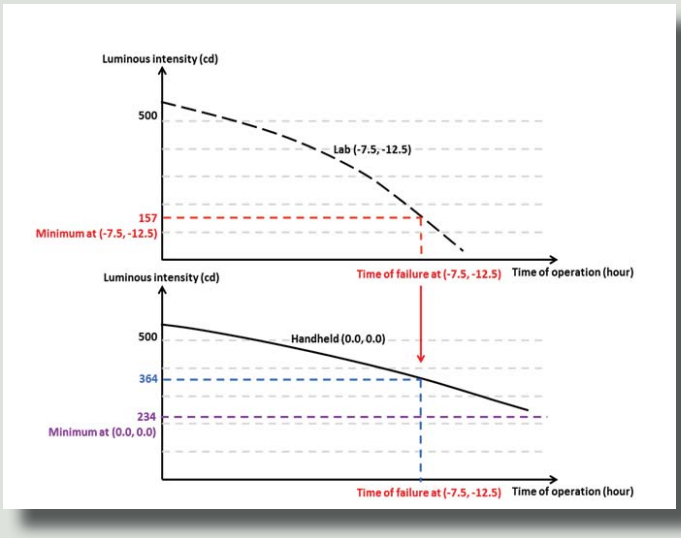

Figure 1
Data correlation between lab and in-house measurements

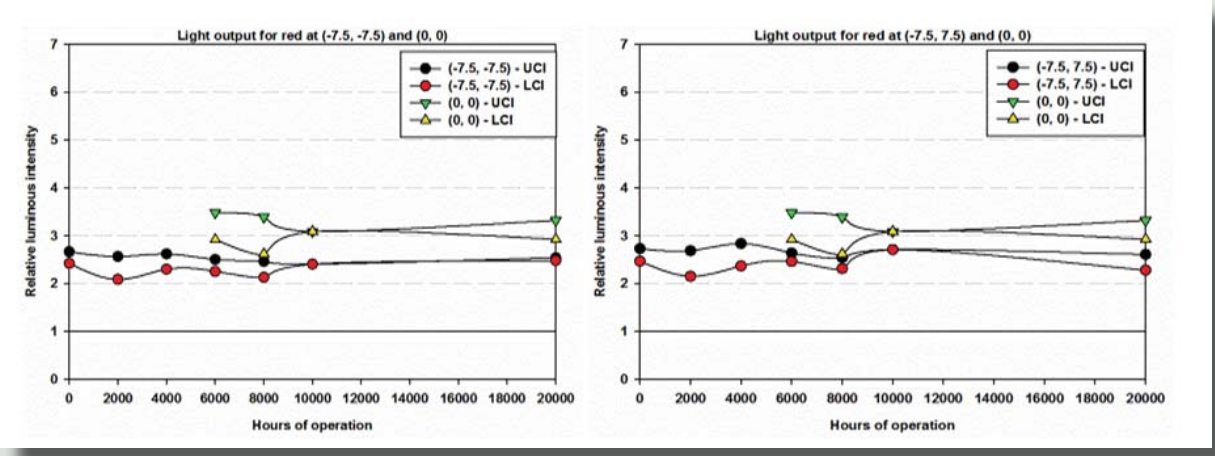

Figure 2
Confidence intervals for red signal modules – 95%