LOUISIANA TRANSPORTATION RESEARCH CENTER

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RESEARCH
PROJECT CAPSULE

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[10-3P]

TECHNOLOGY TRANSFER PROGRAM

Light Emitting Diode (LED) Circular Traffic Signal Lifetime Management System

JUST THE FACTS:

Start Date:
November 1, 2010

Duration:
33 months

End Date:
July 31, 2013

Funding:
SPR: TT-Fed/TT-Reg

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Sponsored jointly by the Louisiana Department of Transportation and Development and Louisiana State University

POINTS OF INTEREST:

Problem Addressed / Objective of Research / Mehodology Used Implementation Potential

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PROBLEM

There are 3,350 intersections built throughout Louisiana's districts, which require the operation of more than 100,000 LED circular traffic signal modules in this state. In order to manage the operation of such a number of units, the Louisiana Department of Transportation and Development (DOTD) has specified that traffic signal replacement be made in compliance with the manufacturer's warranty. As a result, DOTD's general rule is to schedule traffic signal replacement every five years from the date of the installation. A management practice of this kind generates hazards at intersections because it disregards the minimum luminous intensity for red, yellow, and green circular traffic signals that were established by the Institute of Transportation Engineers (ITE). DOTD is currently seeking a management strategy for replacing traffic signals that conforms to ITE's requirements for a driver approaching the intersection to be able to see the light emitted by the traffic signal. Since luminous intensity degradation is an outcome of the traffic signal's operational environment, DOTD is considering a replacement schedule based on traffic signal lifetime curves.

A lifetime curve is a graph where coordinates represent the measure of the equipment's performance and the equipment's time elapsed in operation, respectively. The boundary condition of the curve's equation is the equipment's operational environment. Creation of a lifetime curve requires accelerated stress testing. This method allows monitoring the performance at a reduced period of time than the typical time in operation by applying one or more type of stimuli to accelerate the sample's degradation. In order to plot the sample's performance on the lifetime curve, the number of hours in operation under accelerated stress testing needs to be translated into the number of hours in operation under typical conditions.

In DOTD's case, LED traffic signal lifetime curves will depict the luminous intensity degradation of a sample in continuous operation from the moment the sample is turned on until the moment that the luminous intensity of the sample reduces to ITE minimum values. As the current that drives an LED array and the weather temperature are known to have an impact on the degradation of luminous intensity, these factors are considered to be the boundary conditions of the equations of DOTD's lifetime curves. Each model of a traffic signal that operates in Louisiana, therefore, requires a specific lifetime curve because the value of an electric current is intrinsic to the design of a traffic signal. Figure 1 exemplifies the pattern of degradation of luminous intensity of an LED traffic signal. At time zero, the ordinate shows the initial value of luminous intensity for a sample of unused traffic signals of the same model. The graph also shows the safe traffic signal operation area between the curve and ITE minimum luminous intensity value. This area represents how long it takes for the luminous intensity of the sample to reduce from the initial value to the ITE minimum value. At this minimum value, the abscissa shows what time will be necessary to replace the traffic signals to guarantee a safe operation. Knowing this information, DOTD will be able to schedule a traffic signal replacement taking into consideration the minimum luminous intensity values established by ITE.

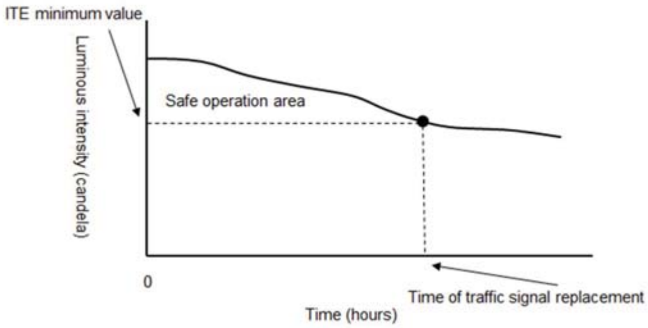

Figure 1 – Example of LED traffic signal lifetime curve in compliance with ITE minimum requirement for safe quantity of luminous intensity at the intersections

OBJECTIVE

The objective of this research is to build lifetime curves for red, yellow, and green LED circular traffic signals through 20,000-hr. accelerated stress testing of samples operating under Louisiana's environmental conditions.

METHODOLOGY

In order to build lifetime curves, DOTD's Traffic Services Section will run 20,000-hr. accelerated stress testing on LED circular traffic signals. A data acquisition system will monitor the operation of 21 red, yellow, and green traffic signal samples produced by the same manufacturer. The samples will be installed in the back of DOTD's Traffic Signal Shop. A lab will measure the luminous intensity of the samples using a goniophotometer, which is a device that measures properties of the visible light in relation to a specific angular position of the light source. Three distinct red, yellow, and green samples will be measured at time zero, then every 2,000 hrs. up to 10,000 hrs., then finally at 20,000 hrs.

Traffic Services will try to establish a correlation between lab and field measurements of the luminous intensity by using a handheld light meter every 500 hrs. up to 20,000 hrs. Data acquisition system's sensors connected to the sample will measure electric current and voltage consistent with the frequency of the field measurement of luminous intensity. Moreover, weather temperature will be collected from a specialized Web site at this same frequency. Finally, lifetime curves for red, yellow, and green traffic signals in compliance with ITE requirements for safe operation of circular traffic signal modules will be established by interpolating luminous intensity data in relation to current and temperature.

IMPLEMENTATION POTENTIAL

The key benefit of implementing the lifetime curves resulting from this research is to guarantee that Louisiana conforms to ITE requirements for safe operation of traffic signals. DOTD plans to implement the lifetime curves to reduce the cost of replacing traffic signals if the research's results show that these units can operate safely for more than five years. The longer the time in operation within the safe area of the lifetime curve, the more significant the cost savings. DOTD's Traffic Services Section estimates that the annual cost of labor and materials to replace Louisiana's entire inventory of LED traffic signals, based on the current five-year replacement strategy, is about $900,000. The following examples show projected costing savings by Traffic Services resulting from implementing the lifetime curves in two distinct scenarios.

In the first scenario, traffic signals will operate for six years before being replaced, which will generate an annual projected cost savings of about $150,000. In the second scenario, traffic signals will be in operation for seven years before replacement is necessary, which will result in an annual projected cost savings of about $250,000.