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LIFETIME PREDICTION OF LED LUMINAIRE

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The performance and the reliability LED luminaire have been continuously increased since the high power LED was introduced in the market. LED luminaire lifetime along with luminous efficacy has been phenomenally increased since both semiconductor and packaging technologies have improved. However, lifetime estimation for LED luminaire has not been well established for LED manufacturers without any loss of generality. Considering rapid and recent advancements in high power LED technology, manufacturers have an urgent need to develop efficient and accurate method to determine LED luminaire lifetime. Accelerated life test (ALT) is a well accepted method to predict lifetime of electronic devices and has been widely used in microelectronics industry.

Unlike the conventional light sources such as incandescent and fluorescent light, LED does degrade gradually over its lifetime. Conventional light sources typically stop functioning or cause significant performance degradation at a certain point of time. Lifetime for the conventional light sources is evaluated when 50% of the testing units fail. However, a different definition is required for LED failure due to its gradual degradation characteristic. The failure time of LED light source is determined when there is a pre-determined amount optical power reduction occurs. LED luminaire failure criterion is universally accepted by industry at 30% reduction of initial optical power. Nevertheless, LED lifetime measurement under operating conditions within a reasonable period of time is not feasible. LED manufacturers set their own maximum test time limit typically ranging from 1,000 to 6,000 hours to collect the degradation data for lifetime prediction. It is believed that this long test time is required to secure enough data to minimize the prediction errors. However, the amount of data collected over thousands of hours may still not be enough to accurately predict the lifetime considering very long LED lifetime.

ALT has advantages over normal operation test as well as potential risks. ALT can be a promising candidate as a standard lifetime LED luminaire prediction method replacing common degradation tests if it is carefully designed. Prediction errors can be induced by the unexpected failure that will not occur under normal operation if ALT is poorly designed. In ALT, the failure is intentionally induced in a reasonably short period of time. ALT, therefore, may be superior lifetime prediction method compared to the other types of degradation test done under normal operating conditions in that 1) failure mechanisms can be identified by analyzing failed units, 2) time-to-failure data, not partial degradation information, can be extrapolated to determine lifetime, and 3) statistical analysis for the time-to-failure distribution and well established physical model such as Arrhenius relationship are used to predict the lifetime at operating conditions.