BRIGHT PAPER

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Effects of Debris on Thermal Performance of the Ephesus Visium Luminaire

Abstract: ***Ephesus Visium fixtures have the ability to perform effectively with the accumulation of dust, sand, and dirt. In order to achieve this potential, the light-emitting diodes (LEDs) must be properly managed both thermally and electrically, and in particular, the heat sink must offer the ability to cool the LEDs despite the decrease in surface area of the heat sink exposed to the air. This Bright Paper examines the thermal performance of the Visium when covered by various debris.***

Introduction

Over the past few years there has been an increase of interest in LED lighting. One the benefits of LED fixtures is their long lifetime compared to current fixtures being used. Because of the longevity of these fixtures, they are more likely to accumulate dust and other debris. A large amount of debris affects the thermal management of the fixture, decreasing the ability of the heat sink to cool the LEDs, resulting in a decrease of the LED's lifetime.

The Ephesus Visium heatsink is designed to thermally manage the heat from the LEDs, and testing shows the collection of dust and debris negligibly affects the long term performance of the fixture. The LEDs maintain a temperature that is within the tolerance to perform optimally and still last the guaranteed lifetime.

Methods

To test the thermal management of the Visium fixture, talcum powder, sand, and top soil were applied to the fixture. Each material was applied in various thicknesses and measured using a dipstick, seen in Figure 1A. The powder was applied as a dusting (light coating covering the entire fixture), and in thicknesses of ¼", ½", and ¾", which can be seen in Figure 1B. The sand was applied in thicknesses of ¼", ½", and ¾" as seen in Figure 1C, and the top soil was applied to cover the entire fixture (did not use different thicknesses because it was too difficult to apply uniformly due to its heterogeneity) and can be seen in Figure 1D.

To measure the effect that debris had on thermal management of the Visium fixture, type-k thermocouples were used to monitor different temperature points throughout the fixture. Thermocouples were placed on the junction of the LED, in the center of the LED board, in the middle of the heat sink, on the outer edge of the heat sink, and one to measure the ambient temperature.

To ensure that the readings were accurate, after the application of each new debris, or change in thickness of the current debris, the fixture's temperature was stabilized. In order to understand the data more clearly, the ambient temperature was subtracted from the LED temperature (temperature differential) so that the fluctuating ambient temperature, ranging between 24˚C and 26˚C, did not influence the results.

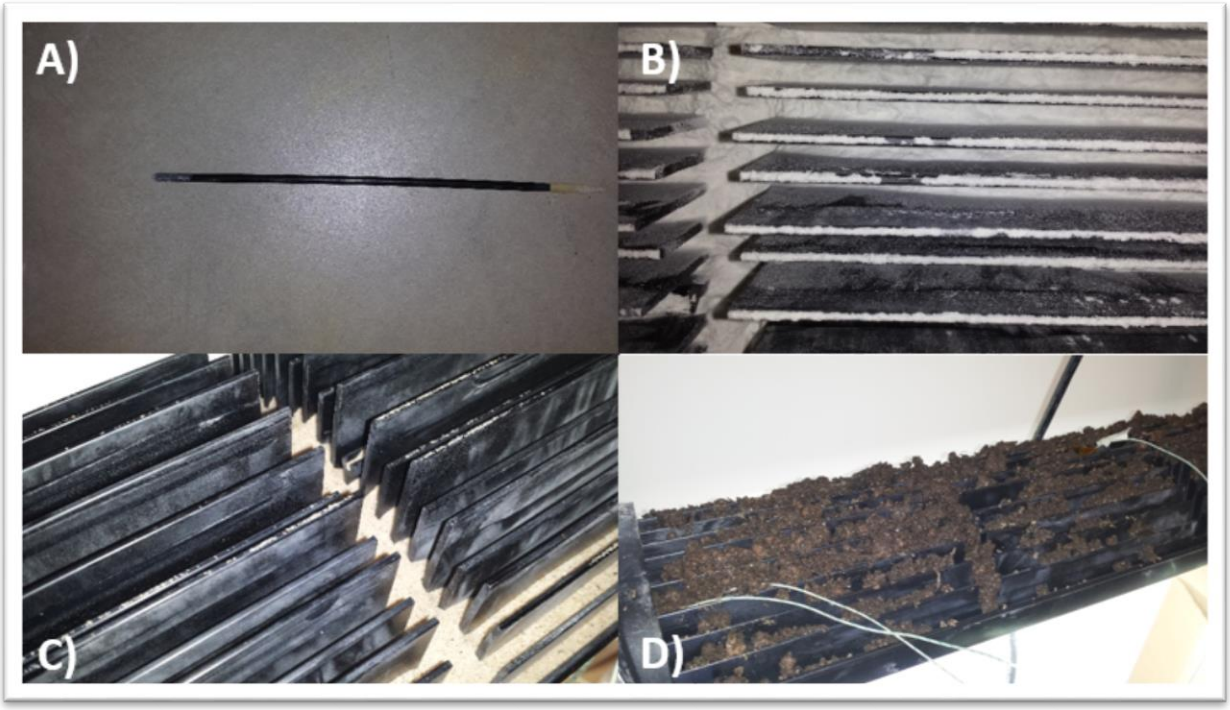

Figure 1: (A) Dipstick used to measure the depth of (B) powder and (C) sand. (D) Image of the heatsink covered by top soil.

Results & Discussion

Applying the various debris to the Visium fixture increased the temperature of the fixture. The Visium's worst case performance occurred when the top soil was applied to the fixture. The resulting data can be seen below in Table 1.

Table 1: The effect of talcum powder, sand, and top soil on the thermal management of the Visium.

		Talcum Powder				Sand			Top Soil
	Control	Dusting	1/4"	1/2"	3/4"	1/4"	1/2"	3/4"	Layer
Max LED Temp (˚C)	80.09˚C	81.56˚C	82.09˚C	83.04˚C	83.39˚C	82.36˚C	82.79˚C	84.38˚C	90.77˚C
Temperature Difference from Ambient (˚C)	55.99˚C	57.19˚C	56.94˚C	57.64˚C	58.4˚C	57.9˚C	57.91˚C	59.7˚C	65.42˚C
Temperature Rise Compared to Control (˚C)	-	1.2˚C	0.95˚C	1.65˚C	2.41˚C	1.91˚C	1.92˚C	3.71˚C	9.43˚C
Percent Rise Compared to Control (%)	-	2.14%	1.70%	2.95%	4.30%	3.41%	3.43%	6.63%	16.84%

The worst case scenario of talcum powder was ¾" thick but only increased the LED temperature by 4.3%. The worst case of sand was ¾" thick but only increased the LED temperature by 6.63%. The overall worst case scenario occurred when a layer of top soil was applied to the heatsink, increasing the LED temperature by 16.84%. Although the thermal fins were thickly packed with top soil (worst case), the LED temperature was still below the recommended limit provided by the Cree LM80 test data. This demonstrates that there is no impact on the longevity and reliability of the Visium's LED chip with the accumulation of debris.

In order to supplement the data found by the thermocouples, a simulation was completed in SolidWorks. The set up for this analysis can be seen in Figure 2. A simulation was done for sand at thicknesses of ¼", and ¾" on the heatsink. The first simulation, seen in Figure 3A, uses a sand thickness of ¼" and shows a resulting maximum temperature of 77.78˚C at the LEDs. This shows that the experimental results from Table 1, confirms the accuracy of the simulation because the maximum experimental LED temperature (82.09˚C) since there was only a percent difference of 5.54%. A second simulation was done with a sand thickness of ¾", seen in Figure 3B, and shows a resulting maximum temperature of 84.69˚C at the LEDs. The experimental results from Table 1 also confirm this simulation because the maximum experimental LED temperature (83.39˚C was only a percent difference of 1.54% from the simulation.

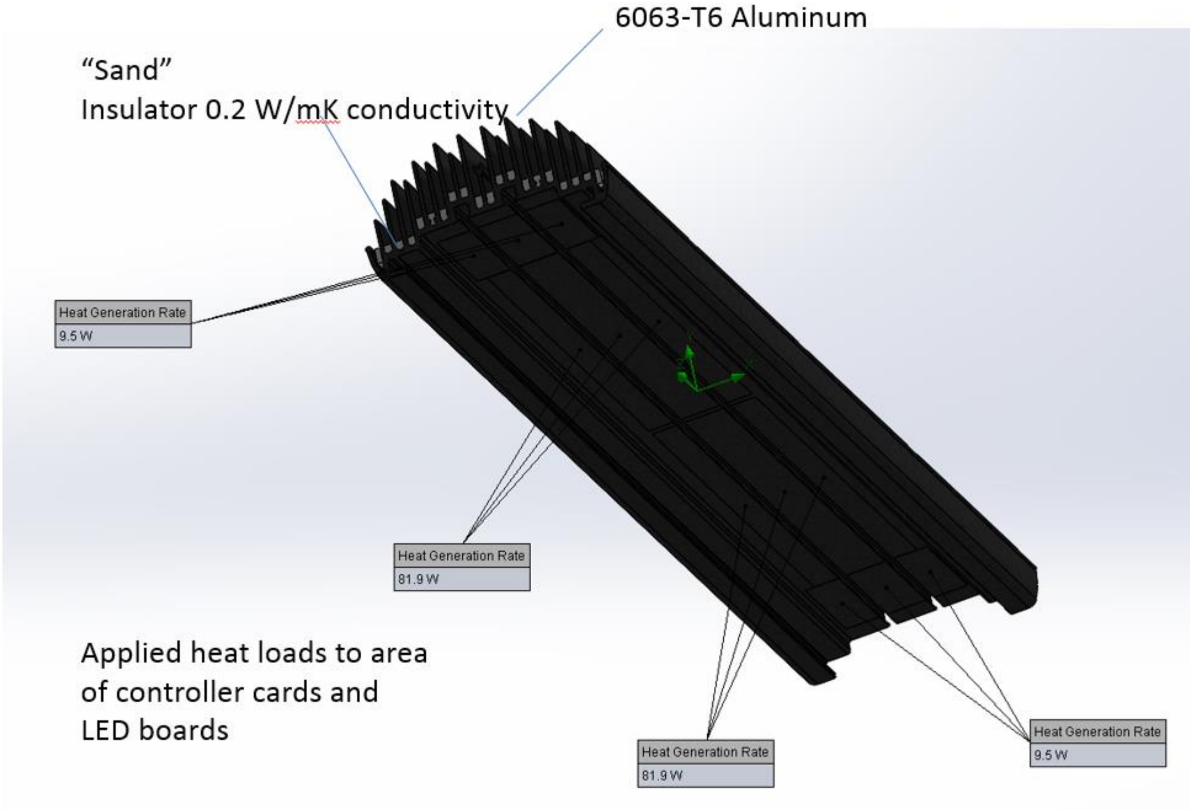

Figure 2: Simulation set up that shows the different loads that are applied to the heat sink by the LEDs.

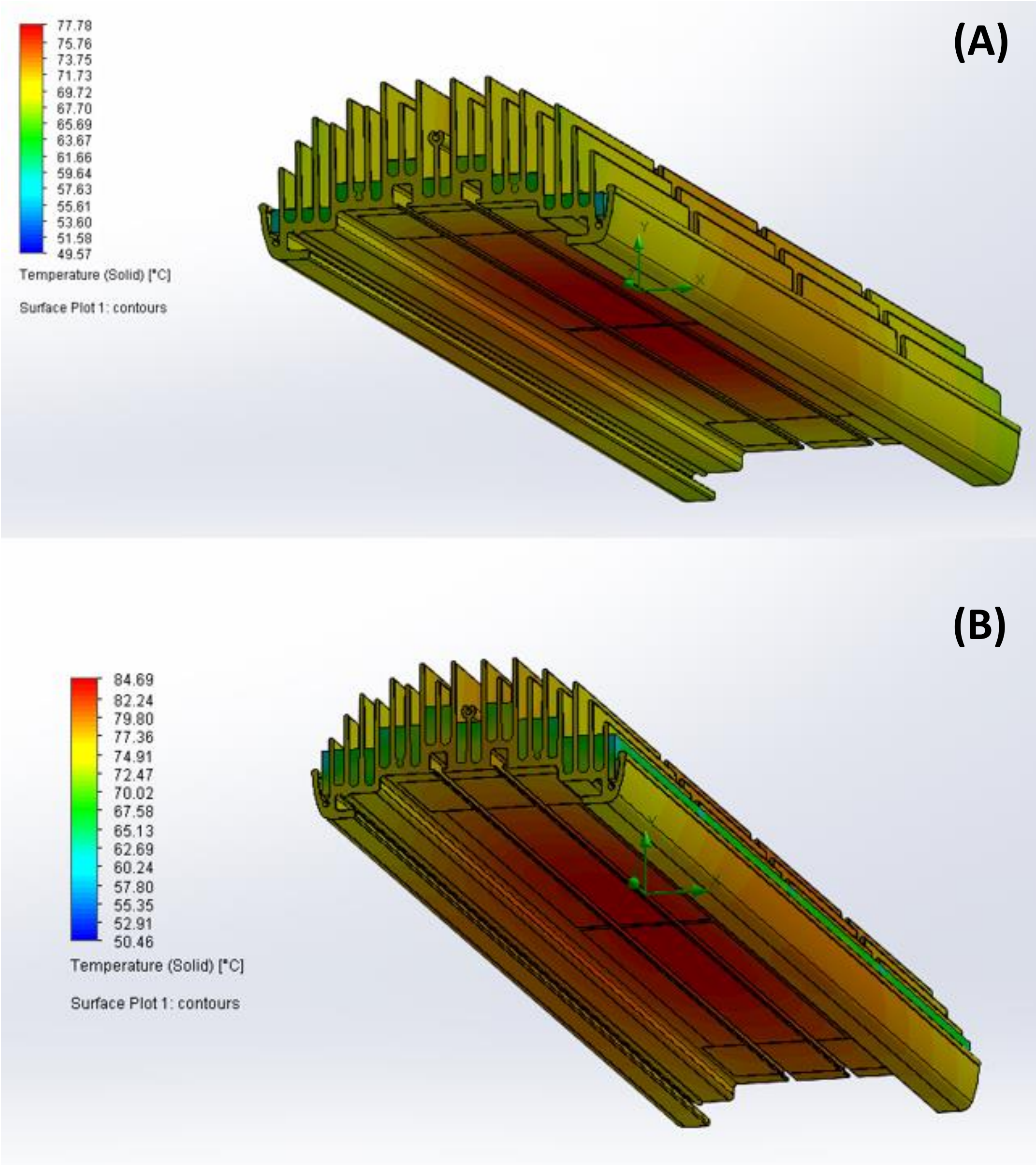

Figure 3: SolidWorks simulation for sand thicknesses of (A) ¼" and (B) ¾". With a ¼" of sand, the maximum theoretical LED temperature is 77.78 ˚C, and with ¾" of sand, the maximum theoretical LED temperature is 84.69˚C.

Conclusion

The Ephesus Visium fixture has the ability to perform effectively even with the accumulation of dust, sand, and dirt. Despite the decrease in thermal fin surface area and reduction of airflow, the Visium fixture maintained an acceptable operating temperature, with no effect on LED performance. After these tests, it is clear that the Visium can perform well in harsh environments amidst various debris types and still maintains its longevity and reliability.