Halogen Light Bulbs in a Humid Environment

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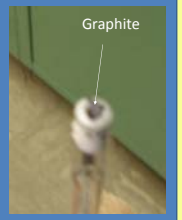
This research project involves enhancing the performance of an instrument that is used to accelerate the weathering process of pressure treated wood. Lumber samples are taken through repeated cycles of rain and drying to simulate multiple years of outdoor weathering. A high intensity halogen light bulb is used to simulate the drying and UV exposure that is caused by the sun. A local company used this system to test if new preservative chemicals that had been developed were resistant to being leached from the wood during weathering cycles. The unique environment inside the weathering instrument causes additional failure modes of the halogen bulbs which greatly reduces their lifespan. Random bulb failures were plaguing the weathering tests. This research project involved investigating the viability of a method that been developed which appeared to solve the bulb failure problems.

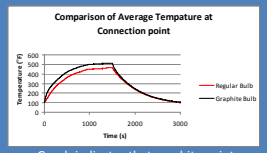
The Problem/Possible Solution

Halogen light bulbs are used in a wood weathering machine that is designed to accelerate the weathering process of pressure treated lumber. This machine determines how fast chemicals leach out of treated lumber. Unfortunately, the halogen light bulbs that are used to heat and dry the wood corrode prematurely on the electrical connection points of the bulb. This causes the ends of the bulbs to explode which damages the light fixture. In an attempt to fix this problem a thin layer of graphite paint was used on the contacts to help prevent corrosion and increase electrical conductivity.



Graphite paint applied to the electrical contact.

End of halogen light bulb destroyed by corrosion.



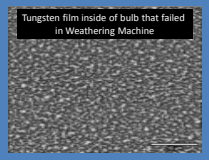
Graph indicates that graphite paint reduces contact temperature.

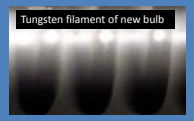
Investigation of Solution

The graphite paint should increase the thermal conductivity at the electrical contact area of the bulb and reduce corrosion. LabVIEW (a computer interfacing program) was used to log the temperature of the contacts during a typical weathering test. This showed that that the fixture contact temperature was increased, which decreased the bulb contact temperature. This implies that the rate of corrosion formation should be reduced.

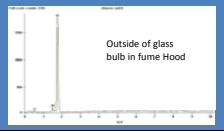
Halogen bulb with tungsten coating on inside of bulb.

Unfortunately, cooling the electrical contacts of the bulb appeared to interrupt the halogen cycle. This causes coating of the inside of the quartz bulb with evaporated tungsten. The coating keeps the light from escaping which reduces the effectiveness of using the bulb for drying wet wood.

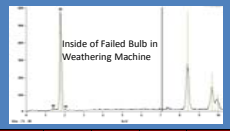




Optical and electron microscopy was used to inspect the inside and outside of the bulbs to look for additional reasons for bulb failure. These investigations revealed that the quartz envelope on some bulbs would cloud up after a short time period. This clouding would cause an increase in bulb temperature which would increase the rate of filament evaporation coating the inside of the bulb with tungsten and thus reducing the bulb lifetime. The increase in temperature would also increase the rate of electrical contact corrosion.



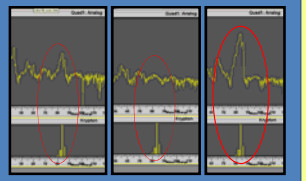
Element	Net Counts	Weight Conc %	Atom Conc %	Compnd Conc %
O	320	23.60	35.12	23.60
Al	685	3.27	2.88	3.27
Si	15976	73.14	62.00	73.14



Element	Net Counts	Weight Conc %	Atom Conc %	Compnd Conc %
W	7950	100.00	100.00	100.00

Optical microscopy also indicated that there may be cracks in the bulb surface which would allow the halogen gas to escape. This is an additional failure mode. We investigated this possibility by smashing failed bulbs and new bulbs separately and analyzing the gas inside them with a Residual Gas Analyzer instrument. The gas analysis showed that gas did in fact leak out of one of the failed bulbs but another failed bulb showed that the gas was still inside that bulb.

Smashing a halogen light bulb to determine if the halogen gas leaked out.



New bulb Failed bulb Failed bulb

Conclusion

Our experiments revealed the following. First and foremost, halogen light bulbs are much more complicated than we were originally anticipating with multiple failure modes. Next we found that putting a graphite coating on the end of the bulb connections will not significantly alter the lifespan of the halogen bulb. However, the graphite did help prevent the ends of the light bulbs from exploding and ruining the light fixture. Finally, our experiments indicate that turning the lights on and off is what allows the corrosion to begin to form. Thus, our solution is to just leave the lights on all the time. This will not affect the weathering process of wood, but will increase the cost of the tests due to greater electricity used.

Acknowledgements:
UW-Eau Claire Differential Tuition
UW-Eau Claire Faculty Student Research Collaboration Grants
UW-Eau Claire Physics and Astronomy Department